PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE
ESCUELA DE INGENIERIA

USING ORCHESTRATION TO INTEGRATE ICT INTO THE EDUCATIONAL PROCESS

ANITA DÍAZ SUÁREZ

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

Advisor:
MIGUEL NUSSBAUM VOEHL

Santiago, Chile, October 2015

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To my parents, for being a solid example of hard work and perseverance. To my sister, for her time and understanding. And to Nicolás, for his love and companionship.

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GENERAL INDEX

INDEX TABLES

PAGE

INDEX FIGURES

PAGE

PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE
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ORQUESTACIÓN PARA LA INTEGRACIÓN DE TIC EN EL PROCESO EDUCATIVO

Tesis enviada a la Dirección de Investigación y Postgrado en cumplimiento parcial de los requisitos para el grado de Doctor en Ciencias de la Ingeniería.

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RESUMEN

La búsqueda constante de idear y desarrollar herramientas que proporcionen estrategias para perfeccionar el proceso educativo está generando una alta tasa de inserción de nuevas tecnologías al proceso de enseñanza apuntado, entre otros objetivos, a una mejora en el proceso de aprendizaje de los alumnos. No obstante lo anterior, la buena instrucción no es sólo determinada por los factores a nivel de la escuela y los conocimientos, creencias y actitudes de los profesores sino también por la consideración de las necesidades de los estudiantes y de factores a nivel de la clase y los alumnos. En esta tesis se plantea la necesidad de considerar lo que ocurre dentro del aula, la relación social de los actores, en particular los intereses y necesidades de los profesores y alumnos cuando dentro de las aulas enfrentan el desafío de generar ambientes propicios para el aprendizaje. El propósito de esta tesis es generar discusión y propuestas pedagógicas y no tecnológicas, en el marco de políticas de informática educativa. En este sentido, el objetivo es generar evidencias sobre una herramienta, llamada orquestación, que agrupa y coordina diversas prácticas docentes centradas en el estudiante, para lograr efectividad en la integración de recursos digitales y convencionales.

Con el fin de entregar una amplia comprensión de la orquestación como andamio para los profesores en su tarea de manejar una nueva tecnología en su clase y a la vez promover un efectivo ambiente de aprendizaje, se realizaron diferentes estudios. Primero se analizaron los elementos logísticos y pedagógicos que conciernen a una clase cuando existe

tecnología, siendo esta una primera aproximación teórica a la orquestación. En segundo lugar, se estudió si en un escenario donde existe tecnología, poner a disposición de los profesores diversidad de recursos convencionales y digitales orquestados, mejora el aprendizaje de los alumnos, siendo esta la primera aproximación de la orquestación en el aula. Esto se estudió en el marco de una política gubernamental en Uruguay (Plan Ceibal) y mediante un diseño cuasi experimental con un grupo control y un grupo intervención analizado con un Modelo Lineal Jerárquico. Tercero, mediante una investigación mixta de métodos cualitativos y cuantitativos, se estudiaron elementos implícitos dentro del aula, explorando si existen necesidades e intereses divergentes entre profesor y estudiantes. Esto con el fin de identificar elementos que pudieran enriquecer el modelo de orquestación ya probado. Finalmente, en el marco de un programa interministerial del gobierno de Colombia y por medio de un análisis de Regresión Lineal Multivariado en un diseño cuasi experimental de grupo control e intervención, se volvió a estudiar la correlación entre el uso de orquestación y mejoras en el aprendizaje de los estudiantes, pero esta vez con un modelo de orquestación enriquecido con los elementos implícitos dentro del aula estudiados previamente.

A partir de los estudios realizados, esta tesis ofrece una serie de resultados. Primero, entrega como resultado un marco que especifica el rol de la tecnología en un ambiente en que se integran prácticas convencionales y prácticas basadas en recursos digitales. Esto entrega una estructura para el desarrollo de orquestaciones. Segundo, constata para el contexto de Uruguay que el aprendizaje de los estudiantes mejora en la medida en que sus docentes tienen acceso y usan sistemáticamente la orquestación para integrar apropiadamente recursos de diferente naturaleza. Esto sugiere la importancia de considerar dentro de políticas de entrega de computadores en escuelas, el apoyo y guía para que los docentes usen apropiadamente la tecnología en aula. Tercero, identifica que existe disparidad entre la visión de profesores y estudiantes en torno a los objetivos dentro del aula, necesidades de los estudiantes, expectativa de los estudiantes sobre el rol docente, y participación de las familias en el proceso educativo. Con estos resultados se sugiere el desarrollo de estrategias que ayuden a los docentes a acortar las brechas entre las visiones que convergen en su aula, facilitando así la consecución de las metas de la comunidad

educativa. Cuarto, se constató en un contexto diferente al primero, que los estudiantes cuyos maestros han dispuesto de orquestaciones para integrar la tecnología en su labor pedagógica, mostraron un mayor incremento en aprendizaje frente a alumnos cuyos profesores no tenían orquestación. En esta misma experiencia se constata una asociación positiva entre los incrementos en los aprendizajes de los estudiantes y el uso sistemático del material que aborda las debilidades individuales de los alumnos. Esto sugiere la importancia de considerar dentro de las actividades pedagógicas y elección de recursos, los diferentes ritmos de aprendizaje presentes en el aula y no solo las exigencias curriculares.

Finalmente, esta tesis propone trabajos futuros en torno al estudio de la orquestación en distintos niveles y áreas curriculares, enriquecer nuevos modelos de orquestación con elementos relacionales que ocurren en un aula, y estudiar la instalación de capacidades en docentes en servicios para que ellos desarrollen sus propias orquestaciones.

Palabras Claves:

Orquestación; Integración de recursos digitales y no digitales; Políticas de informática educativa; Prácticas pedagógicas y tecnológicas escolares

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ABSTRACT

The constant search to create and develop tools that provide strategies with which to perfect the educational process is leading to the insertion of new technologies within the teaching process. One of the aims of these technologies is to improve the learning process for students. However, good teaching is not just determined by school-level factors or the knowledge, beliefs and attitudes of the teachers. It is also determined by taking into account the needs of the students, as well as other classroom- and student-level factors. This thesis sets out the need to take what happens in the classroom into consideration, as well as the social relationships between its actors. Of particular importance are the interests and needs of the teachers and students when faced with the challenge of creating effective learning environments.

The purpose of this thesis is to generate discussion regarding ICT in education policies, as well as to provide the field with pedagogical rather than technical proposals. In this sense, the aim is to provide evidence to support a tool called orchestration, which groups together and coordinates various student-centred teaching practices in order to achieve an effective integration of traditional and digital resources.

Various studies were conducted throughout this thesis project. The aim of this was to provide a broad understanding of how orchestration can be used by teachers as scaffolding when introducing new technology into their classes. Another aim was to encourage the creation of an effective learning environment. Firstly, the logistical and

pedagogical elements that affect a class when using technology were analysed. This provided a first approach to orchestration. Secondly, in a setting with technology it was studied whether or not providing teachers with a series of orchestrated conventional and digital resources improves student learning. This was the first approach to using orchestration in the classroom. This was studied within the context of a government policy in Uruguay (Plan Ceibal) using a quasi-experimental design with a control and intervention group. The results of this study were analysed using Hierarchical Linear Modelling. Thirdly, mixed methods (quantitative and qualitative) research was used to study elements that are implicit in the classroom and explore whether the teacher and students' needs and interests are divergent. The aim of this was to identify elements that might enrich the existing orchestration model. Finally, and within the context of an inter-ministry government program in Colombia, the correlation between the use of orchestration and improvements in student learning was again studied. This was done using Multivariate Linear Regression with a quasi-experimental design involving a control and intervention group. However, this time the study was conducted using an orchestration model that was enriched by taking into account the implicit elements of the classroom highlighted in the previous study.

Based on these studies, this thesis offers a series of results. Firstly, it provides a framework that specifies the role of technology in an environment where conventional teaching practices are integrated with practices based on digital resources. This provides a structure with which to develop orchestrations. Secondly, in the context of Uruguay, it establishes that student learning improves as teachers have access to and make systematic use of orchestration. When developing policies to provide schools with computers, this suggests the importance of supporting and guiding teachers so that they use the technology appropriately in the classroom. Thirdly, it identifies a disparity between the teacher and students' view of the classroom objectives, the students' needs, the students' expectations of the role of the teacher, and the participation of the family in the educational process. These results lead to the suggestion that strategies should be developed to help teachers reduce the gap in the views that converge within the classroom. Doing so would therefore make it easier to achieve the goals of the educational community. Fourthly, in a different context, it established that students whose teachers use orchestration to integrate technology into their teaching practice demonstrated a greater improvement in their learning than students whose teachers did not. This study also established a positive association between increases in student learning and systematic use of materials that address the students' individual weaknesses. This suggests the importance of taking into account the different paces at which students learn when looking at teaching activities and selecting resources, and not just the demands of the curriculum.

This thesis proposes future work based on the study of the use of orchestration with different grade levels and areas of the curriculum. It also suggests enriching new orchestration models with relational elements that are present in the classroom. Finally, this thesis recommends studying the possibility of providing active teachers with the training that is required in order for them to develop their own orchestrations.

Keywords:

Orchestration; Integrating digital and non-digital resources; ICT in education policies; Teaching practices and educational technology.

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1. INTRODUCTION

The ratio of students to computers within Chilean educational establishments is currently 9:1. This number is far from the reality described in a 2009 census, where it was calculated that there were 22 students per computer in each establishment (ENLACES, Chilean Ministry of Education, 2013). The latest figure acknowledges the investment made by governments such as Chile's in educational technology. Although such investment improves teacher and student access to digital resources, it has not managed to demonstrate improvements in the learning process (Cristia, Ibarrarán, Cueto, Santiago, & Severín, 2012). Research reveals that integrating technology into educational processes is not a simple matter. It involves a complex process that must take into account the actors that are involved, as well as other factors. Hernández-Ramos (2005) suggests that integrating technological resources into the educational process is not just about providing access; it is also about providing a tool with which to improve productivity within the teaching profession and encourage improvements in student learning.

International evidence calls into question initiatives such as One Laptop per Child (OLPC) (Kraemer, Dedrick, & Sharma, 2009), an initiative which has drawn attention for providing low-cost computers to students across the world, with the aim of improving their learning. Although this initiative has been implemented in over twenty countries, there are still major doubts concerning its possible impact. Independent assessments have been carried out which conclude that providing each child with a computer boosts the development of their digital skills (Diether, Cristia, Cruz-Aguayu, Cueto, & Malamud, 2013). However, there is still no evidence to show improvements in learning in mathematics or reading comprehension (Cristia, Ibarrarán, Cueto, Santiago, & Severín, 2012).

When technology became increasingly present in schools, different ideas emerged regarding the role it should play in the learning process. There is now plenty of evidence to suggest that technology will not work on its own and that the digital learning environment must be linked to the learning experience (Luck et al., 2012). Strategies that link traditional teaching methods with more modern practices must be transferred in order to encourage successful use of technology and shed some light on the issue of which pedagogical objective the technology can best address. This is made possible through orchestration.

This chapter looks at the concept of orchestration in greater depth. It also analyses the components of orchestration and the critical challenges it faces in order to provide the technological infrastructure that is available in classrooms with a pedagogical use.

1.1 Technology in the classroom

There are innumerable policies throughout the world that provide schools with technology. The aim of such policies is to improve the quality of education. However, international evidence shows that, at best, there is a weak or negative relationship between the use of Information Communication technologies (ICT) at school and student performance. Slavin (2008) conducted a meta-analysis of the evidence that exists regarding the impact of different programs that support the teaching and learning of mathematics. This analysis reveals that programs based on Computer-Assisted Instruction (CAI) provide moderate or limited evidence in terms of their effect on learning. However, it should be noted that these findings only considered the impact on mathematics. There is therefore a lack of evidence regarding the impact of such programs on other areas of learning. In this sense, it is worth considering going beyond digital materials or CAI resources in order to guide the changes in teaching that are required by the introduction of technology.

In line with this, a study using the data from the ICT for Education Census conducted in Chile (Diaz & Nussbaum, 2014 [Appendix 1]) concluded that there was a positive significant relationship between academic performance (as measured by the national SIMCE test) and a school's ICT infrastructure and management. This shows that as a school's ICT infrastructure and management improves, so does academic performance. However, pedagogical use of ICT turned out to be the only variable without any sort of significant relationship to academic performance (Díaz & Nussbaum, 2015b). This supports the findings from the study conducted by Claro et al. (2013), where the introduction of technology in 1,591 schools in Chile was analysed. In this case, the leading factor in not using the infrastructure was a lack of pedagogical support.

Policies that provide schools with technological infrastructure, including the policy that has been in place in Chile for more than 20 years (Enlaces – Donoso, 2010), should start to include helpful guidelines for teachers, such as orchestration (Nussbaum et al., 2013). Research has looked at how to support teachers in the task of adding value to learning experiences by using technology (Guzmán et al., 2009). This is achieved by successfully managing aspects of logistics and pedagogy, as well as encouraging social interaction within the classroom whenever the technology is available (Nussbaum & Díaz, 2013 [Chapter 2 of this thesis]).

Sharples (2013) reflected on the modern classroom being an increasingly complex and demanding place. Within this context, the teacher is not just responsible for preparing lesson plans, adapting the curriculum and worrying about discipline and safety; they are also responsible for understanding and using a variety of resources to enrich the learning process. Given this range of demands, the author proposes using orchestration to accompany the technology, providing a personal guide for teachers and students. Furthermore, Prieto et al. (2011b) suggest that the presence of multiple forms of communication and access to information do not guarantee improvements in learning. They also suggest that by coordinating the use of different resources and tools, orchestration provides the teacher with the flexibility to adapt activities in response to different structural and emerging needs (Prieto et al., 2011a). In this sense, orchestration can be seen as supporting the teacher's decision making process when implementing teaching strategies and practices that involve technology (Perrotta & Evans, 2013).

1.2 Theoretical Background

When thinking about introducing technology to the classroom, it is natural to think about the relationship between the elements and processes that converge within. The classroom is a systemic environment in which the correct functioning of each of its elements affects the adjoining elements. Acknowledging this reveals interdependence between the logistical and pedagogical elements that underlie the teaching/learning process. An orchestration is a guide that helps the teacher to structure their classes so as to successfully integrate conventional and digital resources (Nussbaum et al., 2013). An orchestration of classroom work using technology details the actions that are required by a teacher in order to implement new strategies. These can include novel tasks that are aimed at integrating a range of different resources. In this case, the orchestration guides the teacher throughout the process.

This type of strategy does not draw on traditional teacher development processes. Instead, it is a practical, step-by-step guide or set of guidelines that can be given to teachers digitally or as a small booklet. When designed well, this booklet can allow the teaching process to be focused on something other than the teacher (Goodyear & Dimitriadis, 2013). It can also empower students to participate and play a leading role in their own learning, with the teacher acting as a mediator (Nussbaum et al., 2013).

1.2.1 What does orchestration orchestrate, and why?

There are several different approaches to determine which elements make up an orchestration and which are left out. The study by Prieto et al. (2011a) made a valuable contribution to this area by reviewing the different meanings of the concept and suggesting that there is still no consensus with regards to how to understand orchestration.

In particular, the concept of orchestration proposed by Nussbaum & Díaz (2013) [Chapter 2 of this thesis] considers a context where there is a process of lesson planning associated with a standard curriculum, and where the teacher’s actions are detailed from both a logistical and pedagogical point of view. In this case, logistics refers to aspects of space and time, as well as strategies for handing out and collecting the resources back in (both technological and conventional). Pedagogy, on the other hand, refers to all the elements that together make up the process of teaching. This includes the type of questions to ask the students, examples, type of monitoring, forms of interaction with the students, classroom dynamics (individual work, small-groups), etc. Table 1-1 shows the elements that are included in the sort of orchestration proposed by Nussbaum & Díaz (2013) [Chapter 2 of this thesis]. These are classified as either logistical or pedagogical, with a brief description and example given for each.

An example of an orchestration can be found in Appendix 2. This orchestration is for a single class taken from a series of eight classes that focus on the same learning outcome. The orchestration from Appendix 2 was taken from a set that were developed for a project in Colombia (Díaz et al., 2015) [Chapter 4 of this thesis]. This example shows a combination of the different elements that are explained in the following Table 1-1.

Table 1—1 Framework specifying the elements of an orchestration

Element[1]	Category	Description	Example[2]
Target grade or class	Pedagogical	Grade or class that the pedagogical activity is aimed at.	*5^{th} Grade*
Area of the curriculum	Pedagogical	Area of the curriculum to which the pedagogical activity belongs.	*Mathematics*
Unit name	Pedagogical	Specific topic to which the pedagogical activity belongs.	*Fractions*
Allocated time	Logistical	Approximate amount of time required to carry out the pedagogical activity.	*45 minutes*
Week in which the contents will be covered	Logistical	Week of the semester, month etc. in which the pedagogical activity should be carried out, depending on the school's system.	*1^{st} week, Second unit (Depends on the school's system)*
Class activities: Time assigned to each activity	Logistical	Time suggested for each activity, visualizing the distribution of the available time.	*10 minutes of opening phase* *30 minutes of instructional phase* *5 minutes of closing phase*
Class phase: Opening phase, Instructional phase and Closing phase	Logistical	Identifies the ideal moment for carrying out the pedagogical activity (either the opening, instructional or closing phase)	*Instructional phase*
Cognitive process: Recall, Understand, Apply, Analyse, Evaluate or Create	Pedagogical	Cognitive ability that the pedagogical activity will be focused on.	*Recall (Depends on the curriculum)*
Specific unit objective	Pedagogical	Learning objective associated with the unit. This can be taken literally from the curriculum or adapted to fit the school's plan.	*Read, write and graphically represent various fractions, as well as identifying situations where they are used in everyday life.*
Class objective	Pedagogical	Specific objective of the pedagogical activities for the particular class. Together with other classes, this will help achieve the unit objective.	*Work individually through trial and error on the contents covered previously by using technology and completing a worksheet.*
Prior knowledge required	Pedagogical	Knowledge required in order for the students to be able to do the pedagogical activity.	*Parts of a fraction* *Concept of whole and set* *Understand what a cardinal and ordinal number is*
Skills and attitudes to be developed by the students	Logistical	Methodology proposed for the students during the development of the pedagogical activity.	*The class will be divided into two (equal) groups, where one of the groups will work with technology and the other with worksheets in order to work through the contents.*
Resources	Logistical	Physical resources (Worksheets, Interactive guides on the computer, Presentations with/without audio-visual support, Complementary activities/homework, Online resources).	*- Printed worksheet for each student* *- Printed worksheet for the teacher* *- Netbook with software (1-2-1)*
Criteria for maintaining control of the learning environment	Pedagogical	Classroom dynamics when carrying out the pedagogical activity.	*The dynamic is based on individual work, with each student working on the math problems either digitally or on paper. Although the class is divided into two groups, this only determines whether the group uses technology or pen and paper. Other than during the closing phase, the students do not work together as a group.*
Class activities: General indications regarding the organization of students	Logistical	Specification regarding classroom layout during the pedagogical activity.	*The room will be arranged so that the half of the class that will be working with pen and paper is in one place, while the students working with netbooks are in another. This will aid how the teacher monitors the*

[1] NOTE:

- The presence of each element will depend on the school system in which the orchestration is used (e.g. characteristics of the curriculum)
- The arrangement of the elements is flexible.
- Sometimes, an instruction will contain more than one element, or an element could be further divided based on the specifications required by the range of resources that are to be integrated. The format of the orchestration is flexible.

[2] The examples have been taken from an orchestration that was part of a project carried out in Barranquilla, Colombia, in 2013 [Chapter 5 of this thesis] and financed by the International Development Bank. The orchestration of the class featured in the examples can be found in Appendix 2.

			classroom and provides the students with differentiated learning (personalization).
Class activities: Guidance in the use of the resources for each activity	Logistical	Logistical guidelines regarding the use of resources during the pedagogical activity.	*Once all of the students have their netbook in place, ask them to choose their name from the available list and to select the "Group work" mode, Topic 1. (This work is complementary to and coherent with the work done on paper by the rest of the class).*
Class activities: Description of the planned activities, referring to the specific actions of the teacher, and explicitly stating what is expected of the students	Logistical	Description of the steps that the students and/or teacher must follow when carrying out the pedagogical activity.	*For the digital activity, give the following instructions to the students:* *- When shown a graphical representation of a fraction, you must choose the fraction that it represents.* *- When shown a fraction, you must choose the drawing that represents it.* *- When shown a fraction in words, you must choose the image that represents it.*
Visibility: Teacher to student, student to student, student to teacher	Pedagogical	Student monitoring and interaction suggested when carrying out the pedagogical activity.	*During the digital work, the teacher is expected to walk around the room and help the students with their work. It is recommended to stop the activity every 10 minutes in order to clear up any general doubts that may arise.*
Formative assessment guidelines: Tools	Logistical	Resource that will be used for formative assessment. This can be digital or non-digital.	*Online website*[3]
Formative assessment guidelines: Specific questions to be asked to the students and the expected answers	Pedagogical	Suggested questions for the teacher to check whether the pedagogical activity is benefiting the students.	*Guide your students using questions such as:* *- What does a fraction's denominator tell us?* *- What does a fraction's numerator tell us?*

1.2.2 How does orchestration differ from lesson planning?

While some aspects of an orchestration are also found in a lesson plan, Perrotta & Evans (2013) distinguish between the two by suggesting that an orchestration explicitly details the social interaction that can develop within the classroom, something which is not covered by a lesson plan. The authors conclude that orchestration must be understood as a cultural process that helps show how teachers in a particular context can adopt innovative practices by bringing technology into their teaching.

Furthermore, one of the advantages that is acknowledged of orchestration is its flexibility and adaptability when faced with different contexts and, therefore, with different needs. This suggests that the flexibility of the orchestration and the use of the

3 http://odas.educarchile.cl/objetos_digitales_NE/ODAS_Matematica/Ed_Matematica/fracciones_orden/player/start_fs.html?idx=0 (Only available in Spanish)

concepts that frame how it is read will depend on the position and pedagogical view of the context/reality in which it is going to be implemented. It is also worth noting that different guidelines will be provided depending on whether the orchestration is designed from a teaching or learning perspective. In both cases, these guidelines will act as scaffolding for the teaching/learning process.

1.2.3 Which elements accompany orchestration?

a) Taking the local context into account

Innumerable international cases have been studied in order to suggest improvements to pedagogical practices and to design scaffolding that allows teachers to harmoniously coordinate learning experiences based on conventional and digital resources. However, the literature suggests that nothing will be achieved through general policies that look to improve schools without acknowledging their local context and reality (Lupton, 2005). For example, when designing and implementing an orchestrated model for schools in Uruguay (Díaz et al., 2015 [Chapter 3 of this thesis]), one of the project's weaknesses was identified as being not taking into consideration the teachers' local knowledge regarding how to implement the curriculum. Although the design of the orchestrations was based on the current national curriculum at the time, by not taking into consideration the timeframes that had already been tested by the teachers, in some cases this translated into the systematic use of guidelines and resources being somewhat irregular.

However, in a later project in Colombia, and based on the lessons learnt in Uruguay, teachers were invited to participate in the process of gathering data and analysing information regarding the implementation of the curriculum to aid the design of the orchestrations (Díaz et al., 2015 [Chapter 5 of this thesis]). This proved to be a turning point, where taking local knowledge into consideration became fundamental in order for the proposal to make sense to the participants. It was also essential for covering needs that were detected not just by researchers and policymakers, but also by the protagonists of the pedagogical process.

Before launching processes to support teachers, a needs analysis must first be conducted based on the teachers' knowledge of the local reality. This will better focus the efforts of initiatives that look to support teachers and will ensure that they deal with aspects that they identify as being critical. Whether they are orchestrations, lessons plans, action plans or technological elements, as long their definition comes from the reality of the users (in the Colombia example, the teachers themselves), it is likely that positive results will be obtained in terms of their adoption and systematic use. This will encourage periodic and organized integration of the technology, as they are no longer isolated experiences that are detached from the students' educational process. Penuel et al. (2011) highlight the importance of the systematic use of digital devices in a program that covers mathematics. They explain that, based on their findings and in line with the experience in Uruguay detailed above, the cases where there was no systematic use did not produce positive results. This was not the case for schools where there was systematic use.

In this sense, taking into consideration local knowledge and detecting contextual needs are both essential when designing orchestrations. In order to make decisions regarding educational policy and, therefore, to assess the impact of strategies such as orchestration when compared with other practices for improving school effectiveness, the schools' social context must be taken into consideration (Thrupp, 2006). In the same way, an orchestration developed with a particular reality in mind will not necessarily be suitable for another (in terms of its structure and content).

b) Training

Training courses that accompany orchestrated models are focused on a pedagogical discussion rather than on the technological devices that are to be used. There is a series of evidence to suggest that teacher training is a basic requirement when introducing technology into schools. Falck et al. (2013) highlight the importance of mechanisms that allow teachers to develop the ability to successfully bring technology into the classroom. Incorporating ICT into the process of initial and further training should therefore be a priority for any country interested in introducing these tools into their schools system. However, studies such as Kozma (2008) show that although there are many government programs that provide teacher training, these sometimes only focus on basic productivity tools such as email, internet and other administrative software. Such training is neither sufficient nor essential to the work of a teacher.

The training that accompanies orchestration looks to address one of the critical issues that has been focused on by the literature (Prieto et al., 2011b; Mishra & Koehler, 2006; Shechtman & Knudsen; 2009). This issue refers to a teacher's pedagogical view of technology. There have been very few research projects to date that link the development of technical skills with pedagogy. Instead, teacher training programs mainly focus on the potential of new tools, regardless of local teaching practices (Jung, 2005). This link is further analysed in the study by Koehler & Mishra (2009). In their study, the authors propose an important triangulation between three types of knowledge that are needed in order to successfully use technology within the context of teaching: pedagogical knowledge, technological knowledge and (curricular) content knowledge. In this sense, orchestration training takes these three axes into consideration given that they integrate logistical elements (technological knowledge) with pedagogical elements (pedagogical and content knowledge). The training therefore focuses on the knowledge that is required by teachers in order to introduce different learning resources and dynamics into their teaching practice (Beetham & Sharpe, 2013).

The experience in Colombia (Díaz et al., 2015 [Chapter 5 of this thesis]) described above featured a teacher training process that incorporated the characteristics detailed in the previous paragraph. This process was carried out in parallel with an element of coaching, detailed below (Figure 1—1). The training model implemented in Colombia consisted of two training sessions, with regular in-classroom coaching sessions in between. The first training session marks the beginning of the implementation process and sets the foundation for transferring the orchestration based on the characteristics and pedagogical needs of each teacher. The second training session comes at a critical moment in which the effort required by teachers has increased. This is because the orchestration demands changes in their practices, as guided by the scripted instructions. Here, the training is focused on the processes of change that have been implemented thus far. Teachers are invited to reflect on what the most effective elements of the orchestration have been so far, as well as those that needed to be adapted. By verbalizing their experience, the teachers begin to cement their appropriation of the orchestration and thus the effort required by them starts to decrease. The coaching sessions focus on how the orchestrations can adapt to the teacher's local context and reality, thus leading to greater autonomy. The wrap-up meeting signals the end of the pilot and of the first study of the use of orchestration in the context of education. Following this, the next step is the transference of the orchestrations to other teachers, grade levels and/or areas of learning. Figure 1—1 shows an outline of the training and coaching conducted in Colombia during the implementation of the orchestration model.

c) Coaching

The importance of in-classroom coaching comes from the real transference of the orchestration model to the teachers. This is done by modelling its use in situ, as well as showing how flexible it is and how it can be adapted to each context. The aim of this is to empower the teachers to use the orchestration correctly. The idea to include an element of coaching in the implementation of programs based on orchestration comes from the evidence regarding coaching in different fields that has been tried and tested in the US. It is proposed that this training method could be introduced into the education sector with positive results given its practical focus (Knight, & van Nieuwerburgh, 2012).

Evidence (Russo, 2004) suggests that, following years of disappointing results from continuing professional development programs, many programs now feature the use of coaches. The role of these individuals is to carry out coaching sessions in order to improve the results of school innovations. Successful coaches are those that emphasize showing teachers how and why certain strategies make a difference to students. The coaching strategy is based on the work of a coach with a small group of teachers. The aim of this is to allow the teachers to correctly use the guidelines contained within the orchestrations. By doing so, they are able to improve their teaching practice in the classroom and, therefore, their students' performance.

Based on a review of the literature concerning the impact of coaching on programs to support and improve teaching practices (Knight, & van Nieuwerburgh, 2012), the role of the coach is to put into practice the theoretical concepts. This contributes towards generating change based on pedagogical actions. This differs from the role of the trainer, who looks to a model of professional development by broadening the teachers' theoretical knowledge in the field of classroom management strategies.

As highlighted above, Figure 1—1 shows the training and coaching model that was developed when implementing orchestrations in Colombia (Díaz et al., 2015 [Chapter 5 of this thesis]). The figure shows the two sets of coaching sessions that teachers received in the classroom. The objective of the first set of sessions (Coaching Sessions 1 and 2 in Figure 1) is to accompany the teacher in the classroom when they start to use orchestrations, as well as modelling how to use the orchestration and how to follow the instructions suggested by the script. The second set of in-classroom coaching sessions (Coaching Sessions 3 and 4 in Figure 1) focuses on empowering the teacher and having them adopt the orchestration by helping them to see how adaptable, flexible and relevant they can be. The objective of this second set of sessions is to promote autonomy in the management and use of the orchestration.

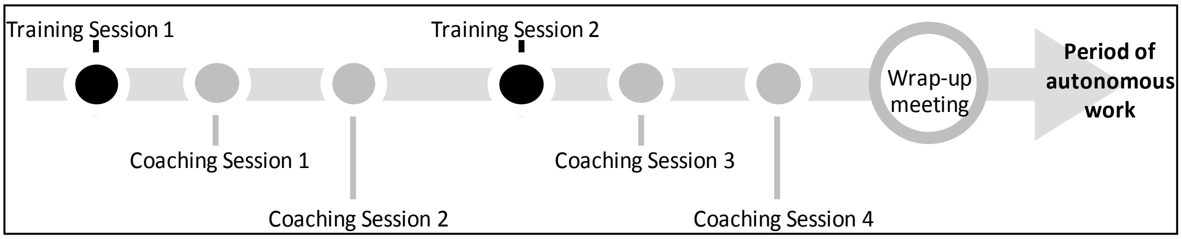

Figure 1—1 Training and coaching model based on the experience of implementing orchestrations in Colombia (Díaz et al., 2015).

d) Monitoring and evaluation

As an extension of orchestration, it is vitally important to consider indicators for follow up and monitoring which allow the implementation and use of the orchestrations to be tracked. The aim of this is to gather input that will allow the experience to be evaluated. It will also allow decisions to be made in terms of adapting, improving or changing the orchestrations. By including a pre-planned process of monitoring, pilot policies ranging from medium to large-scale initiatives can be evaluated. Analysing the criteria that are monitored can determine the most important elements in each context in terms of how they facilitate or hinder the implementation of orchestration that look to enhance learning in environments that are equipped with technology.

1.2.4 Contextual elements that determine the effective implementation of orchestration

a) Role of the management team

The literature (Leithwood et al., 2004) reveals the importance of involving the management team in the teaching/learning process. Therefore, in parallel to orchestrations, which refer directly to the work of the teachers, someone from the school's management team should help with the implementation of new strategies to support the teaching practice. Support from school management has been analysed in studies associated with educational policy and practice, as has the relationship between a set of school-level variables and the process of innovation and change using ICT in schools (Law et al., 2008).

Research such as that by Area (2010) and Valverde at al. (2010) propose that the integration of technology in educational processes is not just a simple question of doing. Instead, they suggest that it is a complex process where it is necessary to take into account the different actors and factors that are present. Vanderline et al. (2014) suggest that the use of technology should not just be considered at a teacher level but also at a school level. They argue that around 14% of the variance in the use of technology by teachers is due to characteristics of their school. Furthermore, census evidence reveals that student performance is greater in schools where there is a national policy for providing technology, coupled with high-levels of management and support in terms of pedagogical use of the resources by teachers (Díaz & Nussbaum, 2015 [Appendix 1]).

Changes and improvements in the student learning process must be considered in direct association with the management process in each school. This is because the literature reveals the effects (both direct and indirect) of school management on student learning. Here, it is estimated that 25% of student progress could be due to the work done by the school's management team (Leithwood et al., 2004). It can therefore be claimed that it is not enough to just have commitment from the teacher and to empower them in the pedagogical use of the technology. Instead, it is also essential to involve the management team in the project.

b) Transformational leadership and openness to change

The process of change is often facilitated in schools where the institutional leadership is characterized as being transformational. This type of leadership is where the leaders use their influence on their followers (Bush, 2014). In this case, the management team uses their influence on the teachers. The leaders believe that they are the ones who can inspire their colleagues to become more committed to the organizational goals (Leithwood et al., 1999). A link between instructional leadership (based on learning goals) and transformational leadership is only possible if the organizational objectives for change are focused on learning (Bush, 2014). In this sense, integrating orchestration within school practices becomes a change that is focused on strengthening the teachers' practices and therefore on improving the students' learning experience.

Although no evidence has been found regarding the openness to change that is required when implementing orchestration in a school, it is worth noting that the evidence does suggest that it is essential to take change into account when designing support or improvement plans for schools. Murillo & Krichesky (2012) put forward the idea that change in schools is like a process with set milestones, where concerns, reactions and changes to the improvement plan are expected, among others. This cycle of change includes an initiation phase where, for some reason, an individual or group initiates or promotes a new program or project. This phase also includes a diagnostic of the current situation. The second phase in this cycle includes planning, where the general direction of the program or project is defined, as well as the next steps. The third phase includes the implementation, where the relevant strategies or actions are put into practice. The fourth phase is based on a period of reflection or assessment. As a result of this, the fifth phase looks to expand upon or share the most successful innovations through a series of efforts to institutionalize any strategies that have turned out to be particularly effective.

As can be observed, each of these phases is entirely compatible with the start of one of the orchestration's design and implementation processes. The aim of this is to identify how to guide teachers through the change and improve their teaching practices:

– First phase: This is the moment when a group of people demonstrate an interest in initiating or promoting change in pedagogical practice in contexts where technology is available for classroom work. Meetings are held with the school community in order to identify their expectations and needs.

– Second phase: During this period, the group that is interested in initiating an improvement/support program for teachers works with the school community to plan the elements that will be included in the orchestration. It is important from this stage that the process of change makes sense to both the management team and the teachers.

Orchestrations are developed during this stage based on the information gathered during the process of detecting needs and expectations.

– Third phase: During this phase the strategies or actions are put into practice. The implementation of the orchestrations begins in the classroom with the teachers putting into practice the strategies and actions suggested by the pedagogical script (orchestration). This period begins with teacher training and includes in-classroom coaching sessions, accompanying and advising the teacher on how to effectively use the orchestrations in their classroom.

– Fifth phase: This is the period at the end of the pilot program for implementing orchestrations in an educational setting. It is based on reflection and evaluation of the processes of change that were experienced in terms of student learning, pedagogical practice and management of the technological resources within the school.

– Fifth phase: This period is the result of the fourth phase and extends the use of orchestrations to other grade levels or areas of learning. During this period, the changes and their results are shared. On an establishment level, this is made up of a series of efforts that together form strategies that have managed to be particularly effective.

c) Practices in line with the context

Although it is not possible to establish an ideal context in which orchestrated models work best, it is worth highlighting the relevance of how orchestrations make accommodations for the reality of each classroom. This is something that is directly related to how teachers receive and appropriate the orchestration and the final impact that this will have on student learning. In schools with a lower socioeconomic status or in less effective schools, the pressure of the social role played by schools often leads to inadequacies in the teaching/learning process as the school's requirement to provide social services generally trumps its educational role (Auwarter, 2008). In general, these contexts often see low levels of appropriation and systematic adoption of new strategies due to the range of different roles that are often bestowed upon the school community (often social roles). This again brings us back to the final discussion from the "Local context & reality" section of this chapter. It also reveals the inefficiencies of general policies that propose model educational practices for contexts that have different priorities in terms of needs and support.

When designing orchestrations it is essential to take into account the diversity of contexts that exist. It must consider the existence of contexts that require differentiated support given the characteristics of their geographical location and the socioeconomic status of the families of the students who attend (Lupton, 2005).

1.2.5 How can we maximize the impact of orchestration programs?

a) The process of appropriating technology

The literature reveals characteristics of the process of adopting technology for teachers. These must be taken into account when designing and implementing the orchestrations so as to maximize their impact. Aldunate & Nussbaum (2013) propose a model for appropriation as a process of dynamic transitions. They conclude that the teachers who are early adopters of technology and spend a significant amount of their time in the classroom introducing educational technology to their teaching are more likely to adopt new technologies regardless of how complex they are. However, teachers who are not early adopters and use little technology in their classes are less likely to adopt new technologies and are prone to abandoning adoption at the stages identified by the aforementioned process.

This process is shown in Figure 1—2, where three critical points can be identified. The first of these (Point A) represents the initial state where the user has still not managed to master the technology and their experience gets gradually worse until Point B. From here (B), the user starts to master the technology but until they cross the axis (Point C), their experience is worse than before the technology was introduced. Orchestration must acknowledge these critical points and take into account the support that is needed through coaching in order for the user to overcome them.

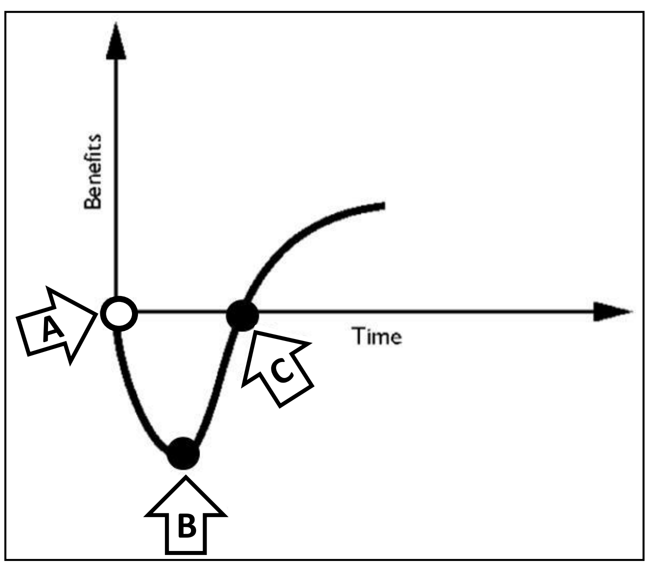

Figure 1—2 Process of adopting technology (Aldunate & Nussbaum, 2013)

Figure 1—3 again shows the diagram that illustrates the combination of coaching and training that was used in the experience of implementing orchestrations in Colombia (Díaz et al., 2015 [Chapter 5 of this thesis]). However, this time the diagram also includes the critical points from Figure 1—2. Figure 1—3 therefore shows that Point A in Figure 1—2 relates to the initial training that kicks off the project. Point B in Figure 1—2 is a critical moment as it is when the teacher sees least value in using the orchestrations. This moment therefore requires coaching, not just to work through the teacher's doubts but also to reinforce all of the areas where weaknesses can be observed in the classroom work. Point C represents the moment when the teacher starts to see the benefits of using the orchestrations. Up until this point, the teacher is supported through in-classroom coaching. This point signals the beginning of the period of autonomy for the teacher and is marked by a wrap-up meeting for the project. This is followed by a period of reflection, as well as extending the use of orchestrations so that it becomes a school-wide practice (once beyond the critical period surrounding the beginning of the change process).

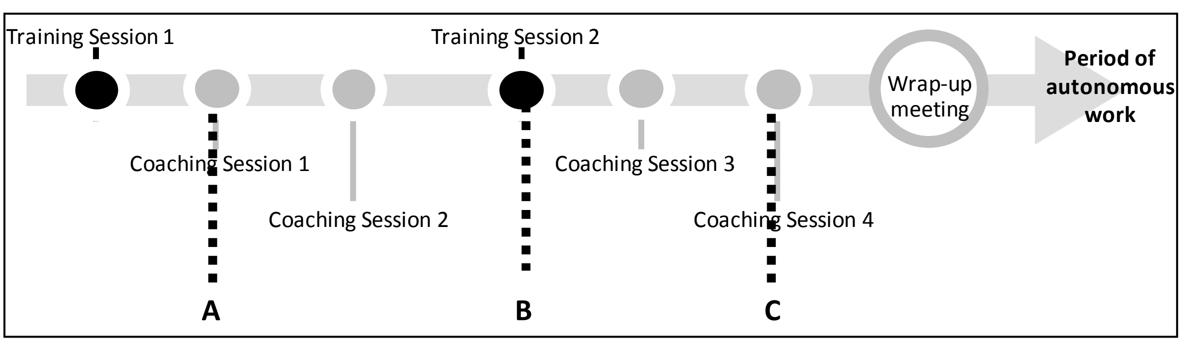

Figure 1—3 Training and coaching model based on the experience of implementing orchestrations in Colombia, as well as the critical points in the process of adopting technology

b) Pedagogical support

Evidence reveals the negative effects when national policies for providing schools with technological equipment lack pedagogical support for the teachers (Claro et al., 2013). As background information for their study, Suárez et al. (2013) highlight that technological skills are related to knowledge of different technological resources, as well as the skills relating to their use. Pedagogical skills, on the other hand, are those that allow teachers to use these resources when designing and developing a study plan, as well as in their planning process. In this sense, it is once again highlighted that in order to take full advantage of the potential offered by technology, it is essential to propose innovation based on pedagogy. Hermans et al. (2008) studied the relationship between teacher beliefs regarding learning and their use of technology in the classroom. The results concluded that there is a positive effect of constructivist beliefs on the use of technology. Traditional beliefs, on the other hand, have a negative impact. Suárez et al. (2013) conclude that there is a stable relationship between technological and pedagogical skills and identify that the former has a direct effect on the latter. This reveals the need for strategies that detail the relationship between technology and pedagogy, thus maximizing the expected results of the implementation of the orchestrations.

Summarizing what we have analysed thus far, we see that when implementing an ICT for education program based on orchestrations, pedagogical support is present in three dimensions: technical pedagogical training, in-classroom coaching for implementing the orchestration, and guidelines that suggest pedagogical interactions in order to cover the curricular contents in the classroom.

c) Digital contents

There are studies regarding the range of digital content that is openly available on the internet and their effect on student learning (Johnstone, 2005; Beetham & Sharpe, 2013; D’Antoni, 2013). The experience of implementing orchestrations in Uruguay (Díaz et al., 2015 [Chapter 3 of this thesis]) revealed a series of weaknesses in terms of the quality of the digital resources being used by the teacher and students. For example, these often lacked informative feedback to the students’ responses. In this sense, the study by Díaz et al. (2015) [Chapter 3 of this thesis] analyses how the orchestration responded to the framework published by NESTA (Luckin et al., 2012). This framework identifies characteristics and opportunities that digital content should provide when supporting the teaching practice and in order to have an impact on student learning.

d) Collaboration between peers

Another element that the literature has highlighted as being important and enriching for learning experiences among children is collaborative work (Nussbaum et al., 2009). Although orchestrations suggest activities for every group dynamic in the classroom (Fischer and Dillenbourg, 2006), whether this be individual, small-group, large-group or whole-class, the model for orchestration detailed in this chapter has not described in concrete terms how collaboration between students is achieved. This is therefore understood to be an additional resource that must be orchestrated. In this sense, a model of orchestration could maximize its impact by detailing guidelines for the teacher to promote and guarantee effective collaborative work in small groups, where the students work together as a group through peer support, positive interdependence, social responsibility, etc. (Caballero, et. al., 2014).

As with multi-platform work, collaboration is one of the 21st century skills proposed by modern society, in an era where different media will open the path to innumerable ways of working and communicating. Within this context, social skills such as building arguments and negotiating must transcend physical barriers and, therefore, be skills that are solidly developed.

1.3 Research hypotheses

The following hypotheses were used to frame the work carried out for this thesis:

1) A tool which identifies the logistical and pedagogical elements that affect a class can define the specific role to be played by technology in the teaching-learning process.

2) In a setting with technology, providing teachers with a series of orchestrated conventional and digital resources improves student learning.

3) Within the classroom, the teacher and students' needs and interests are divergent.

4) An existing orchestration model is enriched by the students' view of the learning process.

1.4 Research questions

The research questions that guided the work that was carried out for this thesis are the following:

1) What should the characteristics be of a tool that defines the role of technology when integrated with non-digital teaching activities?

2) Does student learning improve when teachers are provided with a variety of conventional and digital resources which form a coherent orchestrated unit?

3) Which are the elements that improve learning when introducing digital resources into the classroom?

4) What are the classroom objectives for teachers and students and how well aligned are they?

5) Does the teacher understand the needs of the students in the classroom?

6) Are the views of the teacher and the students aligned in terms of how the classroom environment should be?

7) Do teachers and students share the same expectations of one another?

8) Do students and teachers share a similar view of the role that should be played by the family in the educational process?

9) Is there a significant increase in student learning when the teacher uses orchestration?

10) What elements are associated with a greater increase in learning within a context of orchestrated learning experiences?

11) When systematically implementing strategies that consider student learning pace, what type of impact does this have?

1.5 Objectives

The objectives of this thesis are the following:

1) To propose a model of orchestration that specifies the role of technology in the classroom.

2) To explore the effect that orchestration has on student learning.

3) To identify contextual variables that improve the implementation of orchestration in an educational establishment equipped with technology.

4) To study the characteristics of the elements that converge within the educational process from the teacher and students' perspective, identifying the main motivations, needs, interests and objectives within the classroom, with the aim of enriching the orchestration model.

5) To study whether student learning improves by providing teachers with a series of orchestrated conventional and digital resources that take into consideration the different paces at which students learn, and not just curricular requirements.

1.6 Results

The studies from this thesis have produced a series of results that are described below:

1) A framework for the orchestration of digital and non-digital resources.

2) Student learning (in terms of curricular objectives) improves as teachers have access to an orchestration strategy for integrating digital and non-digital resources.

3) Learning improves when there is systematic use of the resources and when the school's infrastructure facilitates the use of technology.

4) There is a disparity between the classroom objectives of the teacher and the students.

5) Teachers do not understand their students' needs. In general, the teacher's opinion and the opinion of their students are completely contradicting.

6) In general, students and teachers coincide in that there is huge heterogeneity among the students in their classes. Furthermore, the responses by both are aligned in terms of the main element where this heterogeneity can be observed, i.e. the different paces at which students learn.

7) There is a convergence of opinions between students and teachers with regards to the students' expectations of the role of the teacher. However, there is no convergence with regards to role of the students that is expected by the teachers. Convergence can also be observed in terms of the perception that teachers and students have of the expectations that society has of both groups.

8) Teachers and students do not share the same opinion regarding the participation of the family. The majority of students suggest that families should play an informative role, while teachers suggest they should play an active role in the educational process. This is consistent with the lack of alignment between the objectives and expectations that each have regarding the educational process, as both elements involve actors with different roles (e.g. the role of the family)

9) Within the specific case that was studied, it can be seen that students whose teachers used orchestrations to integrate technology into the classroom showed a greater increase in learning between the pre- and post-test than students whose teachers did not use orchestrations. In this case, the orchestration was established as a concrete link between technology and pedagogy, revealing its potential in low socioeconomic status settings and where there were lower indices of curricular management.

10) Within the context of using orchestrations, an association has been identified between the orchestrated teaching strategy and greater increases in student learning in cases where:

- Students have lower scores on the pre-test.

- The resources included in the orchestrated strategy are used systematically.

- The teacher has sufficient knowledge of mathematics and the necessary technological skills.

- The following teaching practices are present: teachers structure their classes, implement the suggestions made by the orchestration, and adequately explain each topic and activity (instead of doing this quickly).

11) There is a positive association between increases in student learning and systematic use of materials that address the students' individual weaknesses, taking into account the different paces at which students learn in the classroom.

1.7 Research limitations

Although the development of this thesis has produced various results that provide evidence to support the use of orchestrations in our region, it is worth highlighting the limitations that have been identified so as to visualize the projections set out by this study. The limitations that have been identified are the following:

1) The studies upon which the findings of this thesis are based are set within a Latin American context. In this sense, it is worth highlighting the importance of studying the design and implementation of orchestrations in other countries that have a policy of providing schools with technology. This should be done with an experimental model where one set of schools represents the intervention group (using orchestrations) and another set of schools represents the control group.

2) Furthermore, the two field studies included in this thesis focused on the subject of Mathematics. Given that the studies required an analysis of a foreign curriculum, the precise nature of mathematics facilitated the design and development of the teaching materials. Developing teaching material for Reading, Art, Social Sciences or Natural

Sciences, among others, will without doubt require further analysis of the context within which the curriculum is delivered. This undoubtedly increases the logistical costs of carrying out the study and developing teaching materials for the orchestrations. Not being able to implement orchestrations for other areas of the curriculum represents a limitation of this thesis.

3) Due to institutional interests of the foreign counterparts, with whom partnerships were formed in order to implement the orchestrations, the grade levels that were selected for both studies were from elementary school. This also represents a weakness when it comes to generalizing the proposal for orchestration set out in this thesis. This is because it is necessary to have extensive evidence in different grade levels and areas of the curriculum in order to be able to put forward a generalizable strategy.

4) Measuring effective strategies and/or tools for student learning requires long periods and systematic measurements that allow robust and generalizable conclusions to be reached. The studies included in this thesis were conducted over a short and specific period of time that was determined by the budgetary constraints of each of the projects. In this sense, although the field studies included in this thesis reveal interesting results with which to test the hypotheses and research questions, one of the limitations of this thesis is the lack of a large-scale system of assessment carried out over a longer period of time. This would really allow the effects (or lack thereof) of the proposed orchestration model to be observed, not just in the children's learning, but also in the teachers' practices and pedagogical concepts.

1.8 Theses outline

This thesis is based on studies that were carried out in order to meet the objectives detailed above. These studies constitute different research papers which are all currently at different stages of publication. Some have already been published, others have been accepted, while others have been submitted and are awaiting a response from the respective journals' referees. Below is a description for each chapter of its constituting paper, the topic that is addressed, the title of the paper, the authors, and the corresponding journal.

Chapter 2: The title of the paper included in this chapter is Classroom Logistics: Integrating Digital and Non-digital Resources, by the authors Nussbaum, M., & Díaz, A., from 2013. This paper was published by the journal Computers & Education (Impact Factor of 2.630), with the identification (69), 493-495. Based on a particular need (described in the paper's introduction), this study sets out a proposal of a framework to be taken as the basis for designing an orchestration. As this paper does not include a field study, it is brief and based on identifying a need before providing a proposal to satisfy this need.

Chapter 3: The constituting paper for this chapter is titled Orchestrating the XO computer with digital and conventional resources to teach mathematics, by the authors Díaz, A., Nussbaum, M. & Varela, I., from 2015. This paper has been accepted for publication by the Journal of Computer Assisted Learning (Impact Factor of 1.023) and its contents can be accessed digitally via *doi: 10.1111/jcal.12081*. This study describes the implementation of an orchestration in 20 fourth grade classrooms in schools across

Montevideo, Uruguay, set within the context of a national policy of ICT in education. In this case, only 10 teachers used orchestrations for teaching mathematics, leaving the remaining 10 teachers to use their own planning system for integrating conventional and digital resources. The findings from this study discuss the increases in learning among the groups of students that experienced orchestrated classes, versus those that did not. Based on this, certain elements were identified as facilitating or hindering the implementation of a national ICT in education policy complemented by orchestration.

Chapter 4: This chapter includes the study Teacher and student views regarding the educational process: how aligned are they?, by the authors Díaz, A., Cabezas, V., Nussbaum, M., Barahona, C., & Infante, C, from 2015. This paper has been sent to the journal Contemporary Educational Psychology and is currently in the review process. This paper explores the view that teachers and students have of the teaching and learning process. The main objective of the study is to identify implicit elements that are present in the classroom so as to enrich the design of the orchestration. A new orchestration design that takes into account not just the needs of the curriculum and the ICT in education policy, but also the needs and interests of the students, can further facilitate the development of studies of learning based on different resources. The findings from this study reveal a lack of strategies or tools that encourage a shared view of the teaching and learning process by the students and teachers. According to the literature, this is needed to significantly and effectively meet the teaching objectives.

Chapter 5: This chapter includes the paper Orchestration: Providing teachers with scaffolding to address curriculum standards and students' pace of learning, by the authors Díaz, A., Nussbaum, M., Ñopo, H., Maldonado, C., & Corredor, J, from 2015. This paper has recently been accepted for publication by the journal Educational Technology & Society (Impact Factor of 1.34). This paper describes the implementation of an orchestration in 20 fifth grade classrooms in schools across Barranquilla, Colombia, set within the context of a national policy of ICT in education. The work carried out in this study is based on the experience of implementing an orchestration model in Uruguay by taking into account the lessons that were taken from said study regarding the inclusion of contextual variables when defining the timing for covering the curriculum. Furthermore, the orchestration design in this study incorporated one of the items that emerged heavily from the study described in Chapter 4. This referred to the different paces at which students learn in the classroom and which the teacher can sometimes fail to realize as they are too focused on the need to cover the curriculum. As with the study described in Chapter 3, only 10 of the 20 classrooms used orchestrations for learning mathematics. The findings from this study reaffirm the value of teachers using orchestration as scaffolding when facing the challenge of integrating technology into their teaching practices. The findings also highlight the importance of having strategies to address the different paces at which students learn in the classroom, as well as how technology can be a valuable ally when faced with this need.

1.9 Thesis structure

The structure of this thesis is based on the research objectives mentioned in section 1.5. Table 1—2 below summarizes all of the objectives, hypotheses, research questions, papers and results that are included in this thesis. Figure 1—4 also provides a model which shows the connections between each of these components.

Table 1—2 Summary of the thesis structure

Hypotheses	
H1	A tool which identifies the logistical and pedagogical elements that affect a class can define the specific role to be played by technology in the teaching-learning process.
H2	In a setting with technology, providing teachers with a series of orchestrated conventional and digital resources improves student learning.
H3	Within the classroom, the teacher and students' needs and interests are divergent.
H4	An existing orchestration model is enriched by the students' view of the learning process.
Research Questions	
Q1	What should the characteristics be of a tool that defines the role of technology when integrated with non-digital teaching activities?
Q2	Does student learning improve when teachers are provided with a variety of conventional and digital resources which form a coherent orchestrated unit?
Q3	Which are the elements that improve learning when introducing digital resources into the classroom?
Q4	What are the classroom objectives for teachers and students and how well aligned are they?
Q5	Does the teacher understand the needs of the students in the classroom?
Q6	Are the views of the teacher and the students aligned in terms of how the classroom environment should be?
Q7	Do teachers and students share the same expectations of one another?
Q8	Do students and teachers share a similar view of the role that should be played by the family in the educational process?
Q9	Is there a significant increase in student learning when the teacher uses orchestration?
Q10	What elements are associated with a greater increase in learning within a context of orchestrated learning experiences?
Q11	When systematically implementing strategies that consider student learning pace, what type of impact does this have?
Objectives	
O1	To propose a model of orchestration that specifies the role of technology in the classroom.
O2	To explore the effect that orchestration has on student learning.
O3	To identify contextual variables that improve the implementation of orchestration in an educational establishment equipped with technology.
O4	To study the characteristics of the elements that converge within the educational process from the teacher and students' perspective, identifying the main motivations, needs, interests and objectives within the classroom, with the aim of enriching the orchestration model.
O5	To study whether student learning improves by providing teachers with a series of orchestrated conventional and digital resources that take into consideration the different paces at which students learn, and not just curricular

	requirements.
Papers	
P1	Classroom logistics: integrating digital and non-digital resources
P2	Orchestrating the xo computer with digital and conventional resources to teach mathematics
P3	Teacher and student views regarding the educational process: how aligned are they?
P4	Orchestration: providing teachers with scaffolding to address curriculum standards and students' pace of learning
Results	
R1	A framework for the orchestration of digital and non-digital resources.
R2	Student learning (in terms of curricular objectives) improves as teachers have access to an orchestration strategy for integrating digital and non-digital resources.
R3	Learning improves when there is systematic use of the resources and when the school's infrastructure facilitates the use of technology.
R4	There is a disparity between the classroom objectives of the teacher and the students.
R5	Teachers do not understand their students' needs. In general, the teacher's opinion and the opinion of their students are completely contradicting.
R6	In general, students and teachers coincide in that there is huge heterogeneity among the students in their classes. Furthermore, the responses by both are aligned in terms of the main element where this heterogeneity can be observed, i.e. the different paces at which students learn.
R7	There is a convergence of opinions between students and teachers with regards to the students' expectations of the role of the teacher. However, there is no convergence with regards to role of the students that is expected by the teachers. Convergence can also be observed in terms of the perception that teachers and students have of the expectations that society has of both groups.
R8	Teachers and students do not share the same opinion regarding the participation of the family. The majority of students suggest that families should play an informative role, while teachers suggest they should play an active role in the educational process. This is consistent with the lack of alignment between the objectives and expectations that each have regarding the educational process, as both elements involve actors with different roles (e.g. the role of the family)
R9	Within the specific case that was studied, it can be seen that students whose teachers used orchestrations to integrate technology into the classroom showed a greater increase in learning between the pre- and post-test than students whose teachers did not use orchestrations. In this case, the orchestration was established as a concrete link between technology and pedagogy, revealing its potential in low socioeconomic status settings and where there were lower indices of curricular management.
R10	Within the context of using orchestrations, an association has been identified between the orchestrated teaching strategy and greater increases in student learning in cases where: - Students have lower scores on the pre-test. - The resources included in the orchestrated strategy are used systematically. - The teacher has sufficient knowledge of mathematics and the necessary technological skills. - The following teaching practices are present: teachers structure their classes, implement the suggestions made by the orchestration, and adequately explain each topic and activity (instead of doing this quickly).

R11	There is a positive association between increases in student learning and systematic use of materials that address the students' individual weaknesses, taking into account the different paces at which students learn in the classroom.

Figure 1—4 demonstrates the connections between each of the hypotheses with its respective research questions, objectives, research papers and results. In two cases, the results form part of the evidence that was considered when establishing a hypothesis and its subsequent sequence of elements.

Hypothesis 1 (H1) "A tool which identifies the logistical and pedagogical elements that affect a class can define the specific role to be played by technology in the teaching-learning process" relates to question 1 (Q1) "What should the characteristics be of a tool that defines the role of technology when integrated with non-digital teaching activities?" and objective 1 (O1) "To propose a model of orchestration that specifies the role of technology in the classroom". This series leads to the first research paper (P1), upon which this thesis is based, "Classroom logistics: integrating digital and non-digital resources". The result of this paper (R1) is a "framework for the orchestration of digital and non-digital resources."

R1 provides a product that leads to the formulation of the second hypothesis (H2) "In a setting with technology, providing teachers with a series of orchestrated conventional and digital resources improves student learning", which in turn leads to questions 2 and 3 (Q2 – Q3) "Does student learning improve when teachers are provided with a variety of conventional and digital resources which form a coherent orchestrated unit?" and "Which are the elements that improve learning when introducing digital resources into the classroom?". These questions are answered by proposing a study which looks to

"Explore the effect that orchestration has on student learning" (O2) and "To identify contextual variables that improve the implementation of orchestration in an educational establishment equipped with technology" (O3) and is described in the second research paper (P2) contained in this thesis. This study suggests that "Student learning (in terms of curricular objectives) improves as teachers have access to an orchestration strategy for integrating digital and non-digital resources" (R2) and that "Learning improves when there is systematic use of the resources and when the school's infrastructure facilitates the use of technology" (R3).

Hypothesis 3 (H3) "Within the classroom, the teacher and students' needs and interests are divergent" is made up of the questions "What are the classroom objectives for teachers and students and how well aligned are they?" (Q4), "Does the teacher understand the needs of the students in the classroom?" (Q5), "Are the views of the teacher and the students aligned in terms of how the classroom environment should be?" (Q6), "Do teachers and students share the same expectations of one another?" (Q7) and "Do students and teachers share a similar view of the role that should be played by the family in the educational process?" (Q8). These questions are addressed by the objective "To study the characteristics of the elements that converge within the educational process from the teacher and students' perspective, identifying the main motivations, needs, interests and objectives within the classroom, with the aim of enriching the orchestration model" (O4), covered by the third research paper (P3) in this thesis: "Teacher and student views regarding the educational process: how aligned are they?" The results from this paper suggest that "There is a disparity between the classroom objectives of the teacher and the students" (R4), "Teachers do not understand their students' needs. In general, the teacher's opinion and the opinion of their students are completely contradicting" (R5), "In general, students and teachers coincide in that there is huge heterogeneity among the students in their classes. Furthermore, the responses by both are aligned in terms of the main element where this heterogeneity can be observed, i.e. the different paces at which students learn" (R6), "There is a convergence of opinions between students and teachers with regards to the students' expectations of the role of the teacher. However, there is no convergence with regards to role of the students that is expected by the teachers. Convergence can also be observed in terms of the perception that teachers and students have of the expectations that society has of both groups" (R7), and that "Teachers and students do not share the same opinion regarding the participation of the family. The majority of students suggest that families should play an informative role, while teachers suggest they should play an active role in the educational process. This is consistent with the lack of alignment between the objectives and expectations that each have regarding the educational process, as both elements involve actors with different roles (e.g. the role of the family)" (R8).

Finally, hypothesis 4 (H4), which states that "An existing orchestration model is enriched by the students' view of the learning process", is explored by the research questions "Is there a significant increase in student learning when the teacher uses orchestration?" (Q9), "What elements are associated with a greater increase in learning within a context of orchestrated learning experiences?" (Q10), and "When systematically implementing strategies that consider student learning pace, what type of impact does this have?" (Q11). These questions are in line with the objective of this thesis, which looks to "To study whether student learning improves by providing teachers with a series of orchestrated conventional and digital resources that take into consideration the different paces at which students learn, and not just curricular requirements" (O5). This objective and the corresponding research questions are the focus of the thesis' fourth research paper (P4), titled "Orchestration: providing teachers with scaffolding to address curriculum standards and students' pace of learning". This paper has produced a series of results which reveal that "Within the specific case that was studied, it can be seen that students whose teachers used orchestrations to integrate technology into the classroom showed a greater increase in learning between the pre- and post-test than students whose teachers did not use orchestrations. In this case, the orchestration was established as a concrete link between technology and pedagogy, revealing its potential in low socioeconomic status settings and where there were lower indices of curricular management" (R9) and that "Within the context of using orchestrations, an association has been identified between the orchestrated teaching strategy and greater increases in student learning in cases where: Students have lower scores on the pre-test; the resources included in the orchestrated strategy are used systematically; the teacher has sufficient knowledge of mathematics and the necessary technological skills; the following teaching practices are present: teachers structure their classes, implement the suggestions made by the orchestration, and adequately explain each topic and activity (instead of doing this quickly)" (R10). A final result of this paper was that "There is a positive association between increases in student learning and systematic use of materials that address the students' individual weaknesses, taking into account the different paces at which students learn in the classroom" (R11).

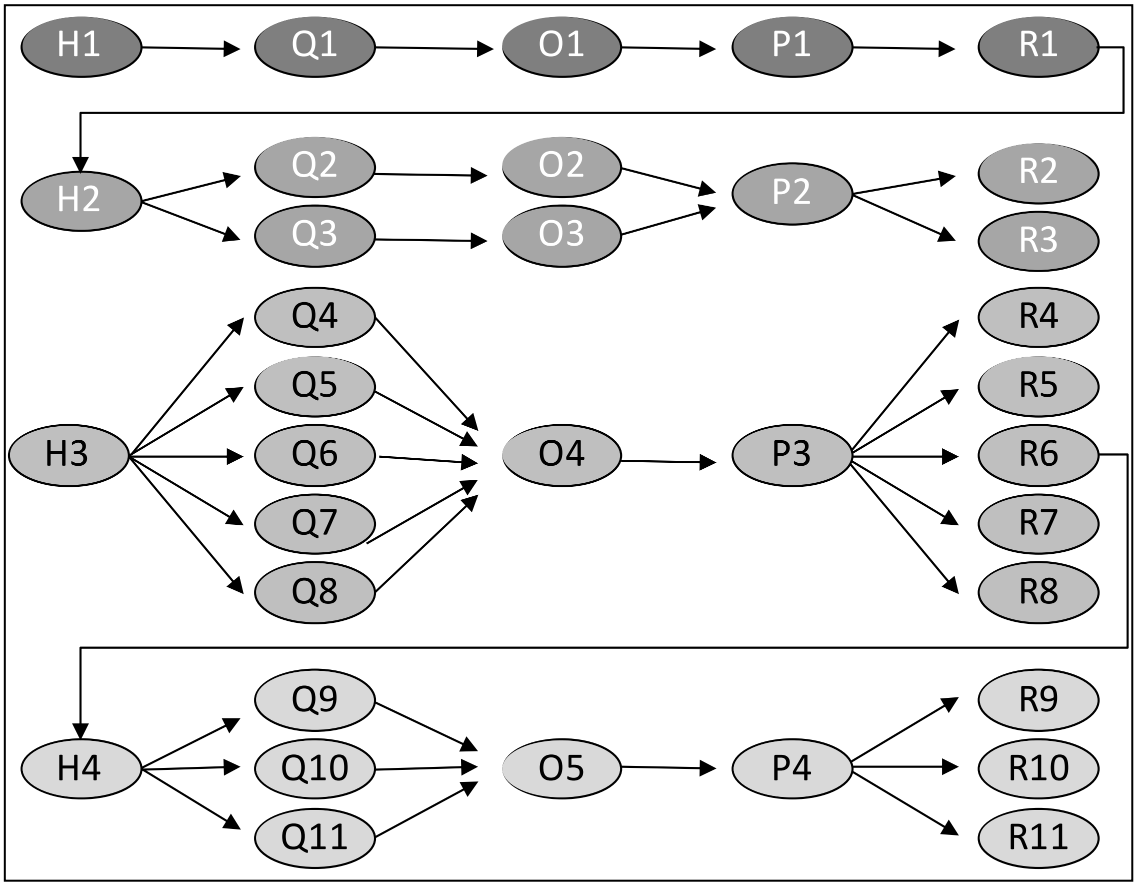

Figure 1—4 Connections between the hypotheses, research questions, objectives, papers and results

2. CLASSROOM LOGISTICS: INTEGRATING DIGITAL AND NON-DIGITAL RESOURCES

2.1. Abstract

This response to Dillenbourg's postulations on Orchestration analyses the relationship between classroom logistics and learning. It is necessary to detail the precise actions that the teacher must perform in order to apply the proposed strategies for the integration of digital and non-digital resources. It is not about teacher training; it is about giving teachers the tools to structure their classes and empower them beyond the training process. Every aspect of the class should be specified, leaving what finally will be performed to the teacher. We conclude that an adequate orchestration helps to guide the teacher through the work to be performed in the classroom, allowing a shift from an instructor-centred arrangement, in which the teacher radiates knowledge before a passive class of students, to one where the students actively participate, with the teacher acting as a mediator.

2.2. Introduction

We support Dillenbourg's postulations on Orchestration presented in his article 'Design for Classroom Orchestration' and want to apply them to classroom logistics, analysing in greater depth the relationship between classroom logistics and learning.

Do you remember using Word 2003? You felt confident, and found it easy to use. Then, the day arrived when you had to upgrade to Word 2007. For most of us, it was an unproductive week that we do not remember fondly. Put yourself in the shoes of a teacher, bearing in mind they most likely do not possess the same technological experience as you. Now, imagine that they were given a short training session on a specific educational program and, subsequently, were expected to use this software in front of the entire class. Why should that teacher feel any more comfortable and confident than you did during those first moments with Word 2007?

School logistics have been neglected. We presume that knowing how to use a program is enough. Dillenbourg indicates that there is a continuum of activities from those intrinsic to the scenario to activities extrinsic to learning. It is important to orient teachers navigate this continuum and guide them through the process of integrating conventional resources, which are already familiar to them, with digital technology. In order to achieve this, it is not enough to merely plan a class that integrates different resources. Instead, it is necessary to detail the precise actions that the teacher must perform in order to apply the proposed strategies for the integration of digital and non-digital educational tools and effectively complete their work with the students.

The adoption process will be successful if the teacher feels that it is an improvement on their existing teaching habits. Our aim is for the teacher to feel that “it works in my classroom”. In that moment the adoption has succeeded and the proposed orchestration belongs to the teacher.

2.3. A proposal

Our classroom logistics have to be defined for everybody. There are only a few heroes, and they can manage by themselves. Our proposal is to empower the teacher in all areas of the classroom, analyse all aspects of what Dillenbourg defines as extrinsic constraints, and embrace those intrinsic constraints which define a class. We aim to do this by providing teachers with different strategies to maintain student interest throughout a range of challenges, with the ultimate goal of achieving the proposed teaching objectives. In defining what the classroom work should be, we specify three elements, shown in Table 2—1. The first two, Context and Aim, determine the orchestration conditions, while the third, Specification, defines the orchestration. Every aspect of the class should be specified, leaving what finally will be performed to the teacher.

Table 2—1 Elements of classroom logistics

1. Context::	2. Aim:	3. Specification:
• Grade or class targeted by the activity. • Curriculum area • Unit name • Time dedicated to the class. • Week in which the material will be taught. • Number of sessions in which the material will be taught. • Difficulty level. • Previous learning required for the development of the class.	• Specific objective of the unit. • Objective of the class. • Skills and attitudes to be developed in the students. • Cognitive Process (Recall, Understand, Apply, Analyse, • Evaluate, Create) (Anderson et al., 2001).	• Class-time moment (Mehan, 1979): - Opening phase. - Instructional phase. - Closing phase. • Pedagogical Process (Guthery, 2007): - Deductive process. - Inductive process. • Class Activities: - General indications about the organization of students. - Description of the planned activities, referring to the specific actions of the teacher, and explicitly stating what is expected of the students. - Guidance in the use of the integrated resources for each activity. - Time assigned to each activity. • Formative assessment guidelines (Black and William, 1998). - Online tools. - Specific questions to be asked to the students and their expected answers. • Visibility - Teacher to student. - Student to student. - Student to teacher.

		• Criterion for maintaining control of the learning environment • Resources: - Paper guides. - Interactive guides on the computer. - Presentations with/without audiovisual support. - Individual/group work with/without technological support. - Participatory work involving the whole class. - Complementary activities/homework. - Online resources.

For example, one of the orchestrations we developed for schools in Uruguay is for teaching a “Decimal Numbers” lesson for a fourth grade math class. A specific orchestration is for the unit of “Multiplication of decimal numbers”, which covers three sessions and lasts 2 h and 10 min, scheduled for the 11th week of the school year. The difficulty level is average and requires students to already be able to “recognize the positional values in decimal numbers, multiply positive fractions, and know how decimals are converted into fractions”. Once the context is defined, we then specify the aim. In this case, the objective of the unit is “mental arithmetic for multiplication of decimal numbers” and the objective for the specific class is “procedures for mental arithmetic of fractions and decimal numbers”. The skill being developed is how to “identify regularities in different multiplication procedures,” and the cognitive processes are Comprehension, Application and Analysis.

The main body of the orchestration is the class’ specification. For instance, for the instructional phase, we indicate a deductive pedagogical process, with class activities such as “visual presentation of the new content in a contextualized situation”. Each activity is described and the suggested duration is indicated. The machines used are Linux-based XO that provide neither online nor visibility tools. However, formative assessment guides are given, such as, “Supervise the students work, paper or digital, and when an error is detected in several students, stop the whole classroom and ask one of the students to solve the problem with your guidance.” We provide the resources indicated in Table 2-1, such as PDFs in the form of power point presentations, since overhead projectors are not widely available, paper-based exercises, and URLs for complementary activities such as electronic exercises and mathematical puzzles. Finally, there is a guide on how to maintain order in the classroom. For example, we direct the teacher to give clear and concise instructions to the students and encourage the teacher to move around the classroom in order to clear up students’ doubts and problems and better connect with them.

2.4. Conclusion

Warschauer indicates that the introduction of information and communication technologies in the schools he observed served to amplify existing forms of inequality (Warschauer & Knobel, 2004). The aim of our proposal is to transform the role of technology in the classroom to empower the teacher and transform the learning process. An adequate orchestration helps to guide the teacher through the work to be performed in the classroom, allowing a shift from an instructor-centred arrangement, in which the teacher radiates knowledge before a passive class of students, to one where the students actively participate, with the teacher acting as a mediator. This aims for a class with a dual flow of information which, as Dillenbourg indicates, emphasizes the coherence of the different elements as they converge in the teaching and learning processes. Orchestration, as we see it, is not about teacher training; it is about giving teachers the tools to structure their classes and empower them beyond the training process.

Our proposal, which incorporates the design principals proposed by Dillenbourg and takes into consideration the elements of Table 2-1, is currently being used in Chile, Colombia and Uruguay in more than 60 schools. This proposal can be seen as a bridge toward embracing the learning process as an interactive and collaborative experience between the teacher and the students. However, these design principles cannot always be fully applied, i.e., not all elements of Table 2-1 are always present and will depend on the characteristics of the digital resources. For example, online tools and tools that support visibility are not common in all educational technology applications.

3. ORCHESTRATING THE XO COMPUTER WITH DIGITAL AND CONVENTIONAL RESOURCES TO TEACH MATHEMATICS

3.1. Abstract

Recent research has suggested that simply providing each child with a computer does not lead to an improvement in learning. Given that dozens of countries across the world are purchasing computers for their students, we ask which elements are necessary to improve learning when introducing digital resources into the classroom. Understood the orchestration as the coordination of conventional and digital resources, we examine whether effective resource orchestration improves student learning. To do so, an eight month study was undertaken across 17 schools in Uruguay, involving 544 fourth grade students. A treatment group worked under an orchestrated strategy, while a control group followed the national strategy, which includes the One Laptop Per Child Computer (XO). Our study confirmed that the national strategy alone is capable of producing significant progress in student learning. However, we also found that the orchestration produces a statistically significant improvement in the results when compared to the control group. The main finding indicates that when teachers have an orchestrated strategy to integrate digital and non-digital resources, student learning is enhanced in relation to the curricular objectives. Finally, we discovered that learning is improved in the treatment group when there is systematic use of resources, and when the school's infrastructure facilitates the use of the technology.

3.2. Introduction

The One Laptop per Child (OLPC) initiative (Kraemer, Dedrick, & Sharma, 2009) has promoted the supply of low cost computers to students around the world with the aim of improving their learning. Although over 20 countries are already putting this initiative into practice, considerable controversy remains as to its possible impact (Nugroho, 2010). Independent studies have concluded that providing each child with a computer does not lead to improvements in learning mathematics or reading (Cristia et al., 2012).

One of the countries to join this initiative was Uruguay, following a countrywide policy implemented in 2009 to provide every primary school student with an XO computer (Wikipedia, 2012). One of the initiative's objectives is to improve teaching and learning processes and increase motivation in order to connect with student and teacher knowledge (Flores & Hourcade, 2009). In order to achieve this objective, and to make best use of the computers, enough resources must be made available to ensure that they are adequately maintained and that the relevant content and services are accessible.

Sharples (2013) reviews the relationship between resources and the interaction between individuals in a classroom. He claims that the classroom has become a more complex and demanding place, in which the teacher no longer merely plans a lesson, adapts to official programs and takes care of safety and discipline, but must now also understand and manage a variety of technologies. As the teacher must not only learn and manage a new form of technology, but also promote direct interaction between themselves and the students, between the technology and the students, and among the students themselves, supporting the teacher and providing them with a set of guidelines is essential (Hämäläinen & Oksanen, 2012). This set of guidelines is known as orchestration.

Orchestration provides an innovative robustness to teaching and learning, while taking classroom ecology into account; efficiency, as it enables the use of tried and tested resources; adoptability, as it facilitates the teacher's organization of relevant resources; and adaptability, as teachers are equipped with strategies for adjusting the resources according to possible outcomes (Roschelle et al., 2013). In addition to this, Mercer & Littleton (2007) highlight the possibility of the teacher generating an environment conducive to productive discussion and a sense of mediation within the learning process. This allows for concentration on higher order issues, leaving lower order issues (such as the application and combination of basic solutions using ICT resources) at the mercy of an orchestration model.

However, the presence of multiple forms of information and communication, with and without ICT resources inside the classroom, does not guarantee an improvement in student learning. It must be accompanied by the pedagogical orchestration of the resources involved (Prieto 2011). This gives rise to the first research question, which seeks to evaluate the effect of an ICT integration model with other orchestrated learning resources on the work of a teacher: Does student learning improve when teachers are provided with a variety of conventional and digital resources which form a coherent orchestrated unit?

In order to analyse the findings from the first question in greater depth, and get a better understanding of the environment when the learning achievements are similar or different among various groups of students, we asked a second research question: Which are the elements that improve learning when introducing digital resources into the classroom?

The following chapters present the intervention model, where the treatment and pedagogical strategy implemented are explained in detail; the experimental design, which explains the sample and data collection; the research results, which explain the obtained findings through different statistical techniques; and the conclusions, which discuss the lessons drawn from this experience.

3.3. Intervention model for treatment group

The content developed throughout the eight-month study focused on mathematics and in particular the following concepts: Place Value, Division, Fractions, Decimals, and Geometry, all at fourth grade level. These math topics are documented in Table 3—1.

Table 3—1 Table of contents for the curricular work covered during the study

Math topic	
1.	Place value in numbers up to 10,000
2.	Numbers in expanded form
3.	Division with and without remainders
4.	Ordering fractions
5.	The sum of common fractions with different denominators
6.	Calculating using rational numbers (fractions)
7.	Dividing with rational numbers (fractions)
8.	Converting fractions to decimals
9.	Reading and writing decimals
10.	Locating decimals on number lines
11.	Multiplying whole numbers and decimals
12.	Multiplying and dividing whole numbers and decimals
13.	Perimeter of shapes
14.	Measuring and estimating the size of an angle
15.	Interior angles and regular polygons
16.	Rules for the sides of a triangle
17.	Intersecting and parallel planes
18.	Interpreting information from simple bar charts
19.	Interpreting information in a table

Within this curricular framework, the goal of the in-class research was, on the one hand, to practice the standard procedure, and on the other, to experiment with different representations of the math topic, helping the student to integrate the two ways of looking at an operation. The intervention was framed by three components:

3.3.1. Teaching strategy orchestrations and resources

The pedagogical proposal was based on the integration of digital and non-digital resources, supported by the orchestration of resource integration in the classroom and serving as a guide for the teacher. This design was structured to answer the paper's first research question: Does student learning improve when teachers are provided with a variety of conventional and digital resources which form a coherent, orchestrated unit? Different learning modules were developed for each of the math topics included in the study. Each of these modules consisted of a variety of teaching resources that could be used together to achieve a given objective, along with an orchestration to guide the teacher on associated logistical and pedagogical aspects.

The orchestration booklet was designed based on the model described by Nussbaum & Díaz (2013) and consists of logistical and pedagogical guidelines for integrating and implementing digital and non-digital resources that aim to achieve the same teaching objective. The orchestration booklet included a guide on how to approach each math topics from both a logistical and pedagogical point of view. In terms of logistics, this included suggestions for how to manage the time, space and resources to enhance the learning experience. In pedagogical terms, it included guidance on how the teacher should interact with the students when acquiring the new knowledge (key questions, examples etc.). The resources included in the orchestration for each of the math topics are listed and described below:

Material for exploring and discovering content: Power Point presentations to introduce the content to students in a methodologically sound and interactive way, placing new concepts within a narrative that significantly improves student comprehension (Burton, 2002). Figure 3—1 shows an example of how a math topic is taught using an everyday situation, where two children are presented with a challenge they must solve. This must be done as a group, mediated by the teacher, and using the new procedures that have been studied for "Calculating using rational numbers (fractions)" (Table 3—1, Topic 6).

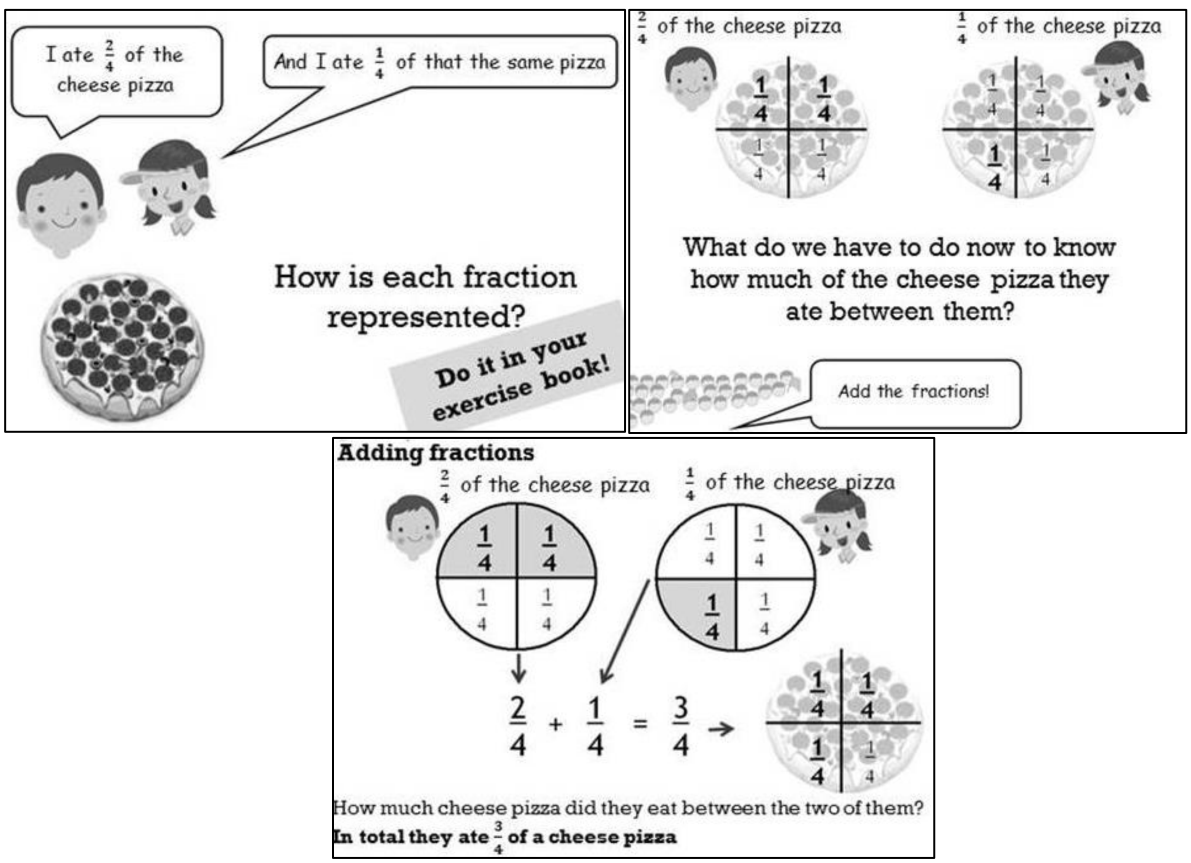

Figure 3—1 Example narrative in PPT

Personal interactive activity: Digital content for personal practice, where the students work at their own pace. For the digital work, the XO Computer acted as a mediator allowing the teacher to choose between two different open source activities for each math topic. In general, the available open source activities lacked an adequate narrative and feedback, as well as containing graphics that were inconsistent with the rest of the intervention's educational resources.

Personal activities using paper-based exercises: Non-digital work where worksheets were proposed to develop argumentation and procedural skills for mathematics. Students were encouraged to investigate and practice using different methods to solve the exercises relating to the new concept.

Transferring content to new situations: Game-based educational resources in which students were able to establish connections with prior learning by using Power Point, XO and study guides. For example, Figure 3—2 shows a game-based activity in which the children worked in groups of three and had to apply the new math topics in order to complete the game. In this case the teacher mediated the interactions between the groups, ensuring that the challenges were correctly solved by the students. In some cases, the materials used in the activities included cut-outs to use as markers or pieces for the game.

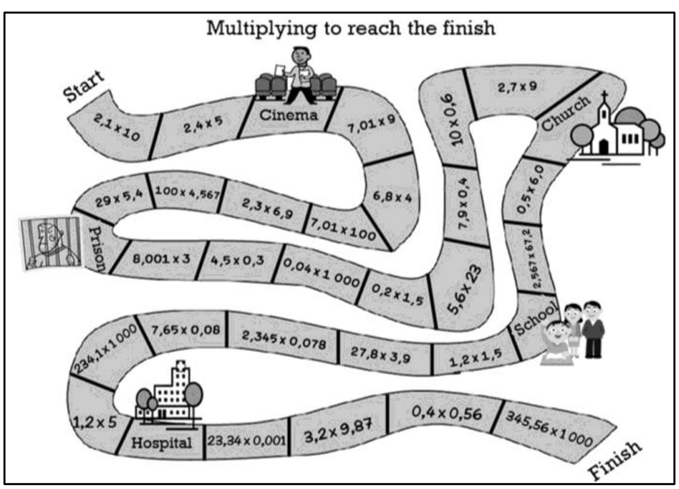

Figure 3—2 Example game

Table3-1 outlines an example which is the orchestration of Class 1 on the math topic of converting fractions to decimals, focusing on exploring content through the use of Power Point and strategies to activate prior knowledge. The rest of the orchestration for this topic, not shown in Table3-1 due to space restrictions, provides the teacher with instructions on how to integrate and adjust various learning experiences in order to teach the same math topic by making use of different resources.

Table3-1 Orchestration Example (Class 1 of 3)

Class 1: Content presentation (2 activities, 45 minutes in total)			
Obs.	**Time**	**Teacher Guidance**	**Resources**
	15 minutes	**ACTIVITY 1** **<u>Objective</u>:** To recall prior knowledge (fractions and decimals) in conjunction with students in order understand new content (converting and forming relationships between fractions and decimals). **<u>Expected results</u>:** Students are expected to recall concepts previously studied in order to undertake the following introduction, practice and application activities on converting and forming relationships between fractions and decimals. Begin the class by briefly outlining the challenges of introducing **<u>decimal and fraction</u>** content. In order to help students recall the characteristics of fractions, ask them the following questions: • ***"Can anyone give an example of a fraction?"*** Ask four children to provide examples. • ***"What are its different parts?"*** Together, go through the numerator and denominator. • ***"Can anyone give an example of a decimal? What are its different parts?"*** Together, go through the whole number and decimal number. Ask your students to ***"note down a decimal in your exercise book"***, distinguishing between the parts of a decimal. Pay close attention to this task, and then ask four pupils to come to the front of the class and write their example on the whiteboard. This way, the exercise can be checked and discussed by the class, noting the parts of a decimal. • Next, tell your students, ***"Now, note down a fraction, once more noting down its different parts".*** Having watched the students complete this task, asking four of them to come to the front of the class to write their examples on the whiteboard is recommended. This ensures a clear identification of the required work. • To complete the introduction to the class, ask "Where can we find decimals in day to day life? What could be represented by a fraction within the classroom?" Discuss different examples with your students, ensuring the necessary prior learning for the study of this content.	- Each student's exercise book - Whiteboard - Pencil - Eraser
	30 minutes	**ACTIVITY 2** **<u>Objective</u>:** To understand how to convert fractions to decimals and vice versa. **<u>Expected results</u>:** Students are expected to learn how to convert fractions to decimals and vice versa, through real situations in which the content applies to day to day contexts. Tell your students that they will now learn more about how to convert fractions to decimals and vice versa. Begin by showing them the Power Point (PPT) presentation ***"Converting fractions to decimals"***. This resource **explains the relationship between decimals and fractions using pictorial representation**. Two friends, Gustavo and Ignacio, present the new material and finish with different exercises to help with feedback and the clarification of possible doubts. To conclude this activity, it is recommended that students complete the "Using your calculator" game-based activity, in order to consolidate their learning. To end the class, ask your student to answer the following questions: "How do you convert a fraction into a decimal? And how do you convert a decimal into a fraction?" Ask for examples and remember to answer questions, thereby helping students to understand the content.	- Teacher's computer for the PPT (01. Presentation – Converting fractions into decimals). - Projector. - Game-based activity "Using your calculator" (02a. Game-based Activity – Using your Calculator, Conversions)

Some of the participating teachers felt that the proposed materials needed to be adapted to the different realities and requirements of each school. These minor changes only altered the order of the orchestration by less than 5% and we can therefore say that, in general, all of the schools followed the same orchestration.

These changes are not considered as bias as the orchestration booklet was designed with timings which would allow for minor changes, bearing in mind the flexibility which Dillenbourg (2013) mentions with regards to orchestration. The documented changes that were made to the orchestration booklet were the following:

- Allocated time for each math topic: rather than working on one math topic per week, the teachers extended the time spent on each concept according to the needs of their students, spending up to three times the original allocated time on a concept.

- Order of the math topics, in line with the school's own pre-established plans.

- Removing a math topic. Only one school removed a specific concept from the program ("Locating decimals on number lines" - Table 3—1, Topic 10).

- Activities based on transferring content to new situations; certain game-based activities were not included due to a lack of time.

- Power Point presentation, subject to the availability of a projector. Where schools did not have access to a projector, the presentation was either shown to the whole class on a single netbook or desktop, or on each XO, where the students followed the teacher's instructions to work through the presentation. In these cases, the schools did not follow the recommendations set out in the orchestration booklet on how to work with Power

Point presentations, where the suggestion was to project the Power Point to the whole class so that every child could see it.

- Two children working on the same XO computer due to a lack of working computers in some schools. In these cases, the XO method suggested by the orchestration booklet was modified as it recommended having each child work individually, in line with the government initiative which refers specifically to 1:1 work.

- Incorporating the school's own strategy and resources into the proposal.

3.3.2. Teacher training and coaching

The training process was designed based on the characteristics of the teaching strategy. This process, aimed at teachers from all of the schools in the treatment group consisted of four sessions to present and explain the pedagogical proposal. The sessions took place in the schools and were attended by the participating teacher, head teacher, and coordinating teacher. Each session lasted 1.5 hours and encouraged the teachers to reflect on the components of the teaching strategy. The objectives for each session were as follows: Initial Session, to understand the objectives of the study and how it would be implemented; Session 1, to introduce the strategy to be used in the classroom through a practical demonstration; Session 2, to plan the logistics of implementing the strategy in the classroom; Session 3, to introduce student tracking and support procedures.

3.3.3. Tracking implementation in schools

The tracking process was developed in order to collect information which would help to answer the second research question, which aims to identify which elements improve learning when introducing digital resources into the classroom. The tracking was composed of three stages: logbooks, classroom observations and meetings.

Logbooks: The orchestrations were developed so as to allow the teachers to adapt them to their specific needs. In order to understand how these orchestrations were implemented by each teacher and to analyse the effects of the systematic use of each material on the progress reported by students, the teachers kept a logbook which detailed the use or non-use of resources for each session and the decisions taken regarding their work in the classroom (the results are documented in detail in Table 3 – 2 and summarized in Table 3-3). Therefore, the systematic use of the teaching strategy's materials was the first level of variables which were analysed in order to answer question 2. These variables correspond to each of the orchestration's materials, and for each math topic: Use of PPT; Use of XO computer; Use of worksheet (WS); and Use of game-based activity (GBA). Descriptive statistics were used to calculate the averages of the various integrated resources and to produce an index for each of these (Table 3-3).

Table 3—2 Logbook record for systematic use of resources, for each of the Treatment Group classes

Class1

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	0	0	0.79	79%
XO	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	0	0.74	74%
WS	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0.68	68%
GBA	1	0	0	1	1	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0.63	63%

Class2

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	1	1	1	1	0	0	1	1	1	0	1	1	1	1	1	0	1	1	0.79	79%
XO	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1	0	1	1	0.79	79%
WS	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1	0.84	84%
GBA	1	1	1	1	0	1	0	0	1	1	0	1	1	1	1	1	0	1	1	0.74	74%

Class3

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	0	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0.79	79%
XO	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	0	1	1	0.79	79%
WS	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	0.84	84%
GBA	1	1	1	1	1	0	0	1	1	1	1	1	1	1	0	1	0	1	1	0.79	79%

Class4

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	0	0	0	0	0	0	1	1	0	0	0	1	1	1	1	0	0	0	0.37	37%
XO	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0.21	21%
WS	0	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	0	0	1	0.63	63%
GBA	0	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	0	0	0	0.58	58%

Class5

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	1	0	0	0	0	1	1	1	0	1	1	1	1	1	1	0	0	0	0.58	58%
XO	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0.21	21%
WS	1	1	1	0	0	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0.63	63%
GBA	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	0	0	1	0.68	68%

Class6

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	1	0	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0	0.68	68%
XO	1	1	0	0	1	0	1	1	1	0	1	1	0	0	0	0	1	0	0	0.47	47%
WS	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0.84	84%
GBA	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0.74	74%

Class7

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0.68	68%
XO	1	1	1	1	0	1	0	1	1	1	0	1	1	0	0	0	0	0	0	0.53	53%
WS	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0.58	58%
GBA	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0.37	37%

Class8

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	100%
XO	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	0	0	1	0.68	68%
WS	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.95	95%
GBA	1	0	0	0	0	1	0	0	1	1	1	1	1	1	1	1	0	1	0	0.58	58%

Class9

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	1	1	1	1	0	0	0	1	1	0	1	1	1	1	1	1	1	1	0.79	79%
XO	1	1	1	1	1	1	0	0	0	1	1	1	1	0	0	0	0	1	1	0.63	63%
WS	1	1	1	1	1	1	0	0	1	1	1	1	0	1	1	1	1	1	1	0.84	84%
GBA	0	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0.37	37%

Class10

Resource	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	Mean	Mean %
PPT	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0.89	89%
XO	1	1	1	1	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	0.79	79%
WS	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0.89	89%
GBA	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0.84	84%

1: use of resource in math topic (T). 0: no use of resource in math topic (T);. PPT: Power Point; XO: Digital activities on one netbook per child; WS: Worksheet. GBA: Game-based activity; T(1-19): Math topic; Mean: average use of each resource; Mean %: average use of each resource by percentage

Table 3—3 Average use of each resource by percentage

	Power Point (%)	XO (%)	Worksheet (%)	Game-based activity (%)
Class1	79	74	68	63
Class2	79	79	84	74
Class3	79	79	84	79
Class4	37	21	63	58
Class5	58	21	63	68
Class6	68	47	84	74
Class7	68	53	58	37
Class8	100	68	95	58
Class9	79	63	84	37
Class10	100	89	100	95

Observations: The teacher support process consisted of individual coaching by the field researchers for each kind of classroom task: exploring content, practicing the content and transferring the content to new situations. Observations were the second level of variables that were recorded in order to answer question 2, and evaluate whether these components were one of the possible determinants of progress in student learning. At the end of the class, the field researcher provided the teacher with feedback regarding the classroom work and the various observed components. The results of these observations were systematized using descriptive statistics (Table 3—4), in which each of the elements that was observed was considered a variable, taking as its value the average performance index from the three observations carried out with each teacher for each of the evaluated components. These were: Class structure; Use of planning; Content explanation; Feedback provided to the children; Resource integration and Group Management.

Table 3—4 Average teacher performance index by each variable observed

Variables	Treatment group									
	Class1	Class2	Class3	Class4	Class5	Class6	Class7	Class8	Class9	Class10
Class structure	4.00	1.67	2.00	2.67	3.00	3.33	3.33	3.00	2.67	3.67
Use of planning	3.67	1.67	2.00	2.33	2.33	2.33	3.00	3.50	3.00	3.00
Resource integration	3.67	2.00	2.33	3.00	2.67	2.67	4.00	3.50	3.00	4.00
Content explanation	4.00	2.33	3.33	2.67	2.67	3.00	3.33	3.50	3.33	4.00
Feedback provided to students	4.00	2.67	3.67	2.67	2.67	2.67	4.00	2.50	4.00	4.00
Group management	4.00	3.00	4.00	3.67	3.67	3.33	4.00	3.00	3.67	4.00

1.00 to 1.99: Insufficient performance observed;2.00 to 2.99: Standard performance observed; 3.00 to 3.99: Good performance observed; 4.00: Optimum performance observed

Meetings: Occasions where the field researcher advised the school team on the systematic nature of the implementation and the integration of resources, analysing possible curricular flexibility according to the particular needs of the teachers. During these meetings, the field researchers recorded context variables in order to analyse the possible effect that each of these elements could have on the students' learning outcomes. Four variables were recorded for each class: whether or not there was Internet, a projector, and a 1:1 computer to student ratio (1 XO per Child), as well as the class size (Table 3—5). These recordings were the third level of variables to be analysed.

Table 3—5 Register of contextual characteristics

	Reliable internet	Projector availability	Equipment ratio 1:1	Class size
Class1	1	1	1	28
Class2	1	0	0	22
Class3	1	0	0	22
Class4	1	1	0	13
Class5	1	1	0	14
Class6	1	1	0	18
Class7	1	1	0	19
Class8	0	0	1	13
Class9	0	0	1	21
Class10	1	0	1	22

1: Condition present; 0: Condition absent

3.4. Experimental design

3.4.1. Sample

To answer the two aforementioned research questions, an exploratory study was undertaken using a quasi-experimental design and applied to 17 public schools in urban Montevideo, Uruguay. Among these 17 schools, 10 classes from 7 schools were identified as the treatment group and 10 classes from 10 schools as the control group. All students were evaluated by applying a pre- and post-test at the beginning and end of the research. Each group was composed of fourth grade students and their respective mathematics teacher.

The sample initially consisted of 544 students (257 treatment group students and 287 control group students). However, by counting only those students who participated in both the pre- and post-tests, the final sample was 400 students (192 treatment students and 208 control group students). This loss of data was due to students being absent on the day of the post-test. Table 3—6 shows the characteristic elements of the process for the control group and the treatment group. It was decided not to do classroom observations nor tracking and monitoring with the control group so as not to interfere and avoid any type of bias which could alter the schools' natural course.

Table 3—6 Sample design

Group number	No. of schools	No. of classes	No. of students	Characteristic elements
Control	10	10	208	Measuring Learning (details 3.2.) Use of XO computer per child
Treatment	7	10	192	Measuring Learning (details 3.2.) Classroom observation (details 2.3.) Teacher training and coaching (details 2.2.) Orchestrations and resources (details 2.1) Tracking and monitoring (details 2.3.) Use of XO computer per child (details introduction)

3.4.2. Instruments

<u>Measuring Learning</u>**:** The quantitative evaluation was undertaken using a paper-based test, for both the pre- and post-test. It consisted of 38 questions, resulting in an exhaustive assessment of math topics covered during the study. The time limit for completing each test was 75 minutes. The test scored a Cronbach's Alpha (Cronbach, 1951) of 0.82 for the post-test, which was taken by 400 students in total. To support this test, an application

protocol was established in order to ensure consistency among the interaction between the evaluators and the children.

<u>Classroom observation</u>: As it was explained in subsection 2.3 “Tracking implementation in schools”, teacher performance was evaluated three times, with each observation lasting between 45 and 60 minutes, corresponding to the time spent on mathematics each day.

Six components were evaluated during each observation: the structure of the class, the use of planning, the integration of resources, content explanation, feedback provided to students and group management. Each of these components was measured on a scale of 1-4 using an observation form, in which 1 is the lowest score and 4 the highest. A member of the research team applied this form to evaluate teacher performance in the classroom once the class had finished. The researchers noted all the information necessary for the assessment (Appendix 3), in line with previously established criteria (Appendix 4).

The observation guidelines were developed by considering the knowledge and skills that are necessary for technology to be adequately integrated into the classroom. Hogan (2007) argues that it is possible to evaluate specific tasks using an instrument consisting of the skills that are necessary for performing an action, skills which are expressed in the observation criteria rubric (Appendix 4).

3.5. Results

3.5.1. Analysis of the treatment and control groups' pre and post-test scores

The study looked into the significance of the difference between the pre- and post-test scores for each student. The analysis for both groups was done independently, taking into account only those students who participated in both the pre- and post-tests. Both the control group and the treatment group showed statistically significant differences al 99% between their pre- and post-test scores (Table 3—7). However, the control group showed a medium effect size (Cohen's d 0.41), while the treatment showed a large effect size (Cohen's d 1.04). This was calculated using descriptive statistics, specifically the mean and standard deviation for each group and for each measurement (Table 3—7), so as to identify the effect size (Cohen's d) of the teaching strategy on student learning when compared with the control group. It should be noted that the outliers were eliminated for this analysis because they could have influenced the results in the differences studied. Thirteen cases, all high, were removed, 8 from the treatment group and 5 from the control group.

Table 3—7 Pre- and post-test results per group

Group	N	Pre[a]		Post[a]		*p*	Cohen's *d*
		$\bar{X}$	SD	$\bar{X}$	SD		
Control	203	9.91	3.70	11.46	4.68	0.00 ***	0.41
Treatment	184	11.61	5.44	17.73	6.98	0.00 ***	1.04

[a] *There was a total of 38 points available on the test.*
****p=0 - 0.001; **p= 0.001 – 0.01; *p= 0.01 – 0.05; ºp= 0.05 – 0.1*

To evaluate the differences in the progress noted in the students from the control group and from the treatment group, the score on the initial measurement was controlled. As shown in Table 3—7, the average for the control group in this measurement was lower than for the treatment group. In order to do this, an analysis of covariance (ANCOVA) was conducted, which is a procedure that eliminates heterogeneity between the treatment groups, relating to characteristics not controlled for in the experimental design. In this case, heterogeneity in the initial learning scores reported by both groups was eliminated, separating out any predictions based on initial student scores in favour of the final progress results.

Table 3—8 shows that the pedagogical strategy employed has a significant effect (p=0.01) on student learning. Even though the initial measurement has a significant effect on progress, this association is inverse, because those subjects who had a higher score on the initial measurement showed lower progress overall (p=0.00). In other words, considering that the students experienced a gain in learning between the pre- and post-tests, each additional point on the pre-test represents an average effect of -0.47 on the final gain.

Table 3—8 Analysis of covariance

	Estimate	*SD*	*t* value	*P* (>|t|)	
Intercept	0.17	0.03	6.12	0.00	***
Pedagogical strategy	0.09	0.04	2.53	0.01	*
Initial measurement	-0.47	0.10	-4.88	0.00	***
Treatment: initial measurement	0.16	0.12	1.36	0,18	

****p=0 - 0.001; **p= 0.001 – 0.01; *p= 0.01 – 0.05; ºp= 0.05 – 0.1*

To confirm the association between the initial score and the progress that the students achieved, the data was submitted to a correlation analysis through a Pearson test. This test revealed significant results (p=0.00) in regards to the previously mentioned negative linear relationship, thus corroborating the finding that the subjects who scored highest at the initial measurement also tended to make less progress in terms of learning achievements, and vice versa, thus favouring the students with lower performance. This correlation is further supported by taking a more in depth look at the scores by the highest and lowest performing students on the pre-test. To analyse the results for student learning in greater depth and understand the increase in the post-intervention standard deviation, Table 3-9 shows the scores for the bottom 10% of students on the pre-test and the top 10% of students on the same test, both for the control group and for the treatment group. In both groups (control and treatment), on average the lowest performing students on the pre-test see a greater increase in their scores than the top performing students on the pre-test (4.59 versus -0.54 for the control group, and 7.40 versus 2.46 for the treatment group).

Table 3—9 Breakdown of results on the pre-test

Group		Pre[a]			Post[a]			Improvement
		$\bar{X}$	Min	Max	$\bar{X}$	Min	Max	$\bar{X}$
Control	Entire group	9.91	1.83	26.00	11.46	1.00[b]	26.00	1.55
Control	Top 10% pre-test	17.03	14.50	26.00	16.48	6.00	26.00	-0.54
Control	Bottom 10% pre-test	3.63	1.83	4.83	8.23	2.17[b]	6.17	4.59
Treatment	Entire group	6.61	0.00	29.33	17.73	3.17	33.67[c]	6.12
Treatment	Top 10% pre-test	21.83	19.33	29.33	24.29	13.17	33.00[c]	2.46
Treatment	Bottom 10% pre-test	3.07	0.00	4.50	10.46	3.17	20.33	7.40

[a] There was a total of 38 points available on the test.
[b] The minimum scores are not the same because the 'entire group' includes all the children from this group, while the statistics for the bottom 10% only include the children who scored in the bottom 10% on the pre-test.
[c] The maximum scores are not the same because the 'entire group' includes all the children from this group, while the statistics for the top 10% only include the children who scored in the top 10% on the pre-test.

This is supported graphically by the Histogram in Figure 3—3, which shows the distribution of scores by children from both groups on each of the tests. In particular, as well as observing an improvement for both groups on the post-test (the data reveal an increase in the median score), an increase in the dispersion of the data can also be observed, both in terms of scores as well as frequency. In other words, there are higher scores on the post-test than on the pre-test and, at the same time, a lower concentration within a set range of scores (the frequency of students with those scores is lower, leading to greater variability).

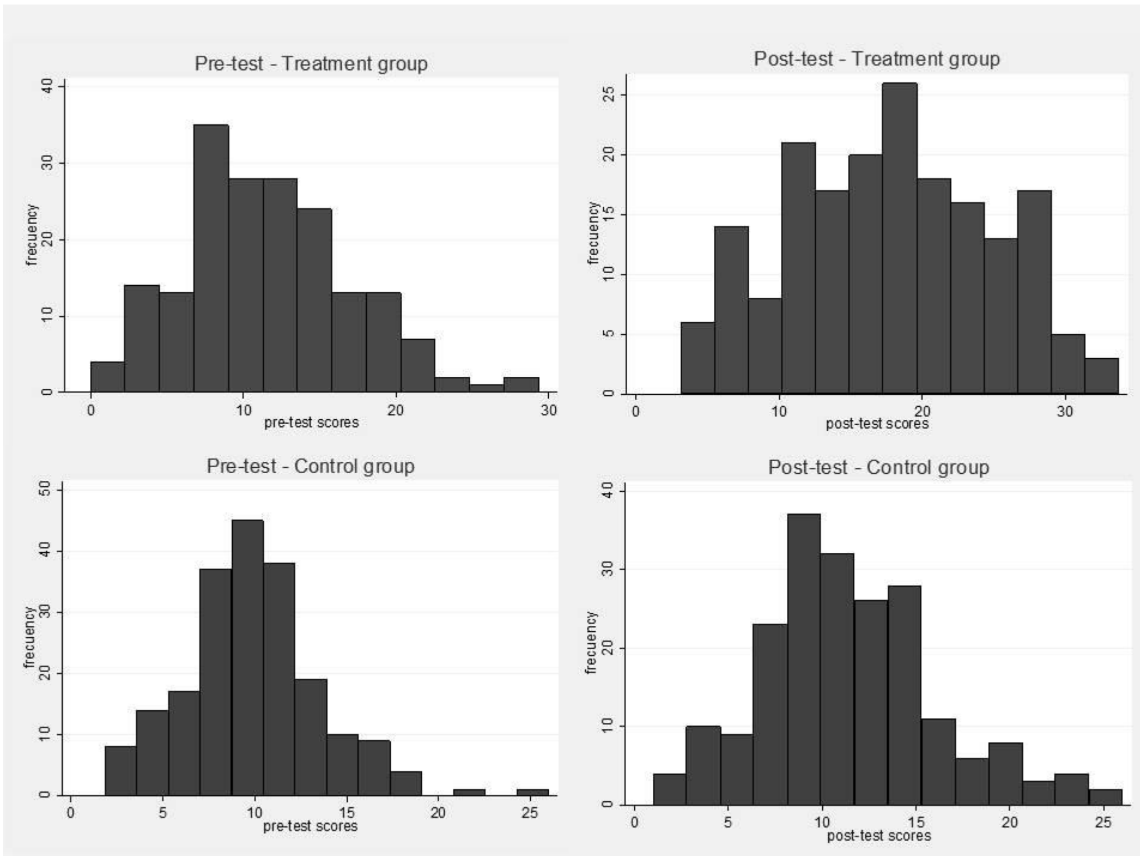

Figure 3—3 Histogram

This can be explained as the effect of the pedagogical strategy on the presence or absence of previous learning. Those children who scored higher in the initial measurement could have received previous training associated with the math topics covered by the measurement instrument, while those who scored low might not. Thus, we may conclude that the presence of the strategy would have the effect of reinforcing the lessons for those children with previous studies, but would act as an introduction and transfer of information for those children who initially started without these studies.

3.5.2. Treatment group analysis

In order to discover student learning determinants within the treatment group (Keppel, 2004), all of the comparisons between treatment classes were done in pairs using the Bonferroni correction. Significant differences were observed between Classes 5 and 10 with Classes 1, 2, 3, 7 and 9; between Class 8 and Classes 2, 3, 7 y 9; and between Classes 4 and 6 with Classes 2, 3 and 9 (Table 3-10).

Table 3—10 Pair wise comparisons using t tests with pooled SD

Mean		Class1 0.15	Class2 0.07	Class3 0.11	Class4 0.22	Class5 0.25	Class6 0.20	Class7 0.12	Class8 0.22	Class9 0.11
Class2	0.07	0.07°	-	-	-	-	-	-	-	-
Class3	0.11	0.31	0.46	-	-	-	-	-	-	-
Class4	0.22	0.29	0.02*	0.09°	-	-	-	-	-	-
Class5	0.25	0.05*	0.00***	0.01*	0.61	-	-	-	-	-
Class6	0.20	0.27	0.01*	0.05*	0.84	0.39	-	-	-	-
Class7	0.12	0.51	0.32	0.77	0.14	0.02*	0.11	-	-	-
Class8	0.22	0.22	0.01	0.05*	0.97	0.61	0.78	0.09	-	-
Class9	0.11	0.36	0.44	0.95	0.10	0.01*	0.06°	0.82	0.06°	-
Class10	0.24	0.04*	0.00***	0.00**	0.67	0.88	0.41	0.01*	0.67	0.01*

****p=0 - 0.001; **p= 0.001 – 0.01; *p= 0.01 – 0.05; ºp= 0.05 – 0.1*

Using the data provided by Table 3-10, a multi-level analysis model has been developed for the treatment group. An analysis of the nested data was carried out in order to explore which contextual and methodological variables involved in the pedagogical strategy impacted —to a greater or lesser degree— learning among children in this group. The dependent variable was each student’s progress and the contextual variables evaluated refer to three areas, which have had tracking during the intervention:

-The systematic use of the teaching strategy materials, with results documented in Table 3-3 and further detailed, in Table 3-2.

-Teacher performance index, following observations throughout the study, with results documented in Table 3-4.

-School infrastructure for each group of students, with results documented in Table 3-5.

The control group has not been included in the HLMs as this analysis included variables that were recorded during tracking and classroom observation. As was explained in sub section “3.1. Sample”, it was decided not to do tracking or classroom observations with the control group so as not to interfere and avoid any bias which could alter the schools’ natural course. Given this decision, class-level variables are not available for the control group and therefore these students cannot be included in the analysis. In any case, this does not affect our second research question.

In order to examine the existence of a possible association between the characteristics of each class and the achievement of each child, the group of treatment classes was analysed for intra-class correlation. The findings indicated that 11% of the variance in progress achieved by all the students in the treatment group is effectively due to the differences between classes. Thus, it should be noted that 89% of the variance is due to other differentiating elements in each classroom which have not been included in this study, as well as individual characteristics such as previous learning experiences on the math topic, family socioeconomic level, class attendance, etc. Table 3-11 depicts the three models analysed using this statistical technique.

Table 3—11 Coefficients from the hierarchical linear model analysis of final student achievement

	Model 1			Model 2			Model 3		
Variable	Est.	*SE*		Est.	*SE*		Est.	*SE*	
Class-level equation: effects on adjusted mean achievement between classes									
Intercept	-0.07	0.10		-0.05	0.21		0.30	0.06	***
Systematic use of resources									
Power Point	0.40	0.21	°						
XO Contents	-0.44	0.13	***						
Worksheet	0.12	0.23							
Game-based activity	0.16	0.10	°						
Teacher performance									
Class structure				0.03	0.05				
Use of planning				-0.03	0.07				
Resource integration				0.04	0.06				
Explanation of the contents				0.06	0.07				
Feedback for the students				-0.12	0.06	***			
Group management				0.09	0.09				
School infrastructure for each class									
Class size							-0.02	0.00	***
Internet reliability							0.15	0.05	***
Availability of a projector							0.01	0.03	
1:1 Ratio							0.15	0.03	***

******p=0 - 0.001; **p= 0.001 – 0.01; *p= 0.01 – 0.05; ºp= 0.05 – 0.1*

Model 1 examines the category systematic use of resources for student learning. It is observed that both greater use of Power Point presentations for introducing material with a narrative as well as work using game-based activities that incorporate math topics and operations, have a marginal but positive association with student learning. However, greater use of XO contents is negatively associated with progress in the children's learning. These results cast doubt on the current use of XO digital content that is accessible on the internet, since some of the characteristics of this content may construct incorrect conceptualizations for mathematical learning. Beyond the individual significance of each variable, Model 1 is statistically significant as a set (p=0.01).

Model 2 shows the association between the variables for the category of teacher performance with the children's final progress in their learning. In this category, the only variable shown to be predictive is feedback for the students. This prediction is inversely linear. Thus, when the teachers gave more feedback to their students, those students showed less progress in their learning. This result could be studied in further detail by analysing the type of feedback given and the contents of the interventions made by the teachers when working with the students. No other variable in this category suggests an association with student progress. In this case, Model 2 is not statistically significant (p=0.12).

Finally, Model 3 evaluates the association of infrastructure variables for each class, demonstrating that there is an inverse effect between class size and progress in student learning. Thus, the students who showed the most progress were those who belonged to the smaller groups. On the other hand, the variables of internet reliability and 1:1 ratios are positively associated with student learning. This could suggest the importance of internal administration at each educational establishment. Even though the Uruguayan government has implemented a public policy for providing internet connectivity for Montevideo (and other cities), the reliability of this service depends on the management of individual resources within each establishment. Likewise, even if 1:1 ratio is a policy implemented on a national level, it should be noted that not all of the schools and classes maintain all of their equipment in working order. Maintenance of the equipment varies between establishments depending on their internal administration and specific context, as well as the level of communication between each establishment and the technical support team provided by Ceibal to assist in this matter. This final model, Model 3, is statistically significant when all of the variables are analysed as a set (p=0.00).

3.6. Conclusion and discussion

In a context in which the national strategy includes the use of XO computers that can independently produce significant improvements in student learning, the results of this study show that the studied intervention produced statistically significant results when compared with a control group. The results of this paper are coherent with those put forward by Luckin et. al (2012) which reveal the importance of avoiding the assumption that technologies in themselves produce learning, and do so effortlessly, given that the children in both groups, treatment and control, had one computer per child.

The first research question, "Does student learning improve when teachers are provided with a variety of conventional and digital resources which form a coherent orchestrated unit?" is answered by the results displayed in Table 3-8, by comparing learning achievement between the control and treatment groups. This shows that student learning (in terms of the curricular teaching objectives) improved in proportion to their teachers having access to an orchestration strategy for digital and non-digital resource integration. This confirms the importance of continuing to develop resource integration strategies that clarify for the teacher the pedagogical aim of the resources used (digital and non-digital) and the desired learning outcome. The value of technology does not lie within the technology itself, but will rather come from the relationship that it has with the other learning experiences that the students develop in the classroom. This highlights the value of orchestration, which coherently lays out the logistical and teaching components required in a classroom when integrating technology and other tools to promote learning.

Regarding the second research question, “Which are the elements that improve learning when introducing digital resources into the classroom?” we discovered that learning is improved when there is systematic use of resources, and when the school’s infrastructure facilitates the use of the technology. Furthermore, our experiments show that when teachers have an orchestrated strategy to integrate digital and non-digital resources, student learning is enhanced in relation to the curricular learning objectives.

A detailed analysis of the different classes comprising the treatment group shows the direct effect of the systematic use of the teaching strategy’s various resources, Model 1 Table 3-11. Quantitative analysis reveals that using Power Point has a positive effect on student learning, allowing new contents to be explored through graphic and contextual narratives. This is also the case with the Game-based activities, through which children interacted with the new content in groups and out of self-interest. However, it is interesting to analyse the negative effect that increased XO use is shown to have on student learning. As was signalled in the Intervention model for treatment group section, the digital content suggested for working with this tool was openly available on the internet. This content was characterized by a lack of informative feedback and, as it was web-based content, its use was directly dependent on the reliability of the school’s internet connection. In general, the schools’ internet connections were adequate, although in a few cases the connection was intermittent, and in two particular cases the connection was completely unreliable, Table 3-5. After taking into account all of the considered resources, a significant effect on student learning is observed. Therefore, a negative effect of the computer itself cannot be established, with a hypothesis put forward instead regarding the quality of the content on the XO computer.

The effect of the XO computer within an orchestrated teaching strategy, controlling the quality of the digital content, will be left as a topic for future research. Accordingly, NESTA (Luckin et al., 2012) points to technological elements that could support teaching practices and impact learning, making direct reference to the use of technology more than the technology itself. These elements, in the context of our study of the orchestrated use of the XOs, include:

Learning from experts. The orchestrations conceptualize expert experience in the classroom and suggest possible interactions for teachers to have with their students when working with technology, and help to transform the experience of working with software into a learning experience.

Learning with others. NESTA (Luckin et al., 2012) suggests this element based on the collaborative or collective experiences which educational software can provide, highlighting learning from peer interaction. Our study did not include collaborative software. However, the orchestration included worksheets and game-based activities which allowed for group work.

Learning through making. Students play an active and leading role in their learning experience with the software, without having to depend on external elements. As mentioned in the Intervention model for treatment group section, the available digital content was not always adequate, as it lacked interactive elements within its exercises, such as feedback and the absence of a narrative in the mathematics problems. Such factors may have contributed to greater levels of passivity and less student involvement in the learning experience.

Learning through exploring. Relevant when student devices are connected to the internet. In this case, the orchestration provides guidance on student exploration, as open navigation can become overwhelming and even detrimental to a child's learning experience.

Learning through inquiry. The available digital content in this intervention did not allow this. However, the orchestrations during the Worksheet and Game-based activities favoured this aspect by setting out challenging scenarios that must be solved in order to progress to the following activities.

Learning through practicing. Technology offers a privileged space which must be adequately orchestrated with other class activities.

Learning from assessment. Feedback is important because it allows the children to become aware of their own achievements and weaknesses. The orchestration proposes formative evaluation strategies in groups, but in this situation it is the software which should provide individual feedback. In our study, the available digital content generally did not always include such feedback.

Learning in and across settings. The digital tool in this intervention did not contribute to this element. However, the orchestration of resources with different content representations (mathematics problems in narrative form, with specific material, and with arithmetic tasks) did achieve this kind of learning and contributed to a deeper level of understanding by the students.

At the same time, our first research question is answered by analysing the teacher performance indices as determinants of the children's achievements, Model 2 Table 3-11.

In this model, the only variable that was shown to be significant is the feedback given by the teachers to the children while they are working. This relationship is shown to be negative. Thus, when the teachers were seen to be giving more feedback to their students, those students showed less progress in their learning. This variable could be biased as a result of the new dynamics integrated into their teaching practices, such as the use of Power Point and the work done with game-based activities. Based on the information obtained by analysing the teacher performance variables, an interesting area for future research would be to further investigate teacher-associated variables, not only in terms of their performance in the classroom but also their beliefs, years of experience, relationship to technology, etc., elements which could reveal instructional patterns in the teaching of mathematics, either in explanations or feedback.

To expand on the answer to our first research question, the contextual elements of each participating school were also evaluated, Model 3, Table 3-11. The evaluation of these variables (especially the infrastructure) revealed the following as determinants of successful student learning: a reliable internet connection and a good student to XO computer ratio. In contextual terms, the group size of each class was also evaluated, establishing significant associations between small groups of students and greater individual learning achievements. This is consistent with the literature (Finn & Achilles, 1999; Hattie, 2005; Brühwiler & Blatchford, 2011; Shin & Raudenbush, 2011). It would also be interesting to investigate whether these contextual elements may be directly associated to each establishment's administrative procedures, as the literature points to the effects (both direct and indirect) of leadership on student learning. It is estimated that 25% of child learning could stem from the impact of leadership within the school (intra-school factors) (Leithwood et al., 2004). In future work it could be relevant to consider other contextual elements, including, for example, the alignment of teacher and administration goals, administration expectations regarding teacher quality, organizational structure and communication channels with the community, professional support and monitoring for teachers provided by the administrative team, etc.

From the results of this study it is possible to conclude that a coherent structure which integrates digital and non-digital resources positively affects learning in children. In this way, the results indicated that providing teachers with an orchestration, in which the management of logistical and teaching elements within the classroom are explicitly outlined, promoted a positive development of activities aimed at achieving curricular learning. It would be interesting to explore the impact of a teaching strategy, such as the one evaluated in the Montevideo schools, in an experimental context, i.e. using a representative sample of schools from a pre-determined population, with the intervention then randomly assigned to some schools. In conjunction, it would also be interesting to consider not just the schools' characteristics, but also the characteristics of each individual student, in order to establish far more substantive conclusions. This would allow the generation of greater precedents which could contribute to the policies of those countries that are currently supplying their schools with netbooks.

4. TEACHER AND STUDENT VIEWS REGARDING THE EDUCATIONAL PROCESS: HOW ALIGNED ARE THEY?

4.1. Abstract

Studies show that schools are effective when they consider their students' needs in the educational process. Through a mixed method research, involving 731 students and 30 teachers at 30 schools from different administrations and locations, we examine the alignment of teacher and student views regarding the educational process. We demonstrate that these views are not aligned when it comes to objectives, student needs, class environment and the role that should be played by the family. In a second stage of the research, we investigate the beliefs held by teachers regarding this gap. We observe how little awareness there is of the problem and how teachers do not feel it is their issue to resolve.

4.2. Introduction

The alignment of the views held by teachers and students is an important area to explore (Könings, Seidel, Brand-Gruwel, & Van Merriënboer, 2014; Moradi & Sabeti, 2014). It enables a diagnosis regarding the presence or absence of a shared vision in terms of the educational process, in which objectives are pursued from the perspective of both teaching and learning. The importance of aligning both perspectives lies in the mutual understanding of different actors in achieving a common goal. In fact, it is difficult for the educational process to be effective when points of view and intentions differ (Penuel, W. R., Riel, M., Joshi, A., Pearlman, L., Min Kim, C., & Frank, K. A., 2010). Research shows that schools are only effective when they consider their students' needs and not just the needs of the economy or society in general (Ron, 1992). In addition to this, studies also show the different components of the teaching-learning process that could be affected by the level of alignment of teacher and student views: elements of the classroom environment (Raviv, Raviv, & Reisel, 1990); disruptive behaviour by students in the classroom (Evers, Tomic, & Brouwers, 2004); local or state-level policies that negatively impact on teacher-student relations (Valli & Buese, 2007); and the social and emotional skills of teachers to establish positive relations with their students (Jennings & Greenberg, 2009).

Good teaching, therefore, is not only defined by school-level factors and the teacher's knowledge, beliefs and attitudes. It is also defined by taking into account the students' needs, as well as class- and student-level factors, which enable this shared view to be constructed (OECD, 2009). When faced with the challenge of creating an environment that is conducive to learning, it is essential to take into account what happens in the classroom: the social relations between the different actors, and, more specifically, the needs and interests of the teachers and students (Slavin, 2006). Relationships between the students and teacher are fundamental in maintaining common goals and, thus, an aligned view of the components that comprise the teaching and learning process. According to proposals put forward by Ron (1992) and the OECD (2009), the effectiveness of schools and good teaching can only be achieved when teachers take their students' needs into account. As such, this relationship should be considered an explicit part of the teacher's role. By forming solid and supportive relationships with their teachers, students can feel more competent and confident at school, make more positive connections with their classmates and perform better academically (Hamre & Pianta, 2006).

From this arises our first research question: What are the classroom objectives for teachers and students and how well aligned are they?

Within the classroom there is a distinction made between regulatory and instructional elements on the one hand, with the students' learning needs on the other. Regulations refer to the rules of social order which define what the teacher and student understand to be acceptable behaviour within the classroom (Bernstein, 1988). These rules range from the "explicit" where power relationships are absolutely clear, such as in a classroom with rows of desks facing the front where the teacher is easily identifiable, to the "implicit", such as an activity where students must work in groups to research a particular topic (Wilbert & Grosche, 2012). In the former case, the teacher acts directly upon the student, while in the latter they act directly upon the context and indirectly upon the student. The regulatory elements stem from the basis of the social relationship formed between students and teachers in the classroom and directly affect the teaching, lesson content and student learning. Students who perceive the school as a legitimate authority, and see their relationship with their teachers as positive are classified as being less detrimental to their own learning environment and that of their classmates (Howes, 2001). As for the instructional element, this refers to the rules directly related to teaching. These range from the "explicit", when the student is fully aware of what to do, how to do it, and what the evaluation criteria of their performance is, to the "implicit", in which the student is not aware (or only very generally aware) of when and how they will be evaluated and the criteria to be met (Wilbert & Grosche, 2012).

From this arises our second research question: Does the teacher understand the needs of the students in the classroom?

Education represents the promise of presenting children and young people the implicit cultural code set out by the curriculum. In this process the school transmits formal knowledge in three ways: the curriculum, pedagogy and assessment. The curriculum determines what is to be considered as valid knowledge, the pedagogy determines what is to be considered as valid knowledge transfer, and assessment determines the valid attainment (manifestation) of this knowledge by the learner (Bernstein, 1977). In this transmission a diversity of cultural codes collide: a curriculum, a pedagogy and a dominant form of assessment, focused on formal knowledge and language (which give rise to opportunities within a given society), and a student body that largely complies to a cultural code, which synthesizes both means and ends at a local and family level (Díaz, 1990). Therefore, learning will be easier the closer the family cultural code becomes to the cultural code prescribed to by the school. As indicated by Bourdieu & Passeron (2009), educational success is known to be highly dependent upon the ability to control the language of ideas within teaching. On the other hand, learning becomes more difficult the farther one distances the family cultural code from the cultural code prescribed to by the school.

The dominant language of the curriculum and pedagogy easily resonate with students from a socio-cultural standing concordant with that language. For such students, their learning takes place within a familiar setting and they possess the necessary cultural capital to adopt and understand the codes implicit in a transmission process (Bernstein, 1988). Conversely, for students more distanced from the dominant cultural code, the curriculum does not only represent the contents to be learned; it also represents a language beyond their social and family background, the acquisition of which requires a previous knowledge base that they often lack. Under these circumstances the student requires a structure that will allow them to follow unfamiliar steps, an "explicit" rule-based pedagogy relating to what will be learned, what needs to be done, how it needs to be done and how they are doing; in which relationships between transmitter and receiver must be clear (Bernstein, 1988; Bernstein, 1997). This clear structural basis is the support that enables the student to move from their normal language to the acquisition of more abstract and elaborate languages and codes. In general, learning has less to do with intelligence (Eyzaguirre, 2004) and more to do with social background. Many children need more structure in their assigned work as well as greater assessment and guidance in the social networks of learning. This allows them to progress from clearly defined and concrete elements to the more abstract, thereby enabling them to display all their personal abilities. From this arises our third research question: Are the views of the teacher and the students aligned in terms of how the classroom environment should be?

The classroom should be a place where students are able to work on instructional tasks, familiarize themselves with learning with minimal disruption and distraction and receive a fair and adequate opportunity to learn (Shulman & Shulman, 2004). As such, teachers have multiple and frequently contradictory needs and intentions (Kennedy, 2005), including:

- Maintaining the pace of the class and avoiding distractions and interruptions (Kennedy, 2005). Teachers' actions should be directed towards appropriate classroom management in order to prevent and deal with noise and distractions as a way of building and maintaining learning opportunities (OECD, 2009).

- Increasing student willingness to participate in class in a relaxed social environment: In general, teachers know that it is difficult to keep all students fully concentrated on all of the learning activities that take place during a class. It is therefore in their interest to boost student motivation as much as possible with regards to the task at hand or, at least, their cooperation during activities, collaboration with classmates and good behaviour so as not to distract other students. Teachers generally feel that by involving students and treating them in a positive way this becomes easier to achieve (Kennedy, 2005).

- Covering course content according to the plan: The constant dilemma is between making progress with the course content according to the established program and sacrificing coverage in order to study a particular topic in greater depth. Given the national education policies and those of the school, the teacher's responsibility for covering the relevant curriculum becomes a heavy burden (Shulman & Shulman, 2004).

- Ensuring that all students have equal opportunities to participate: Given that they must encourage learning among all students, an important concern for the teacher is to ensure that all students have an equal opportunity to participate. Shulman & Shulman (2004) conceives of the classroom as an economic system in which a scarce resource – the teacher's attention and the students' opportunities to perform – must be distributed on an equal basis. The potential for the personal development of each individual must be maximized. However, it must not be done so at the expense of the rest of the students in the class. Time is a scarce resource in the classroom and enabling all students, with their wide range of interests, knowledge and characters, to participate in a limited time is enormously difficult.

- Keeping order and calm in the classroom: It is very difficult for teachers to deliver good classes if they fail to find a way to make classroom life pleasant or, at the very least, calm (Riehl & Sipple, 1996).

From this arises our fourth research question: Do teachers and students share the same expectations of one another?

While many of the learning experiences are formed in the classroom, students have an external environment which can also impact upon their educational process. Epstein (2009) refers to the family as a key element in the educational process, providing different types of participation between both ties (family and school). Family participation has been studied from different perspectives, revealing a generally positive perception of teachers with regard to the family, distinguishing this factor as an essential part of child learning, healthy development and success at school (Lawson, 2003). Additionally, research has been conducted on student perceptions of different levels of participation by their families. Such investigations have revealed that children tend to prefer an active parental participation and that this attitude is related to the degree to which their parents participate (Vyverman & Vettenburg, 2009).

So our fifth and final research question is: Do students and teachers share a similar view of the role that should be played by the family in the educational process?

4.3. Methodology

A mixed methods study was conducted, combining quantitative and qualitative methods in order to better understand the problem posed. This level of understanding could not be achieved by using any one single method on its own (Creswell & Plano Clark, 2007). This approach is particularly valuable when trying to tackle problems that exist within complex educational contexts (Teddlie & Tashakkori, 2009), or when there is an interest in studying interactions between multiple actors or perspectives (Mertens, 2010).

The research was carried out following a sequential design (Mertens, 2010) and planned in two stages: the first quantitative and the second qualitative.

- The objective of the first, quantitative stage was to identify the level of agreement between teacher and student views regarding the different components of the teaching and learning process associated with the five research questions detailed in the introduction.

- The objective of the second, qualitative stage was to understand the teachers' opinions related to the gap detected in the first stage between their views and those of their students.

This is an exploratory study (Corbetta, 2003), given that within the context in which it was undertaken there is little information available regarding students´ beliefs, perceptions and expectations about the teaching and learning process. The same lack of information exists in terms of how aligned the students' views are with those of their teachers.

The following is an outline of the components of the experimental design which framed both stages of the study:

4.3.1. Stage I: quantitative

i. Sampling

The study was undertaken in Chile's Metropolitan Region, that has a population of 6,683,853 inhabitants (*Instituto Nacional de Estadísticas*, 2012). Of these, 427,579 (*Instituto Nacional de Estadísticas,* 2012) are K-12 students. The sample consisted of 11th grade students, mostly aged between 15 and 16 years old. Research into students' personal goals and views within an educational context has focused on gathering information from students of this age, mainly because of the self-appraisal they can have of their own views and opinions (Nicholls, Patashnick, & Nolen, 1985).

Based on the research objectives, the proportion of 11th grade students from across different types of educational administration was calculated. These different types of schools followed two sample criteria in order to obtain a number representative of the Metropolitan Region population. The sample criteria were as follows:

- Administration: determined by the institution's administration as well as State funding for its running. In Chile there are three types: i) Municipal, with State funding (through a subsidy for each student) and municipal administration; ii) Private-subsidized, with private and State funding (also through a subsidy for each student), and private administration; and iii) Private fee-paying schools with private financing and administration (Drago & Paredes, 2011).

- Location: determined by the institution's distance from the closest urban boundary, as established by the official town or city plans, and set by each municipality. A school is considered rural if it is located more than 5 kilometers from the aforementioned boundary. If it lies closer than 5 kilometers to the boundary it is defined as urban (*MINEDUC* [Ministry of Education], Chilean legislation, 2006).

Table 4—1 outlines the theoretical composition of a representative sample of the population in question, plus the true composition of the study's sample. The theoretical sample is based on the Ministry of Education's 2010 database of educational institutions which offered secondary education. As a reference, this sample took into consideration the number of students at each type of school within the Metropolitan Region, with the aim of producing representative data that would not be affected by specific institutions with very low enrolment. By considering a total population of 86,231 students, a 95% confidence level, and a 3% margin of error, a sample of 777 was taken, which was increased by 5% in order to safeguard against situations in which no answer was provided.

Table 4—1 Sample design

	Institution Sample						Student Sample					
	Theoretical sample			Real sample			Theoretical sample			Real sample		
	Urban	Rural	Theoretical total	Urban	Rural	True total	Urban	Rural	Theoretical total	Urban	Rural	True total
Municipal	5	1	6	5	1	6	200	12	212	135	32	167
Private-subsidized	16	1	17	19	1	20	455	12	467	457	26	483
Private fee-paying	4	0	4	4	0	4	98	0	98	81	0	81
Total			27			30			777			731

When data collection began, schools selected in the sample that had grades with low enrolment were identified and new schools were chosen in order to match the theoretical student sample more closely. This selection was done at random using the same selection method as the first sample. Because of this, information was collected in a greater number of schools than was set out in the initial theoretical sample. To avoid school type-administration from biasing the results, an expansion coefficient was calculated to correct the differences between the theoretical and true school samples. By calculating the expansion coefficient, according to the number of schools, a score of 0.84 was obtained for private-subsidized schools, and 1 for the other two types of school, given that the theoretical sample for these was same as the real sample. With this factor, the bias was corrected in the various analyses carried out and followed the theoretical proportion for each school sector.

ii. Data collection technique

The instrument described in this section was applied during the first school semester of 2012 in the classroom of the relevant grade. The selection of the class within each school depended on the criteria of each institution's principal or academic coordinator. They mainly considered logistical aspects and availability when looking at how best to facilitate the application of the survey on a given date. This was then coordinated with the respective teachers by telephone so that both, the teacher and student surveys, were applied simultaneously during class. More often than not, this was done during the class's Orientation or Student Council period. The same researcher, previously trained in how to apply the instrument, administered the survey in all of the sample schools. The research protocol sought to explain the study's objective to both teacher and students, indicate how to answer the survey and make sure that care was taken not to cause any bias.

The study was structured around two questionnaires (Students, Appendix 5 and Teacher, Appendix 6), which came from the five research questions outlined in the introduction. The questions and answers were standardized (Corbetta, 2003). Versions of the teacher's and students' questions matched, as too did the answers: i.e. although not literally identical, the questions and the answers referred to the same elements but from the perspective of the teacher and the students. The questionnaires were designed this way in order to enable their comparison using Krippendorff's alpha. The questionnaires were anonymous but teachers and students were requested to provide their gender, with the teacher also asked for information about their age. This allowed the data to be analysed for any possible correlations.

The questionnaire contained 14 questions; ten with three multiple choice answers plus a fourth open response; one question with four multiple choice answers and one open; and three questions with dichotomous responses. The reason for including the open answered question in the survey's response options was to avoid anyone feeling frustrated at none of the other possible answers reflecting their opinion. By analysing the open answers they were shown to represent a large range of responses. They were not considered among the original alternatives because of their wide diversity and the difficulty of classifying them.

The following gives a neutral outline of the questions and respective possible answers. The true questionnaires, however, were explicitly directed at the teacher (Appendix 6) and the students (Appendix 5), and structured according to the five research questions that guide this research project.

- Research question 1: What are the classroom objectives for teachers and students and how well aligned are they?

Research into the motivation of academic achievement has focused on student goals, suggesting the importance of a deeper understanding of motivation and performance in schools (Guay, Ratelle, Roy, & Litalien, 2010). With this in mind, it would be possible to revise the objectives from a social and value-related perspective (Widdowson, Dixon, Peterson, Rubie-Davies, & Irving, 2014), as well as the objectives of curricular performance (Urdan & Maehr, 1995). Following this framework, the first four questions on the questionnaire seek to answer our first research question:

Question 1: *"What is your main objective within the educational process?"*, with the answers categorized as personal academic learning (Murayama & Elliot, 2009), collective academic learning (Murayama & Elliot, 2009) and collective comprehensive development (Greenberg et al., 2003). Question 2: *"What is the necessary condition for you to fulfil your objective within the educational process?"*, with the answers categorized as classroom order (Komulainen, Litmanen, & Hirsto, 2010), learning pace (Semrud-Clikeman, 2009), educational resources (Quinnell, May, & Lloyd, 2004). Question 3: *"Is this condition met?"*, provides a dichotomous response to explore the issue further with the following question, question 4: *"What motivates you to achieve your objective at school?"*, with answers categorized as duty (Green et al., 2012), social interest (Green et al., 2012), and motivation (Williams & Williams, 2011).

- Research question 2: Does the teacher understand the needs of the students in the classroom?

Studies show that a school is only effective when it focuses on satisfying the students' needs, and not those of the economy or society in general (Ron, 1992), thereby making direct reference to the curriculum. Within this framework the fifth question on the questionnaire arises: *"Is the teacher aware of the students' needs in the classroom?"*, with *yes* or *no* as the possible responses (Bruggink, Meijer, Goei, & Koot, 2014). This leads to the sixth question, which asks *"What is the students' main need in your classroom?"*, with answers categorized as motivation to learn (Williams & Williams, 2011), the learning pace, (Semrud-Clikeman, 2009), and different learning styles (Wilson, 2012).

Considering that the learning environment can influence the students' attitude towards the established objectives both socially and academically, the third question in this group is dichotomous and asks whether the necessary conditions to study are present in the classroom (Urdan & Maehr, 1995) (*"Do you believe that the necessary conditions are present in your classroom for students to study properly?"*).

- Research question 3: Are the views of the teacher and the students aligned in terms of how the classroom environment should be?

The classroom's social environment is the one in which learning experiences and teaching methods unfold. Considering that the greater the student heterogeneity within the classroom, the lower the level of student commitment to study and cooperate

(Evertson, Sanford, & Emmer, 1981), the first question in this line of thought (the eighth question on the questionnaire) is *“Do you believe that there are differences between the students in your class?”*, which is answered with a dichotomous response. Anyone answering in the affirmative proceeds to the following question, *“What is the main factor accounting for heterogeneity in your classroom?”*. Four possible categories were put forward to answer this question: *cultural* heterogeneity, where cultural minorities in the classroom find learning more difficult (Ogbu, 1992); *family* diversity, as there is empirical evidence that shows the relationship between child’s performance at school and their family’s relationships and beliefs (Okagaki & Frensch, 1998); *socio-economic* factors, as this condition has been widely studied in social sciences, demonstrating that this status is directly linked to conditions of health, cognitive, emotional and other forms of development, from childhood to adulthood (Bradley & Corwyn, 2002); and finally the *learning pace*, as the students’ learning heterogeneity limits teachers from implementing a successful learning process given that they need to adapt to the individual needs of each student (Evertson, Sanford, & Emmer, 1981).

- Research question 4: Do teachers and students share the same expectations of one another?

For many young people between the ages of 10 and 15 early adolescence offers the opportunity to choose a path towards a productive and satisfactory life. Conversely, growth can be stagnated due to a perceived lack of opportunities (Braddock II & McPartland, 1993). For this reason questions 11 and 12 asked teachers and students, *“What does society expect of a teacher?”* and *“What does society expect of students?”*.

On the other hand, considering that teachers can be mediate not just in academic issues but also in issues relating to a sense of belonging and responsibility (March & Gaffney, 2010), both teachers and students were asked about one another; questions 13 and 14 read, *"What does the teacher expect from the students?" and "What do the students expect from the teacher?"*. For both sets of questions, following the evidence posed of different emphases on the school experience (Zins, Weissberg, Wang, & Walberg, 2004), from the teachers' perspective, possible answers were categorized according to the *social, academic/professional and value-related link*. In terms of the students' perspective, possible answers were categorized by the consolidation of *social links*, *academic/professional success*, and *value-related development* (Wentzel, 1998).

- Research question 5: Do students and teachers share a similar view of the role that should be played by the family in the educational process?

Schools must take into account the parents' beliefs as to their children's goals and the type of academic assistance they can offer (Okagaki & Frensch, 1998), therefore the only question regarding this referred to the level of involvement that the family should have in their child's education (question 10): *"What is the expected level of family participation in the educational process?"*, with the possible answers of *active participation*, *informative* and *zero*, in line with different participation levels outlined in the *Ley General de Educación de Chile* (Chile's General Education Law) (Ministry of Education, Chilean legislation, 2011).

iii. Statistical techniques used

- **Descriptive statistics:** used for two objectives:

A. Identifying the percentage of the sample student population that agree (and disagree) with their teachers. To achieve this, the percentage of students whose answers matched their teacher's was calculated for each of the questions, with the average of these percentages across all 30 institutions then being calculated. The respective figure was calculated for students answering the respective questions. When a teacher failed to answer a question, none of the students from their class were considered, because there was no response with which to compare.

B. Identifying trends for student and teacher views of the educational process within the target population. This involved calculating percentages for each question based on the number of students that selected each answer. This can be found in the results section, which outlines the percentage of students and teachers choosing each of the alternatives, and consider that 100% related to the total of the number of individuals that responded to each question. This difference of N is due to omissions or double answers, which for reasons of methodological accuracy have been counted as invalid and were not analysed. This enabled the views held by secondary school students regarding their own educational process to be identified. It also led the views held by these students' teachers in regard to the same questions being recorded. Furthermore, the percentage of students in agreement with their teacher was identified. This was calculated by noting the percentage of students from each school that coincided with their teacher and taking an average of this figure from across all 30 schools. Appendix 5 and 6 show that 9 of the 14 questions on the test were open response questions. The responses to these were analysed by identifying the main ideas of the arguments and the frequency with which they appeared. This was useful for identifying new perspectives on each of the topics, although many of the open responses also referenced the closed alternatives.

- **Agreement index (Krippendorff's alpha):** Krippendorff's alpha (Krippendorff, 1970) is a reliability coefficient used to measure agreement between observers, coders, raters or instruments. It embraces other reliability coefficients such as Scott's pi, and it may be used with nominal, ordinal or metric measures and with several coders (Hayes & Krippendorff, 2007). Although it has been mainly used to indicate inter-rater reliability in content analysis, due to its flexibility and robustness it has been appied in other contexts to measure the degree of agreement between two or more observers (Taylor & Watkinson, 2007). A score of 1 suggests perfect agreement and indicates a high degree of reliability. A score of 0 indicates an absence of such agreement and reliability (Krippendorff, 2011).

- **Analysis of explanatory variables:** A multiple regression analysis was undertaken to explore possible determinants of the agreement index between students and their teachers. As such, contextual variables were considered at a school level, including:

– School administration type: municipal, private-subsidized, private fee-paying

– School location: rural, urban

– Teacher's gender: male, female

– Teacher's age: 30 or <, 30-39, 40-49, 50 or >

- School National Standardized Reading Test (continuous variable)
- School National Standardized Mathematics Test (continuous variable)

For all of the above techniques, questions which were left unanswered on the questionnaire were assumed to be involuntary actions as in no case were questionnaires found with less than 80% of questions answered (12 questions out of 15). These non-answers are reflected in the number of observations analysed in each question, as shown in each table in the Results section.

4.3.2. Stage II: qualitative

i. Sampling

The same sample design was used as in the quantitative stage, as the aim was to explore perceptions about the results gathered in the same schools and classrooms. In 13% of the educational institutions that took part in the first part of the study (N=4), it was not possible to stage the interview (generally, the reason given was that they required more time to check the results and prepare their responses). In addition, not all results could be returned to those teachers who had answered the questionnaire during the quantitative stage. This was due to the educational institution's own leadership team deeming it more appropriate for this stage of the study to be carried out with a member of the school in a coordinating role. Given that the approval of the somebody from the leadership team was required in order to coordinate the time and date of the interview with a member of the school community, the research team was not able to intervene in the internal decision making process of each institution. The final sample comprised 26 interviewees, 13 of whom were classroom teachers (ten of whom had completed the initial questionnaire [40% of the qualitative sample]), 7 counsellors and 6 academic heads of the institutions. Table 4—2 shows how the sample changed between the quantitative and qualitative stages.

Table 4—2 Quantitative and qualitative study sample configuration

Characteristic	Initial quantitative stage sample	Final qualitative stage sample
Municipal	6	4
Private-subsidized	20	19
Private fee-paying	4	3
Urban	28	24
Rural	2	2
Total schools	30	26

ii. Data collection technique

The qualitative methodology allows for the perception of teachers, counsellors, or academic heads regarding the initial assessment in their institutions to be explored in greater depth. To implement this stage of the study a protocol consisting of two components was devised:

a. Firstly, a breakdown of the results from each specific institution was provided. This breakdown documented the percentages of teacher and student answers for each of the questions on the initial questionnaire. It also compared these results with the average percentage scores from the participating institutions, plus some general conclusions. This document was explained in detail by the interviewer. The results were then presented in a brief document which included tables in order to make them easier to understand.

b. The second component was a semi-structured interview with an outline of standardized questions, but without standardized answers (Corbetta, 2003). Teachers answered two questions, in which space was given to record opinions throughout the course of the interview: the first one referred to the opinion of the interviewee regarding the results of the initial assessment, and the second as to whether or not they believe they could narrow the gap between student and teacher perceptions, and if so, how this could be achieved.

To implement the qualitative study, three research assistants who received previous training made field visits to each of the institutions. The institutions were randomly assigned to each of the research assistants. Before visiting each institution, the research assistants telephoned to coordinate the visit. All interviews were taped and later transcribed. Subsequently, an analysis of the entire sample was carried out, including a comparative analysis by school type (Administration, Location) as well as according to whether or not the interviewee had completed the questionnaire during the quantitative stage of the study.

iii. Analysis technique used

Content analysis was used to analyse the interviews. One of the key features of this method is its use of categories, through which it seeks to reduce and simplify data in order to make it more intelligible regarding the topics that are covered (Flick, 2002). This is done by producing codes and, subsequently, defining a system of categories; both processes are based on the data expressed in the language of those who participated in the study.

Finally, in order to better understand the scale of the phenomenon covered by this study, the frequency with which these categories appeared was calculated.

4.4. Results

4.4.1. Stage I: quantitative

i. By research question

Research question 1: What are the classroom objectives for teachers and students and how well aligned are they?

When the students were asked which of the alternatives best represented their main objective within the educational process, the majority chose “To follow the curriculum’s objectives”, while the teachers’ view of the same objective was, primarily, “To encourage a fully rounded development among peers”. 23.1% of teachers chose the open response, standing out the objective “To develop life skills” (Table 4—3).

Table 4—3 Views of the main objective within the educational process

Total no. of students: 816 *Total no. of teachers: 30*	Main objective within the educational process	
Percentage of students in agreement with their teacher: 20.68% *Percentage of teachers in agreement with the majority of their students: 13.33%*	Student	Teacher
To learn at each student’s individual pace	*35.90%*	*22.30%*
To encourage a fully rounded development among peers	*15.40%*	*49.00%*
To follow the curriculum’s objectives	*42.30%*	*5.60%*
Other	*6.50%*	*23.10%*
Total	100%	100%

When looking at the students’ view regarding the condition most required in order to meet the aforementioned objective, two conditions revealed a high level of agreement. These included the need to have “Group discipline, enabling curriculum progress” and to have “A variety of resources and learning experiences”. However, for the teachers the most common answer was the second most common alternative given by students, showing that the main condition required by teachers is “A variety of resources and learning experiences". 11.1% of teachers chose the open response, arguing that because all of the closed responses reflected their opinion they were unable to choose just one (Table 4—4).

Table 4—4 Views of the condition needed to meet the objective within the educational process

Total no. of students: 816 *Total no. of teachers: 29* *Percentage of students in agreement with their teacher: 27.02%* *Percentage of teachers in agreement with the majority of their students: 13.79%*	Condition needed to fulfil the objective within the educational process Student	 Teacher
Group discipline, enabling curriculum progress	*36.54%*	*10.48%*
Different time allowances to cover new material and focus on weaknesses	*22.00%*	*34.10%*
A variety of resources and learning experiences	*35.30%*	*44.30%*
Other	*6.18%*	*11.05%*
Total	100%	100%

When asked whether the condition selected in the previous question was present, 49.6% of students responded "Yes" and 50.4% responded "No". For the teachers, 41.9% answered "Yes" while 58.9% answered "No".

When the students were asked which alternative best reflected their motivation for achieving their personal objective at school, the results were largely restricted to open response (30.1%). Among these responses, the three following sources of motivation were highlighted: "Thinking about their professional future", "Desire to improve their current situation" and "Living up to the family's expectations". However, the teachers' gave a different response, with 74.9% of the sample suggesting that their motivation for achieving their objective at school was based on "The school environment". (Table 4—5)

Table 4—5 Views regarding the motivation to achieve the objective at school

Total no. of students: 786 *Total no. of teachers: 29* *Percentage of students in agreement with their teacher: 25.37%* *Percentage of teachers in agreement with the majority of their students: 17.24%*	Motivation to achieve the objective at school Student	 Teacher
It is obligatory	*27.60%*	*10.24%*
The school environment	*17.90%*	*74.90%*
I enjoy what I do	*24.30%*	*14.90%*
Other	*30.07%*	*0.00%*
Total	100%	100%

Research question 2: Does the teacher understand the needs of the students in the classroom?

When looking to answer this research question, both students and teachers were asked whether the teacher understands the needs of their students. 38.8% of students answered “Yes”, they believe the teacher does understand their needs, while 60.7% of the student sample responded “No”, their needs are not being understood by the teacher. From the teachers’ own perspective, 89.1% said “Yes” to understanding their students’ needs, with only 10.9% agreeing with the majority of students in answering that “No”, they do not fully understand their needs.

Following this, the study looked specifically at the students’ main need, both from the students’ and the teacher’s perspective. The majority of students stated that their main need was the “Recognition of different learning styles”, followed closely by “Motivation to learn”. Most of the teachers chose “Motivation to learn” as being their students’ main need, therefore agreeing with the second most popular student response. 12.9% of teachers chose the open response, arguing that because all of the closed responses reflected their opinion they were unable to choose just one (Table 4—6).

Table 4—6 Views of students’ needs

Total no. of students: 801 *Total no. of teachers: 27* *Percentage of students in agreement with their teacher: 30.52%* *Percentage of teachers in agreement with the majority of their students:25.92%*	Students’ needs	
	Student	Teacher
Motivation to learn	*32.26%*	*52.59%*
Recognition of different learning paces	*19.41%*	*11.15%*
Recognition of different learning styles	*41.76%*	*23.39%*
Other	*6.56%*	*12.87%*
Total	100%	100%

The next question explored the students' and teachers' view as to whether or not the necessary conditions for adequate study were present in the classroom. In this case, 56.9% of students responded that these conditions were present in the classroom, whereas 42.5% answered that there were not. In terms of the teachers' responses, the weighting of the responses was the opposite. 44.4% of teachers believed that the necessary conditions were present while 55.6% of the sample did not believe they were.

Research question 3: Are the views of the teacher and the students aligned in terms of how the classroom environment should be?

When investigating the issue of the social environment perceived by both students and teachers, the participants were asked whether there were any differences between the students in the classroom. In this case the teacher and student views were aligned, with 76.8% of students stating that "Yes", there were differences, as opposed to 23.2% who believed "No", that the class was, in fact, homogeneous. Of the teachers, 91.2% responded "Yes", they believed the group to be heterogeneous while 8.8% answered "No", there were no differences between the students.

Having asked about homogeneity or heterogeneity in the classroom, participants were then asked about the main element they see this difference reflected in. The majority of students, 58.5%, suggested that this difference stemmed from "Different learning paces" within their group, something which the majority of teachers agreed with as they also highlighted this as being the main differentiator. It should also be noted that the second largest group of teachers (24.1%) indicated that the main difference between their students came from the student's "Family background", an element which was only selected by 8.12% of students (Table 4—7). Within the open responses given by the students (16.6%), three new elements were identified as being the main reason as to why their class was a heterogeneous group. These were: "Personalities (shy, extrovert, charismatic etc.)", "Disciplined behaviour in the classroom" and "Motivation to learn". None of these elements were mentioned by the teachers, who instead used the open response (23.8%) to suggest that their opinion was best reflected by all of the alternatives as a whole.

Table 4—7 Views of the main element accounting for heterogeneity in the classroom

Total no. of students: 621 *Total no. of teachers: 28* *Percentage of students in agreement with their teacher: 23.80%* *Percentage of teachers in agreement with the majority of their students: 32.14%*	Main element accounting for heterogeneity in the classroom	
	Student	Teacher
Different cultures	*13.54%*	*3.50%*
Family background	*8.12%*	*24.05%*
Different socio-economic backgrounds	*3.25%*	*8.75%*
Different learning paces	*58.48%*	*39.94%*
Other	*16.61%*	*23.76%*
Total	100%	100%

Research question 4: Do teachers and students share the same expectations of one another?

When asking the students about what society expects from their teachers (Table 4—8), the highest number of students responded "To academically train professionals". Upon putting the question to teachers, the most popular response regarding expectations was "To satisfy the students' educational and welfare needs". Among the 33.9% of teachers who chose the open response, the new expectation of "Giving the students a comprehensive education" was revealed.

Table 4—8 Views of society's expectations about the role of the teacher

Total no. of students: 805 *Total no. of teachers: 30* *Percentage of students in agreement with their teacher: 24.05 %* *Percentage of teachers in agreement with the majority of their students: 20%*	Perception of society's expectations about the role of the teacher	
	Student	Teacher
To satisfy the students' educational and welfare needs	*31.67%*	*37.35%*
To academically train professionals	*46.94%*	*14.64%*
To educate and guide the students in their personal behaviour	*14.03%*	*14.09%*
Other	*7.32%*	*33.93%*
Total	100%	100%

Students were also asked directly about what they expected from their teachers (Table 4—9). The answers were largely either "To satisfy the students' educational and welfare needs" or "To academically shape future careers". The teachers' responses were primarily focused on "To academically shape future careers", in line with a significant percentage of students. 18.2% of teachers chose the open response, with the majority of them suggesting that their opinion was best reflected by all of the alternatives as a whole, with a smaller number suggesting that they believed that their students expected their teachers to "Establish relationships with their students based on trust".

Table 4—9 Views of student expectations as to the role of the teacher

Total no. of students: 797 *Total no. of teachers: 29* *Percentage of students in agreement with their teacher: 30.02 %* *Percentage of teachers in agreement with the majority of their students: 34.48%*	Student expectations of the teacher	
	Student	Teacher
To satisfy the students' educational and welfare needs	*40.51%*	*19.09%*
To academically shape future careers	*40.08%*	*46.72%*
To educate and guide the students in their personal behaviour	*11.95%*	*15.95%*
Other	*7.45%*	*18.23%*
Total	100%	100%

Both students and teachers were asked about their perceptions regarding society's expectations of students (Table 4—10 and Table 4—11). The difference in perceptions in this particular question was less, as the majority of the students were in agreement with the majority of the teachers, and vice versa. 78.4% of the students responded that society expects them "To learn so that following school they can continue to study and become professionals". This is in agreement with 64.6% of the teachers who shared this way of thinking in terms of society's expectations of students. However, 23.6% of teachers chose the open response, suggesting that they believed that society expected them to "Teach the students to be comprehensive individuals". In turn, when asking the students what they believe their teachers expect of them, 72% stated that the teachers' expectation was in line with that of society, i.e., that teachers expect students "To learn so that following school they can continue to study and become professionals". The open response was the second most popular for the students, with two noticeable trends: they believe that their teachers expect them to "Have a comprehensive education" and that they "Do not know what their teacher's expectations of them are". However, upon asking the teacher themselves what they expect from their students, the most common response was the open response (55.7%), with two new expectations revealed: "To be people who have a positive influence on their surroundings" and "To meet goals in the future which make them happy".

Table 4—10 Views of society's expectations of the role played by students

Total no. of students: 806 *Total no. of teachers: 29* *Percentage of students in agreement with their teacher: 54.17 %* *Percentage of teachers in agreement with the majority of their students: 58.62%*	Perception of society's expectations of students Student	 Teacher
To build strong, lasting social connections	*5.70%*	*0.00%*
To learn so that following school they can continue to study and become professionals	*78.44%*	*64.58%*
To learn how to behave appropriately	*8.62%*	*11.81%*
Other	*7.23%*	*23.61%*
Total	100%	100%

Table 4—11 Views of teachers' expectations of the role of students

Total no. of students: 805 *Total no. of teachers: 29* *Percentage of students in agreement with their teacher: 33.13%* *Percentage of teachers in agreement with the majority of their students: 34.48%*	Teachers' expectations of students Student	 Teacher
To build strong, lasting social connections	*5.01%*	*0.00%*
To learn so that following school they continue studying and become professionals	*72.04%*	*32.34%*
To learn how to behave appropriately	*11.40%*	*11.97%*
Other	*11.54%*	*55.70%*
Total	100%	100%

Research question 5: Do students and teachers share a similar view of the role that should be played by the family in the educational process?

Having explored perceived differences within the classroom, both teachers and students were asked about an element which can impact upon the educational process from outside the classroom. In this sense, the question was concerning the appropriate level of family participation in the educational process. The highest concentration of students, 48.9%, stated their preference for an "Informative level of participation". Furthermore, a smaller percentage (18.8%) responded that "Zero family participation" is necessary as part of this process. A large majority of teachers, on the other hand, (74.4%) answered that "Active family participation" is necessary in the teaching and learning process, while conversely a small percentage (3.8%) claimed "Zero family participation" to be necessary (Table 4—12).

Table 4—12 Views of the role of the family in the educational process

Total no. of students: 779 *Total no. of teachers: 29* *Percentage of students in agreement with their teacher: 32.94%* *Percentage of teachers in agreement with the majority of their students: 17.24%*	Role of the family in the educational process Student	 Teacher
Active family participation	*31.56%*	*76.40%*
Informative level of participation	*48.92%*	*19.83%*
Zero family participation	*18.79%*	*3.77%*
Total	100%	100%

ii. Data agreement: Krippendorff's alpha

The average index of the 30 teachers and 731 students is 0.11 with a Std. Deviation of 0.20. If we analyse the agreement index presented by each institution between the students that were surveyed and the teacher (Table 4-13), we obtain a maximum score of 0.35 with a Std. Deviation of 0.21 and a minimum score of -0.09 with a Std. Deviation of 0.1, with a median of 0.11 and a Std. Deviation of 0.15. In general terms, a score of above

0.80 indicates a good level of agreement, although in some research scores ranging between 0.60 and 0.80 also indicate agreement, especially in exploratory studies. A negative score indicates disagreement is worse than would normally be expected (Krippendorff, 1970).

Table 4—13 Agreement index between students and their teacher

Agreement index (Mean)	N students	Std. Deviation	School Administration	Location	SIMCE Reading	SIMCE Mathematics	Teacher's gender	Teacher's age
0.12	27	0.15	1	U	224	212	Male	47
-0.09	22	0.10	2	U	222	216	Male	50
0.26	24	0.19	2	U	261	248	Female	55
0.16	19	0.19	1	U	223	225	Female	45
0.11	18	0.13	3	U	273	279	Female	37
0.16	24	0.20	2	U	265	261	Female	28
0.13	29	0.15	2	U	265	267	Male	28
0.34	18	0.19	3	U	263	246	Male	40
0.07	19	0.14	3	U	265	293	Female	55
-0.05	18	0.21	2	U	275	262	Male	50 or >
0.08	24	0.15	2	U	288	299	Male	32
0.35	14	0.21	2	U	261	230	Male	31
0.08	29	0.18	2	U	241	224	Female	45
0.17	27	0.16	2	U	224	190	Female	29
0.00	15	0.25	2	U	249	238	Male	46
0.02	26	0.16	3	U	309	314	Female	58
0.15	29	0.18	2	U	240	220	Male	28
0.16	14	0.16	2	U	278	287	Female	26
0.05	27	0.22	2	U	222	204	Male	63
0.17	31	0.21	2	U	313	331	Male	36
-0.02	24	0.16	2	U	263	236	Female	30
0.18	36	0.20	1	U	275	266	Male	50 or >
0.14	23	0.16	2	U	256	221	Male	-
0.11	34	0.18	2	U	322	331	Male	-
0.06	32	0.18	1	R	226	226	Male	29
0.05	30	0.29	1	U	225	206	Male	50 or >
0.22	23	0.21	1	U	226	209	Male	46
-0.03	26	0.19	2	R	252	220	Female	31
0.16	25	0.25	2	U	265	264	Male	25
0.11	24	0.16	2	U	257	232	Male	35
0.11	731	0.21						

Administration: 1= municipal; 2= private-subsidize; 3= private fee-paying. Location: U=urban; R=rural

iii. Analysis of explanatory variables

To explore possible determinants of the student-teacher agreement index, a linear regression model was implemented using all of the contextual variables from Table 4-13, including explanatory model variables (independent) and the agreement index, Krippendorff's alpha, as a dependent variable (Table 4-14).

Table 4—14 Variables included in the regression model

Variables	Continuous variable	Categorical variable
Krippendorff's alpha	X	
School National Standardized Reading Test	X	
School National Standardized Mathematics Test	X	
School administration		X
Municipal		
Private-subsidized		
Private fee-paying		
School location		X
Urban		
Rural		
Teacher's gender		X
Male		
Feminine		
Teacher's age (by age range)		X
Less than 30 years old		
Between 30 and 39 years old		
Between 40 and 49 years old		
50 years old or more		

Source: authors' own research

In order to do this, records for each participating student were used with information regarding the characteristics of their educational establishment. Such information was the same for all students from the same class. With this in mind, the following chart outlines the variables that were included in the analysis.

The model includes controls for the score for each of the schools in the sample on the National Standardized Test (MINEDUC, www.mineduc.cl), taken from the 2010 results. This variable seeks to reveal whether the agreement index between students and their teacher is related to the management of the curriculum at each institution, which constitutes one of the Chilean education system's quality indices.

Similarly, performance depends on the school's administration because of the structure of the Chilean education system, from which large gaps have been identified in terms of infrastructure, curriculum management, quality index (National Standardized Test), supply of trained teachers, etc. (Elacqua, Contreras, Salazar, & Santos, 2011). The effect of this variable on the agreement index between students and teacher was investigated, analysing whether or not it is a phenomenon which differs between these three types of institution. The socio-economic level of schools was not taken into account as this variable, given that school administration can be highly correlated and constitutes a high degree of collinearity within the analysis.

In addition, the effect of the school's location was studied, looking at whether the school was in an urban or rural location. This parameter is important as it places institutions within the context of areas where there is more or less access to information (MINEDUC, 2006). This variable may have an impact on the view and perspective of the educational process experienced by each individual respondent.

Finally, two variables associated with the teacher were incorporated: gender and age. In certain contexts a teacher's age as much as their gender can produce different impacts on the students' learning environment (Salvano-Pardieu, Fontaine, Bouazzaoui, & Florer, 2009).

By analysing Table 4-15 the impact of the school's administration as a variable can be seen to provide no statistical evidence in terms of this leading to a higher or lower agreement index between the school's students and teachers. In terms of the geographic location of the school, urban schools can be seen to present significantly higher agreement indices than in rural locations. With regards to the teacher gender variable, it is impossible to detect any statistical effect on the agreement index between students and teacher within each of the educational institutions. For the age range variable of the teachers surveyed, it can be seen that teachers over the age of 50 present statistical differences in relation to the youngest group of teachers (< 30 years old), with their agreement level somewhat reduced. The final variable relating to the Standardized National Test which showed a significant margin in Reading implies that schools that perform better academically are likely to have a higher agreement index.

Table 4—15 Contextual multiple regression variable

Variable	Category	Coefficient	Sig
Administration			
	Private-subsidized	-0.048	
	Private fee-paying	0.007	
School location			
	Urban	0.096	***
Teacher's gender			
	Male teacher	0.030	
Teacher's age			
	Teacher between 30 and 39 years old	-0.029	
	Teacher between 40 and 49 years old	0.034	
	Teacher 50 years old or more	-0.075	***
National Standardized Reading Test		0.002	***
National Standardized Mathematics Test		-0.001	
	Constant	-.2282	***
No. of observations		818	

****Significant at 5%*

4.4.2. Stage II: qualitative

By analysing the interviewees' responses, relevant patterns can be detected which complement and allow a more in-depth analysis of the results of our quantitative research. It is worth noting that while collecting qualitative data, the answers provided by the interviewees were not standardized but were instead categorized based on patterns (as indicated in Table 4-16 for the first question and in Table 4-13 for the second question), in order to be subsequently analysed.

Table 4—16 Opinion of interviewees regarding the assessment of teacher and student views

Total number interviewed: 26	Opinion of assessment (Multiple choice)
Interesting, useful and/or a positive contribution to the institution	73.08%
Confirmed previous assumption(s) about the institution or a particular class	26.92%
Provided new information, and therefore made them take note	19.23%
The results are not surprising and they show little concern about the differences	11.54%
The results are worrying	7.69%
Neither interesting nor useful	3.85%
Other	3.85%

By examining Table 4-16, which shows the opinions of interviewees about the assessment undertaken in their school, it can be seen that 73.08% of respondents believed it to be an interesting and useful tool. This was because it allowed them to better understand the student perception of the teaching process as well as to see the differences that exist between student and teacher perceptions. For example, *"I think it's a really good initiative and it's tremendously important to know, more or less, what the opinion is and what the needs of the students are regarding their learning, and the perception they have of the education they're receiving, as well as knowing what their expectations are of their teacher and of their own lives"*.

More important than just the results of the diagnostic (quantitative study), a significant percentage of those interviewed (46.15%) declared that the notable differences between the perceptions of the teachers and students is helpful, as it provides them with new and unknown information and/or because it helps them to confirm previous assumptions (this percentage corresponds to interviewees who responded with the following: "Confirmed previous belief(s) about the institution or a particular class" and/or "Provided new information, and therefore made them take note"). In their own words *"...it surprises me that the teachers and students have different perceptions." "These differences are not much different to what we had already detected at management level. However we* *recognize such details as being a valid way of continuing our paradigm shift."* And, *"It shines a light on certain aspects that in some ways we already know, but it's always good to have this reaffirmed. This is the case especially for the teacher's expectations, because often one doesn't believe or teachers don't think that the kids want to go beyond 12th grade."*

From what can be deduced from the analysis, there are differences in terms of how relevant this topic is. Some teachers (7.69%) state that it is a concerning area which requires attention – specifically indicating, *"it's concerning to see that the as people who spend so much time together, nearly every single day of the year, in some ways we think along totally different lines."* And, *"I think it's a troubling reality the fact that some students believe that teachers don't take their expectations, decisions or background into account, the things that each of them is going through."* On the other hand, other teachers (11.54%) think of it as being normal that the perceptions of people fulfilling different roles and belonging to different generations are different. Some of them state, *"I think that this difference will always exist between a student and a teacher because they don't have the same point of view and they don't see everything involved in teaching. They just look at everything as the results." "It's just that I don't see the gap as being too negative. I don't see it as too problematic."* And, *"I think the views we have as teachers and students are very different… we were educated in one way; they're more linked to technology"*.

Considering that 60% of the respondents for the qualitative sample were teachers that did not complete the questionnaire in the first stage of the study, and that potentially patterns of answers could be affected or not by the results given directly in relation to their classroom work, we analysed the results according to the criteria of whether or not they participated in the quantitative stage of the study. Given the small N in each cell, the results are not reported in this paper. However, it is worth mention that when looking at the data separately for these criteria, a large percentage of the teachers who did not complete the initial questionnaire found the topic to be worrying, with a lower percentage of them finding it to be something quite normal.

With regards to the interview's second question, about whether it is possible to bridge the gap and if so, how it can be achieved, the majority (88.4%) were in agreement that it is difficult to bridge the gap between teacher and student perceptions, although they do believe it is possible. By analysing the results in Table 4—17, more than half (61.5%) can be seen to agree that a better understanding of student needs and expectations is required (this percentage relates to all interviewees who mentioned as part of their answer: 1) to get to know the students better; 2) to generate more conversation and meeting spaces in the classroom, and/or; 3) to work together as an educational community, not as management and pupil separately). For this reason, responses favoured increasing and democratizing meetings and dialogue between teachers and students, as well as working together as an educational community. For example, *"establishing more conversation space outside the formal classroom setting, I think this is fundamental, conversations, breakfasts. The key to me seems to be to strengthen these ties."* These results are striking as it appears that in the natural space where this dialogue should be taking place, no exchange is being encouraged. 19.23% of interviewees specifically mention the need to improve communication in the classroom using more participative methodologies. For example, *“trying to make the class more didactic, more participative, where the student plays a leading role, not the teacher. That is the key to bridging this gap.”* 7.69% of interviewees emphasized incorporating technological elements into the teaching process, as the students find it easier to identify with these types of tools. In this way, technology is identified as a potential bridge between teacher and student perceptions.

Table 4—17 Causes of the gap between teacher and student views raised by interviewees

Total no. interviewed: 26	How do you think the gap can be bridged? (multiple choice)
Get to know students better	34.62%
Generate more conversation and meeting spaces for students	23.08%
Increase participation and democratization of current meeting spaces, especially in the classroom	19.23%
Implement more didactic, practical and entertaining activities in the classroom	15.40%
Very difficult to bridge the gap	11.54%
Introduce more technological elements in the classroom	7.69%
Work together as an educational community, not by separating management and student body	7.69%
Greater self-criticism as teachers	7.69%
Other	23.08%

From the answers to the second question, it is possible to deduce certain causes to which the interviewees attributed the differences between teacher and student perceptions. From the answers one may deduce that one group of teachers (23.09%) primarily attributes it to the lack of student motivation to learn. This is because the solutions posed to bridging the aforementioned gap are focused on how to better motivate students in the learning process, either by introducing technological elements in the classroom or by including more didactic activities (see Table 4—17). The majority of interviewees suggest strategies that focused on modifying the students’ perceptions, as if the students’ views were mistaken, and without any call for self-criticism of the perception held by teachers. One teacher stated, *“I think it’s necessary to improve skills, and not just that but also to give them tools to help them study, and so that it isn’t so boring.”* Indeed, only 7.6% of interviewees suggested more self-criticism as a teacher, as a strategy with which to bridge the gap that between teacher and student perceptions.

The patterns of the qualitative results show no significant differences in terms of interviewees coming from different strata, or the school's administration or location.

4.5. Discussion and conclusions

4.5.1. Discussion

This paper examines how aligned teacher and student views are with regards to the different components that make up the teaching and learning process. To do so, the study examines five important questions, relating to: i) the alignment of teacher and student objectives in the classroom; ii) the teacher's understanding of the students' needs in the classroom; iii) the alignment of teacher and student views regarding how the class environment should be; iv) one group's expectations of the other (teacher-student); and finally, v) to what extent students and teachers share a similar view relating to the role that should be played by the family in the educational process. The paper is complemented with qualitative research to gauge teachers' opinions regarding the gap detected in the first stage between their views and those of their students. The study investigated institutions from a range of administrative dependencies and geographical locations (rural and urban).

As with the present study, Könings et al. (2014) and Moradi & Sabeti (2014) also looked to identify similarities and differences between the views of teachers and students, although the focus of their analysis was different. While our study focuses on the motivation, objectives and expectations that are found at the roots of the learning process, Könings et al. (2014) instead focused on the learning environment by identifying the different roles played by teachers and students and coming to the conclusion that both actors should be involved in instructional design. Moradi & Sabeti (2014), on the other hand, focused their work on identifying the characteristics of an “effective teacher” in language teaching, finding similarities and differences between the emphasis placed by students and teachers on content knowledge, communication skills, management skills and teaching experience.

It should be noted that the results of this paper and the assessment undertaken of each educational institution are valued by the teaching staff as it allows them to better understand the students’ perception of the teaching process and the differences between their view and the teacher’s. It is considered as having made a positive contribution because it highlights previously unknown information or because it confirms previous assumptions. However, despite being positively received, it does not always lead to a sense of urgency within the community. There is a small group of teachers that attributes these differences to generational differences and to the distinct roles played by students and teachers, and that such findings are, therefore, something quite normal. Thus, it can be inferred that if one did want to change the teachers’ ways of thinking, it is not only necessary to show them data highlighting the divergence of views, but also implement interventions that bring about a change in their beliefs and perceptions.

Both in the descriptive and statistical analysis, the evidence clearly reveals that among the different areas explored, the students and their teachers lack a mutual understanding of their motivations, expectations and objectives within the educational process. Statistical analysis of the agreement index shows high levels of disagreement between the views of students and their teachers, producing a very low average agreement index. In some establishments, negative indicators were even found, meaning that disagreement is worse than would normally be expected.

Students and teachers have different perspectives about classroom objectives, about what they need to meet these objectives and about the current conditions in the classroom to meet these objectives. Teachers tend to have a more pessimistic view, with fewer of them believing that the conditions which would allow their objectives to be met are present in the classroom, as well as the classroom conditions required for students to study properly in class. It is interesting to note that when asked about the motivation for achieving their objectives in school (Table 4—5), a large percentage of the students (27.60%) responded that it was through obligation. I.e. their motivation is extrinsic and does not stem from their expectations or from an opportunity to learn. A similar percentage of students across the institutions (24.30%), on average, claimed to enjoy what they do. When answering the same question, the teachers, on the other hand, suggested that it was the school environment (74.90%). However, by delving further during the interviews with the teachers as to the causes to which they attribute the differences between teacher and student perceptions, an important number of them coincidently notes the lack of student motivation.

The patterns, both in the descriptive and in the qualitative analysis, show that a large number of teachers believe they understand the needs of their students (89.1%). However, only 38.8% of students responded that the teachers really do understand their needs. This means that the teachers' response stems from their own perspectives and personal beliefs about the students' needs rather than being genuinely aligned to their real needs, and in the process coinciding with the students' view that their teacher fails to understand their needs. This difference in perspectives is relevant in the teaching-learning process because the student does not perceive the teacher as understanding their needs. This decreases student motivation and does not enable the teachers to adopt and incorporate methodologies and approaches which relate to the students' needs. This is also reflected in the interview responses regarding discussions of how to narrow the gap, where there is little suggestion of self-criticism from the teachers, focusing instead on strategies to change the students' perceptions.

On the other hand, students and teachers do not share a mutual expectation about their role in society. Students expect their teacher to have an impact on their academic and professional career paths, whereas teachers do not focus on the results of the teaching-learning process but rather on the role of general guidance. The majority of students state that the role of the teacher is to academically shape future careers, while teachers responded that their main role is to satisfy the educational and welfare needs of their students (Table 4—8). Society's expectations of students remains centred on learning (Table 4—10), while both teachers and students retain the belief that society expects the student to obtain training in order to later become a professional. In addition to this, when teachers were asked directly about their expectations of their students (Table 4—11) the responses differed significantly and the most common answer was the alternative "Other".

Finally, there is a big difference in terms of the view held by each group regarding the role that the family should play in the educational process (Table 4—12). A large majority of teachers answered that family should actively participate. The most popular student response was, however, that families should participate on an informative level, and a significant number even suggested that families should not participate at all. This difference shows there is no alignment between the views of teachers and students regarding the role of the family. This undoubtedly affects the way in which families relate to school organizations. Studies (Vyverman & Vettenburg, 2009) suggest that when educational institutions allow families to play a more active role in the education process, the students' view of the role played by the family is much more positive, with these students in turn playing a more active role in their own education.

4.5.2. Conclusions

Our conclusions are set out according to the research questions that guided this paper. Regarding research question 1: What are the classroom objectives for teachers and students and how well aligned are they? The results demonstrate the disparity between teachers' and students' objectives in the classroom. It would be interesting to study whether these objectives are the result of family, personal, work or other types of demands, and undertaking an investigation into the motivations of actors within the educational process for planning common goals.

Regarding research question 2: Does the teacher understand the needs of the students in the classroom? The results are conclusive in that there is a lack of understanding by the teacher of their students' needs. In general, in response to the questions on this subject the view of the students and their teacher were totally contradictory. This is undoubtedly a fundamental area of work regarding the tools that classroom teachers could develop in order to identify, take into consideration and respond to the needs of their students within the teaching process.

Regarding research question 3: Are the views of the teacher and the students aligned in terms of how the classroom environment should be? It should be noted here that in general both students and teachers agree that there is heterogeneity among the students in their classes. In addition, there is an alignment of the answers provided by students and teachers, predominantly, in that the main element in which this heterogeneity can be seen are the different learning paces in the class. Therefore, it can be concluded from this research question that there is alignment between students' and teachers' views. However, it is important to note that 24% of teachers responded that the main element of heterogeneity in the classroom were elements that were not present in the questionnaire used in this paper. These could be explored in greater detail by evaluating possible determinants for an improved learning environment.

Regarding research question 4: Do teachers and students share the same expectations of one another? Convergence is seen in terms of student expectation of their teacher, which is recognized by the majority of the teachers. Expectations of teachers and students regarding society's views of both groups also converge. There is no convergence in terms of the rest of the views. As with the investigation into where student and teacher motivation and objectives come from, it would be interesting to look into expectation generation from a cross-section of different educational actors, including management and families. This would enable the outlining of strategies that allow different expectations from different parties to be revealed, thus strengthening the roles within the educational community.

Finally, conclusions about research question 5: Do students and teachers share a similar view of the role that should be played by the family in the educational process? Here the views do not converge, as the majority of students note that an informative participation is what is required on behalf of their families, while the teachers suggest that the families should play an active role in the educational process. This is clearly part of the de-alignment of objectives and expectations they have in relation to the educational process, as both elements incorporate actors with different roles, prior to which the family may or may not be key. Research into this area would provide empirical evidence about the value of the role played by the family from the expectation mentioned and the position they essentially play in the learning process of the students. This would produce important background information that could be used to produce policies on family participation and involvement in each school's educational projects.

In the framework of this paper, this type of information contributes to identifying a part of the educational setting, upon which policies are designed and implemented and which should, first of all, take the views of the actors involved into account. It is interesting to continue the study of determinants at both the individual student level and at the contextual level, such as undergraduate teacher training, working hours within the institution, hours spent in the classroom and planning lessons, experience within the institution, race, religious and political beliefs, etc. Many of these can shape teachers' social positions from which they interact on a daily basis with their students, and that can therefore affect to a greater or lesser extent the agreement index between the teacher and their students. It would also be interesting to study interventions that work explicitly on teacher beliefs and the impact these have on bridging the gap between teacher and student views of the teaching-learning process. The results of this research paper can help us to develop public policy for both undergraduate teacher training and continued professional development.

5. Orchestration: providing teachers with scaffolding to address curriculum standards and students' pace of learning

5.1. Abstract

While investment in technology for use in the classroom is increasing, studies still do not reveal significant improvements in learning. Investigations have shown that aligning the design of learning experiences with students' needs creates synergy in the teaching and learning classroom processes. This can be achieved through orchestration, the guided integration of conventional and digital resources. This study seeks to investigate how orchestration increases student learning while taking into consideration their different pace of learning and monitoring the standards that the curriculum requires of a teacher. This is done by adopting a model which incorporates both the requirements of a school system's curriculum, as well as the students' specific needs based on their effective learning. It also seeks to determine which elements enrich the learning experience within an orchestrated framework. This study experimentally shows a significant increase in student learning when orchestrations are made available to teachers, when teachers successfully integrate technology into the classroom and when systematic use of the available resources is made. Furthermore, this study demonstrates the importance of addressing weaknesses in each student's base of knowledge by adapting the activities in the classroom to their individual pace of learning.

5.2. Introduction

Around the world significant investment in educational technology is being made (UNESCO 2011; Kozma et al., 2014; Schulte, 2014). Independent research has concluded that providing each child with a computer fosters the development of digital skills (Beuermann, Cristia, Cruz-Aguayu, Cueto, & Malamud, 2013). However, there is still no evidence to suggest that having access to a computer improves learning in Math or Reading (Beuermann, Cristia, Cruz-Aguayu, Cueto, & Malamud, 2013).

Integrating technology into educational processes is not simply a case of providing access, but in fact a way of promoting improvements in student learning (Hernández-Ramos, 2005). This begs a rethinking of the supposed connection between the potential provided by these new tools and the existing needs of educational processes. This is worth considering from both the perspective of the teachers, teaching process, as well as of the students, learning process In this sense, there is a need to align the design of learning experiences, i.e., line up the coherence and consistency of the pedagogical activities, with the way in which teachers address student needs (Hermans et al., 2008; Beetham & Sharpe, 2013; Suárez et al., 2013).

Orchestration can provide such an alignment within the process of integrating technology into the classroom. The literature has described orchestration as a tool that provides: robust and innovative forms of teaching and learning, by taking classroom ecology into consideration; efficiency, by facilitating the use of familiar, tested resources; adoptability, as it helps the teacher organize the necessary resources; and adaptability, as teachers can rely on strategies for adapting the resources according to contingencies that may arise

(Nussbaum, M., Dillenbourg, P., Dimitriadis, Y., and Roschelle, J., 2013). In this regard, and within the framework of schools that have access to technology, this study sought to understand: *Is there a significant increase in student learning when the teacher uses orchestration?* In relation to this, our second question aims to identify: *What elements are associated with a greater increase in learning within a context of orchestrated learning experiences?*

Kennedy (2005) points out that the taxonomy regarding the tasks that a teacher should carry out has been based more on idealized conceptualizations than on reality or the teachers' needs. For example, the paces of a class i.e., the different students learning rhythms, or maintaining a favourable learning environment considering aspects as usage of time, space and classroom resources, are fundamental necessities not necessarily considered. However, good teaching is not just determined by school-level factors or a teacher's knowledge, beliefs, and attitudes. It is also determined by considering the needs of the students, as well as other classroom- and student-level factors (OECD, 2009). The importance of student and teacher needs and interests when faced with the challenge of creating favourable learning environments in the classroom has been highlighted (Slavin, 2006). Wu, Tu, Wu, Le, & Reynolds (2012) discuss paying attention to diversity within the classroom, focusing their research mainly on the consideration of a student's individual progress within the learning process, i.e., considering the different paces of learning within a classroom. The third question arises: *When systematically implementing strategies that consider student learning pace, what type of impact does this have?*

By answering these three questions, this study looks to bring new information to the existing literature on orchestration. It also looks to provide the tools to empower teachers when integrating technology into the curriculum. One of the main differences in the design of the orchestration used in this study is that it takes into account each student's individual pace of learning. Furthermore, it also monitors the standards that the curriculum requires of a teacher. Several different kinds of orchestration have been suggested in the past (Jurow and Creighton, 2005; Fischer and Dillenbourg, 2006; Dillenbourg et al., 2009; Prieto et al., 2011; Sharples, 2013; among others). However, none of these take into consideration the curriculum standards that teachers must work towards, nor the students' specific needs based on their effective learning.

This study begins by detailing the intervention model. Secondly, it explains the experimental design and the subsequent results of the analysis. Finally, in light of these results, the research questions are answered and the findings are discussed based on the current literature.

5.3. Intervention Model

To answer the research questions, an experimental design was developed based on the implementation of a pedagogical strategy to integrate digital and non-digital resources. This strategy featured two components:

i. Orchestration: aimed at integrating the teaching processes with the available technology in schools. The used orchestration in this study has been based on a definition that has been proposed by several authors. The work by Fischer & Dillenbourg (2006) refers to orchestration as the coordination of different activities with the use of different resources and in different contexts. To complement this, Hämäläinen & Oksanen (2012) refer to orchestration as a way of supporting the teacher by providing them with a set of guidelines. Nussbaum, Dillenbourg, Dimitriadis & Roschelle (2013), suggest four advantages to using orchestration: (1) it allows the teaching-learning process to be viewed as a whole, taking into account specific contexts; (2) it improves efficiency by allowing teachers to work with tried and trusted resources, (3) it improves adoptability, allowing the adoption of new resources to be presented to the teacher in a well-organized, coherent and attractive fashion; (4) it improves adaptability, acknowledging the fact that the teaching process is often dependent on what happens in real time in the classroom. In this sense, orchestration provides the teachers with explicit strategies for how and when to be flexible with the use of a new resource. This component is directly related to the first two research questions: "*Is there a significant increase in student learning when the teacher uses orchestration?*" and "*What elements are associated with a greater increase in learning within a context of orchestrated learning experiences?*"

For this study, the concept of orchestration refers to a set of logistical and pedagogical guidelines which support the teacher's role in the teaching process (Drijvers, Doorman, Boon, Reed, & Gravemeijer, 2010). These guidelines result in a step-by-step guide for using the available resources (both digital and non-digital). This is done by associating the potential of each resource with different learning objectives and stages of the curriculum (Nussbaum & Díaz, 2013). Although orchestration is based on classroom logistics, the guidelines also focus on how to implement the teaching activity, stimulating the learning experience and promoting interaction between the participants (Nussbaum et al. 2013). In this sense, orchestration is not proposed as being a technical manual or instructional guide. Instead, it looks to provide the teacher with scaffolding for dealing with the flexibility required by their learning environment. The systematic use by teachers of this kind of orchestration will provide their students with an articulated learning experience that aims to meet a specific learning objective (Díaz, Nussbaum & Varela, 2014). This articulation will have a positive impact on the learning outcome as it addresses both the curriculum standards as well as the different paces of learning that are present in the classroom. In this sense, the learning outcome is understood as the progress made by students not just in terms of the curriculum, but also how they reinforce their existing base in order to soundly acquire new knowledge.

ii. Software for curricular work and software for each student's individual needs: the objective of the former is to complement the learning experiences and relates specifically to curricular material, while for the latter it is related to addressing a student's individual weaknesses in mathematics by respecting each student's individual learning pace. This component will allow us to answer the third research question: "*When systematically implementing strategies that consider student learning pace, what type of impact does this have?"*

The study was carried out over twelve weeks and covered Fractional Numbers for the 5th grade mathematics syllabus. The curricular material was broken down into the following six units and organized progressively: (1) Reading and writing fractions in daily life; (2) Types of fractions and ordering fractions; (3) Multiplication and division; (4) Addition and subtraction of fractions with a common denominator; (5) Least common multiple; (6) Addition and subtraction of fractions without a common denominator.

5.3.1. Orchestration model

The pedagogical strategy consisted of the orchestration of digital and non-digital resources. The purpose of this was to frame the use of technology within the curriculum, focusing the teacher's job on the pedagogical aspects of a class and leaving the logistical aspects to prior organization, as suggested by Mercer & Littleton (2007). As mentioned above, these specifications were arranged as a micro-sequencing of specific actions for the teacher and it was left to them to decide whether to strictly adhere to the sequencing or simply use it as a model (Figure 5—1). In this manner, the strategy was shaped by guidelines and resources.

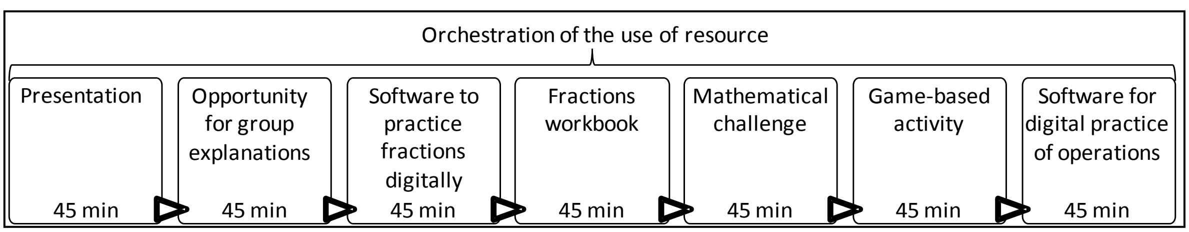

Figure 5—1 Sequence of orchestration

<u>Guidelines</u>:

- **Orchestration of the use of resources:** an orchestration book with logistical and pedagogical suggestions for each resource included in the strategy (indicated below) for each unit. The orchestrations were based on the model described by Nussbaum & Díaz (2013).

- **Opportunity for group explanations:** group activities with the teacher and the whole class aimed at analysing examples relating to the content before continuing with the individual work.

Resources:

- **Presentation:** digital resources which aimed to allow the students to discover and learn more about the topic by presenting it in an everyday narrative to which they could relate. This allowed the students to become significantly more familiar with the new concepts.

- **Software to practice fractions digitally:** software based on practicing fractions in their various representations: graphic, symbolic, number line, etc. The contents of this software included the six units that were covered during the study period. The variety of exercises in this software was based on each student's performance and therefore respected their different learning paces (Alcoholado et al., 2012)**.**

- **Fractions workbook:** based on worksheets for developing process and reasoning skills. To complement the digital practice, the worksheets focused on problem solving exercises which framed the concepts within a specific context. This turned out to be essential for recognizing how and when to apply the mathematical processes that had been covered during the classes.

- **Mathematical challenge:** based on worksheets which included problems that were more difficult than those contained in the fractions workbook. All of these problems incorporated the use of algebra and their objective was to develop application, analysis and evaluation skills.

- **Game-based activity:** a tool which allowed students to establish connections between game-based experiences and the experiences encountered in the presentation, software, and worksheets. These activities were carried out in pairs or groups of three and were included so as to reinforce the students' ability to apply the material to new contexts.

- **Software to practice operations:** students practiced at their own pace the different arithmetic operations working individually weaknesses that were detected by this tool (Alcoholado, et al., 2011). In this way, the strategy not only focused on the specific curricular content, but also on the need to build a solid base of mathematical knowledge for each child.

This set of resources was implemented over a two-week period, which was how long it took to cover each unit.

5.3.2. Training and Coaching

The experimental work included a transfer process designed to ensure that the pedagogical strategy was understood and adopted by both the teacher and the institution. Without this level of adoption, it would have been difficult to implement the work systematically. These four components were:

Training: designed based on the features of the pedagogical strategy, following the hypotheses of previous studies. For example, Lawless & Pellegrino (2007) state that teacher training is essential for effective access to updates for resources and strategies that integrate digital elements in order to reinforce the teaching process. This process included two group meetings with the teachers from the treatment group, each of them three hours long.

Coaching in the classroom: the transfer was extended to each teacher's real work environment by carrying out three coaching sessions in the place where the technology would be integrated. This coaching was included because of studies such as the one done by Slavin (2006). Slavin proposes the need to consider what happens inside the classroom, as well as the social association between the actors. In particular, he highlights the importance of teacher and student needs and interests when faced with the challenge of creating favourable learning environments. The coaching was mainly based on the logistical administration of the classroom, making sure to keep the teacher focused on pedagogical and instructional issues and not on the handling of the technology itself. At the end of each of these sessions, the teachers were given feedback on their work, reinforcing the adoption of the strategy by analysing which elements had already been incorporated and which were yet to be incorporated.

Coaching for Planning: the orchestration suggests how to manage time, space and the use of resources, as well as when to make key interventions while the students work. In addition to this, each teacher was also visited twice in order to help them revise the orchestration based on opportunities and barriers that were specific to their context. During these visits, elements and situations related to the curriculum and the different learning paces observed by teachers were reviewed.

Coaching for Institutional Planning: carried out three times during the project (in week 1, week 4, and week 8) and solely with the participation of representatives from the school's administration, i.e., without the presence of teachers. The literature (Leithwood, Seashore, Anderson, & Wahistrom, 2004) reveals the importance of involving the administration in teaching and learning processes. Thus, in parallel to the work with the teachers, work was also done with a member of the administrative team from each school on scheduling the use of devices, both for the participating teacher as well as the rest of the teachers at the institution. Furthermore, some support tasks for teachers were reviewed, with the recommendation of assigning responsibilities for technical support to someone within the establishment.

5.4. Methods

The study was based on an experimental design with a randomly selected sample that was stratified according to environmental characteristics. These characteristics are explained in sub-section 3.1. Sample. This design was adopted so as to analyse the effect of using orchestration on the student learning process. This effect is understood as the increase in learning between a pre- and post-test, detailed in sub-section 3.2. Instruments.

5.4.1. Sample

The study was carried out with 5th grade students from a group of twenty urban public schools in Barranquilla, Colombia, which had the necessary technological infrastructure to integrate 1:1 computer-based experiences into student work. Of the twenty participating schools, ten were randomly assigned to the control group and ten to the treatment group. The random selection was stratified, meaning that the total sample of schools was fragmented into relatively homogenous strata. This was done by taking into account two characteristics that were observed during initial contact and that could have affected the results of the intervention: the gender composition of the school and school organization. In terms of the first characteristic, some of the schools were mixed (with girls and boys) (n=15) and others were all-girls (n=5). With regards to the second characteristic, the schools were classified into two groups according to how organized they were for the start of classes—if they had official registers, programmed schedules, and assigned sections (n=13), or not (n=7), when the initial assessment was conducted. These criteria provided an institutional management parameter before the intervention, something which has been discussed in several studies regarding the impact that this has on student learning (Leithwood, Seashore, Anderson, & Wahistrom, 2004). Once random selection was performed, it was verified that there were no statistically significant differences between the treatment and control groups in any of the variables given by the Secretariat of Education of Barranquilla in its database, such as: school size, ratio of teachers/students per class, socioeconomic status of the students, in addition to the two aforementioned characteristics (Table 5-1).

Table 5—1 Sample

School	Gender composition	School organization	Group
1	Mixed	Unorganized	Control
2	Mixed	Unorganized	Control
3	Mixed	Organized	Control
4	Mixed	Unorganized	Control
5	Mixed	Organized	Control
6	All-girls	Organized	Control
7	All-girls	Organized	Control
8	Mixed	Unorganized	Control
9	Mixed	Organized	Control
10	Mixed	Organized	Control
11	Mixed	Organized	Treatment
12	Mixed	Organized	Treatment
13	All-girls	Organized	Treatment
14	Mixed	Unorganized	Treatment
15	Mixed	Organized	Treatment
16	All-girls	Organized	Treatment
17	All-girls	Organized	Treatment
18	Mixed	Unorganized	Treatment
19	Mixed	Unorganized	Treatment
20	Mixed	Organized	Treatment

Despite using this technique, the treatment group ended up being composed of schools with a lower socioeconomic status than the control group. Although a general socioeconomic status is given for each school, it does not necessarily reflect the socioeconomic status of each specific student's family. Furthermore, there was a difference in favour of the control group regarding curricular management and student learning, as reported by the 2012 SABER Test scores (a national test given by the Ministry of Education of Colombia) for 5th grade Math students.

The sample of participating students was composed of 702 children, the majority of which came from the southern city of Barranquilla. These students were enrolled in 5th grade at the start of the school year and ranged from 8 to 14 years of age (average age = 10.27), 60% of the total sample were girls. Given that 25% of the schools included in the sample were all-girl schools, 46.47% of the female students were concentrated in these schools. The final sample for analysis was composed of 531 students, due to the failure of some students to complete both the pre- and post-test. From the 171 children not considered in the sample, 73 were from the control group and 98 from the treatment group. The analyses were carried out using a final sample of the control group composed of 263 students (113 boys and 150 girls) and the treatment group of 268 students (95 boys and 173 girls).

There was no sampling of teachers as the analysis of this study was based on the students' progress, i.e., increase in learning, controlling for the schools' environmental characteristics as highlighted previously. In this sense, the teacher variable was considered as an independent variable for all of the analyses.

5.4.2. Instruments

Learning Progress Test: In order to establish the impact of the pedagogical strategy on student learning, both the control group and the treatment group were evaluated before and after the intervention (pre- and post-test). This test was developed by a team of external evaluators who had knowledge of the Colombian curriculum and local terminology. The test was designed based on the standards defined in the Colombian national curriculum for assessing knowledge of fractions. It was also divided into six categories, with each category featuring six questions. Each category was also directly related to one of the six units that comprised the curricular contents covered in this study. The final test therefore contained 36 questions. The reliability analysis showed a Cronbach's Alpha (Cronbach, 1951) of .80, indicating high levels of reliability for the student sample of this study. Both the pre- and post-test were administered by an external evaluator in each school. The tests were held in the students' own classroom, though their regular teacher was not present. Each test lasted for 60 minutes.

Logs: In order to register how each teacher adapted the orchestration to their specific needs, a log was used to record the use (or lack of use) of the different components for each session. This record allowed information to be gathered to support the coaching for planning, as well as to create an index for the systematicity of resource use for each unit. The purpose of this was so that it could be used as an independent variable with which to analyse increases in student learning.

Observation Guidelines: during the coaching sessions in the classroom, the presence or absence of different elements of the pedagogical strategy was recorded so that feedback could be given to the teachers with regards to what had been observed, as well as to generate an index for teaching practices related to the pedagogical strategy. This was done so that it could be used as an independent variable with which to analyse increases in student learning.

5.4.3. Statistical techniques

In order to answer the first research question: "*Is there a significant increase in student learning when the teacher uses orchestration?*", analysis of variance and analysis of covariance was used to compare the increase in learning between the control group and the treatment group.

Analysis of variance (ANOVA): As explained in the description of the experimental design, the sample was randomly selected. However, two variables were identified following the sample selection that could have affected the results of the intervention in the treatment and control schools. These variables were the school's socioeconomic status and their learning and curricular management index, taken from their scores on the 2012 SABER Test in 5th grade Math (Colombian SABER Test for 5th grade Math students during 2012 [ICFES http://www.icfes.gov.co/]). In order to determine whether these differences were statistically significant, a comparison was made using an analysis of variance (ANOVA). This analysis was performed for each of the dependent variables, i.e., the school's socioeconomic status and their learning and curricular management index.

Analysis of covariance (ANCOVA): having established heterogeneity between the control group and treatment group using the variables that were identified once the study had begun (the school's socioeconomic status and their learning and curricular management index), the decision was made to compare the two groups using an analysis of covariance (ANCOVA). This analysis removes the heterogeneity between groups stemming from characteristics which are not controlled by the methodological design. In this case, the aim was to remove the heterogeneity of the 2012 SABER Test 5th grade Math results and the schools' socioeconomic status, thus removing the bias of these variables when comparing the final increase in learning. A second advantage of having used this technique is that it improved the strength of the study as a consequence of controlling for the aforementioned covariates (Morrison, 1990).

Pearson's correlation: In order to answer the second and third research questions: "*What elements are associated with a greater increase in learning within a context of* *orchestrated learning experiences?*" and "*When systematically implementing strategies that consider student learning pace, what type of impact does this have?*", a series of analyses were performed using Pearson's correlation. This technique is often used in studies of human behaviour, where the magnitude of the correlation is of primordial interest (Bonett & Wright, 2000). The increase in learning for each sub-group of students within the treatment group was always used as a variable in these correlations. This was in addition to a range of other variables that are described below.

Construction of Variables

The following sections describe how each variable was constructed and then later used to analyse increases in learning reached by students at the end of the study. These variables were focused on four dimensions: Student, Systematicity of Resource Use, Teachers and Schools. Data is shown in Table 5—2, Table 5—3 and Table 5—4.

For the Students, final attendance records were collected from each student who participated in the study. Based on this record, the "Attendance" variable was defined by calculating the percentage of attendance over the total number of days for the twelve-week study. The second variable for students, "Initial test score," was defined by considering the student's previous knowledge of fractions as shown in the pre-test.

For the Systematicity of Resource Use, information was gathered using a record log filled out by each teacher during the twelve-week study. Through this log, teachers stated whether they used the resources associated with each unit completely, partially, or not at all, assigning 1 point, 0.5 points, or 0 points, respectively. Thus, the percentage of use for each resource was calculated for each of the six units. The resources that were subsequently used as variables are: Presentation, Group Explanations, Workbook, Fractions Software, Mathematical Challenge, Operations Software, and Game-based Activity. Data is shown in Table 5—2.

Table 5—2 Systematicity of Resource Use

School	Presentation	Group Explanations	Workbook	Fractions Software	Mathematical Challenge	Operations Software	Game-based Activity
	Score ($\overline{X}$)	Score ($\overline{X}$)	Score ($\overline{X}$)	Score ($\overline{X}$)	Score ($\overline{X}$)	Score ($\overline{X}$)	Score ($\overline{X}$)
11	1.00	0.83	0.75	0.75	0.83	0.33	0.60
12	0.92	1.00	0.83	0.67	0.83	0.75	0.70
13	0.75	0.83	1.00	0.92	0.75	0.83	1.00
14	0.83	0.83	0.83	0.83	0.67	0.83	0.70
15	0.67	0.50	0.67	0.58	0.42	0.50	0.20
16	0.83	0.83	0.83	0.83	0.83	0.83	0.50
17	0.67	0.75	1.00	0.67	0.83	0.58	1.00
18	0.83	0.83	0.67	0.67	0.67	0.67	0.80
19	0.25	1.00	0.92	0.92	0.67	0.75	0.30
20	1.00	1.00	1.00	0.92	0.92	1.00	0.90

Max: 1; Min: 0

For the Teachers, the field researcher used a check-list during the visits to record the presence, value 1, or absence, value 0, of indicators related to the work expected from teachers when implementing the strategy's resources. These indicators were presented during the training period with teachers and also used as feedback indicators at the end of each visit. In this way, an average performance index was calculated for each teacher based on the three recorded visits. The criteria that were subsequently used as variables are: Subject Knowledge (knowledge of the mathematics covered), Technological Proficiency (user's level of knowledge of computers), Class Structure (presence of activities relating to the introduction, practice and review sections of a class), Use of Orchestration (following the orchestration suggestions in the classroom), Explanation of Material (giving further explanations of concepts and procedures when required by the student learning pace), Feedback for Students (feedback given by the teacher in response to students' answers), Group Management (classroom management, fostering a positive environment for learning), and Management of Digital Resources in the Classroom (implementing strategies for handing out digital devices in the classroom and collecting them back in, organizing spaces that are suitable for their use, etc.). Data is shown in Table 5—3.

Table 5—3 Teachers

School	Subject Knowledge	Technological Proficiency	Class Structure	Use of Orchestration	Explanation of Material	Feedback for Students	Group Management	Management of Digital Resources in the Classroom
	Score ($\bar{X}$)	Score ($\bar{X}$)	Score ($\bar{X}$)	Score ($\bar{X}$)	Score ($\bar{X}$)	Score ($\bar{X}$)	Score ($\bar{X}$)	Score ($\bar{X}$)
11	0.00	0.00	0.63	0.67	1.00	1.00	0.56	0.56
12	0.33	0.33	0.56	0.89	1.00	0.89	0.78	0.67
13	1.00	0.66	0.52	0.78	1.00	1.00	1.00	1.00
14	1.00	1.00	0.63	1.00	1.00	1.00	0.89	0.89
15	0.33	0.33	0.59	0.78	0.89	1.00	0.89	0.83
16	1.00	1.00	0.74	0.89	0.89	1.00	0.89	1.00
17	0.66	0.66	0.67	1.00	0.89	1.00	1.00	1.00
18	0.66	1.00	0.56	1.00	1.00	1.00	0.89	0.89
19	0.66	0.66	0.67	0.67	1.00	0.89	1.00	0.67
20	0.00	0.00	0.19	0.67	0.33	0.56	0.33	0.67

Max: 1; Min: 0

The fourth dimension, School variables, includes contextual elements taken from the school management indicators. The first of these indexes, Leadership and management, was calculated considering three roles (1 if the role was present; 0 if absent): management (observing institutional backing of the time given to the participating teacher in order to prepare technology-based lessons), coordination (observing scheduling and availability of the technological equipment in the classes when the participating teacher needed them), and technical support (observing the operational maintenance of the technological equipment used during the students' learning experiences). The score for this variable ranged from 0 to 3 points, considering the addition of the values obtained for each role. Data is shown in Table 5—4.

The second variable defined the Type of Computer present in the institution: 1 for netbooks; 2 for laptops; 3 for PCs in a computer lab. Data is shown in Table 5—4.

As a proxy for the level of learning achieved by the students from each school in the topics covered by this study, the third variable was the National test outcome in Math, obtained through the school’s average scores on the nation-wide Colombian SABER Test for 5th grade Math students during 2012 (ICFES http://www.icfes.gov.co/). The SABER test is administered in 3rd, 5th and 9th grade, for both reading comprehension and mathematics. The 5th grade Math test was selected as it was conducted with the students of the previous generation of the school at 5th grade, being the best possible approximation for the level of learning for children of that age in each school. Data is shown in Table 5—4.

The final variable in this dimension is the socioeconomic status of the schools. Five social economics status are defined being 5 the highest; the schools present in the sample presents the lower middle class. This data was obtained from the Colombian Institute for the Evaluation of Education (ICFES http://www.icfes.gov.co/). Data is shown in Table 5—4.

Table 5—4 School variables

School	Leadership and management	Type of Computer	National test outcome in Math	Socioeconomic Status of the schools
	Score ($\bar{X}$)	Score ($\bar{X}$)	Score ($\bar{X}$)	Score ($\bar{X}$)
11	2.00	2.00	290	3
12	3.00	2.00	322	3
13	3.00	3.00	311	3
14	2.00	2.00	299	3
15	2.00	2.00	200	3
16	0.00	1.00	223	2
17	3.00	1.00	315	3
18	0.00	1.00	301	2
19	1.00	2.00	285	2
20	2.00	1.00	229	1

5.5. Results

5.5.1. Control and Treatment Group Analysis

In order to verify the homogeneity between the treatment and control groups, an analysis of variance (ANOVA) was carried out. The results of this showed significant differences between schools in terms of their latest test scores on the SABER Test in 5th grade Math (p<.001) and the socioeconomic status of each school (p<0.001). By doing so, a lack of homogeneity between the groups was established. It was therefore decided that an analysis of covariance (ANCOVA) would be carried out in order to control for these variables and make substantial comparisons.

When using the two indicated variables as control variables, belonging to the treatment group turns out to favour increases in student learning (p<0.00). Table 5—5 shows the SABER Test scores and socioeconomic status of each educational institution.

Table 5—5 Variables of interest for comparison between groups

Type	School	Socioeconomic Status	*Total for the group Socioeconomic Status*	SABER Score	*Total for the group SABER Score*
Control	1	2		307	
	2	2		269	
	3	3		293	
	4	3		355	
	5	3	*33*	259	*3297*
	6	4		347	
	7	4		360	
	8	4		320	
	9	4		337	
	10	4		450	
Treatment	11	3		290	
	12	3		322	
	13	3		311	
	14	3		299	
	15	3	*25*	200	*2775*
	16	2		223	
	17	3		315	
	18	2		301	
	19	2		285	
	20	1		229	

5.5.2. Analysis of explanatory variables within the treatment group

Among the schools in the treatment group, differences were observed in terms of learning increases. A subsample was created to explore contextual variables associated with a greater increase in learning and based on a correlational analysis regarding three variables that showed statistical correlation. These were: Attendance (*corr*.=.20, p<.001), Use of Orchestration (*corr*.=.19, p<.001), and the Highest mean increase in learning between pre- and post-tests (corr.=.26, p<.001) (variable taken from the difference in score between the two tests). The five schools that showed a correlation in these three criteria were called the treatment group subsample. For this subsample, the associations between the mean increase in learning at each school and the variables listed in sub-section 3.3. Statistical techniques – Construction of Variables were explored. The results of the correlational analysis are shown in Table 5—6.

Table 5—6 Exploring Associations with an Increase in Learning

Dimension	Variable	Correlation	p-value	
Student	Attendance	.11	.30	
	Initial test score	-.35	.00	***
Systematicity of Resource Use	Presentation	.08	.36	
	Group Explanations	.29	.00	**
	Workbook	.38	.00	***
	Fraction Software	.53	.00	***
	Operations Software	.55	.00	***
	Mathematical Challenge	.25	.00	**
	Game-based Activity	.35	.00	***
Teacher	Subject Knowledge	.59	.00	***
	Technological Proficiency	.50	.00	***
	Class Structure	.33	.00	***
	Use of Orchestration	.37	.00	***
	Explanation of Material	.43	.00	***
	Feedback for Students	.08	.35	
	Group Management	.12	.19	
	Management of Digital Resources	-.03	.73	
School	Institutional Management	-.05	.58	
	Type of Computer	-.46	.00	***
	SABER 5th Grade Math Score	.27	.00	**
	Socioeconomic Status of Institution	-.03	.74	

*******p=0 - 0.001; **p= 0.001 – 0.01; *p= 0.01 – 0.05; ºp= 0.05 – 0.1*

For the first dimension, an association between a greater increase in learning and a lower score on the initial test (*corr*.=-.35, *p*<.001) can be identified. This indicates that students who scored lower on the pre-test showed a greater increase in learning in the post-test. However, no association was observed with the class attendance variable. For the second dimension (Systematicity of Resource Use), a positive association can be shown between a greater mean increase in learning and more frequent use of the workbook (corr.=.38, *p*<.001), fractions software (corr.=.53, *p*<.001), operations software (corr.=.55, *p*<.001), mathematical challenge (corr.=.25, *p*<.001), game-based activity (corr.=.35, *p*<.001) and group explanations (corr.=.29, *p*<.001). The only resource that did not show any association was presentation.

For the Teacher dimension, there is a positive association between teachers who were observed with higher levels of subject knowledge (corr.=.59, *p*<.001) and those with higher levels of technological proficiency (*corr*.=.50, *p*<.001). Similarly, there is a positive association between classes that follow a structure (introduction, practice and review) (*corr*.=.33, *p*<.001), and teachers who follow the orchestration suggestions (*corr*.=.37, *p*<.001) and focus on explaining the material instead of just covering it superficially (*corr*.=.43, *p*<.001). No association was observed between the feedback given by teachers to students, their group management skills, nor their management of digital resources in the classroom.

For the School dimension, the evidence shows that schools that the use of netbooks had a greater average increase in learning (*corr*.=-.46, *p*<.001). As indicated in the Methods section, the three types of computers present in schools were categorized on a scale ranging from 1 to 3, where 1 was assigned for netbooks and 2 for laptops (the subsample of schools did not contain cases with PCs in laboratory, i.e., category number 3). Thus, in this case, the negative sign reflects the inverse association of the netbook in category 1, indicating an association between the schools that used this type of device and a greater increase in student learning, as compared to schools that used notebooks. Additionally, the score achieved by schools on the 2012 SABER Test for 5th grade Math is also associated with better performance on the progress test used in this study (*corr*.=.27, *p*<.001). This means there is a positive association between schools that had a higher score on the national test and schools that saw a greater increase in student learning.

5.6. Conclusion and discussion

From the results of this study, it is possible to answer the three research questions that were posed. With regards to the first research question, "*is there a significant increase in* *student learning when the teacher uses orchestration?"*, it can be observed, within the context of this particular study, that there is indeed an increase. Students whose teachers had orchestrations at their disposal for integrating technology into the classroom showed a greater increase in learning between pre- and post-tests versus students whose teachers did not. In this sense, these findings enhance the appraisal of orchestration previously made by other researchers as being a key component of technology provision programs in educational settings. Orchestration has been established as the concrete link between technology and pedagogy, and its potential for achieving learning objectives has been revealed—in this particular case, in settings of lower socioeconomic status and with lower indices of curricular management (SABER Test). This disadvantage was established in the first analysis indicated in the Results section, by comparing the schools' socioeconomic status in the control group and treatment group, and finding that the treatment schools had a significantly lower status ($p<.001$) than the control schools. Also, a comparison was made between groups regarding the curricular management index (SABER Test), again establishing a statistical difference ($p<.001$) between groups, showing that the treatment group comprised schools with a lower index than the control group schools.

With regards to the second question, *"What elements are associated with a greater increase in learning within a context of orchestrated learning experiences?"* there are a number of components that are directly associated with a greater increase in learning. To analyse these components, we will refer to the dimensions defined in the Methods section. First, regarding student-level variables and in line with the response to the first research question, the orchestrated pedagogical strategy described in this study is associated with a greater increase in learning for students who score lower on the initial test (pre-test). This shows a positive impact where students showed less previous knowledge of fractions. In this sense, the orchestrated strategy helped increase learning in students who were less prepared to learn more complex elements, i.e., students who were at a disadvantage when compared to their peers.

With regards to the systematicity of use of the resources included in the orchestrated strategy, it is worth noting that frequent use of most of the resources was associated with a greater increase in learning. Those resources included: opportunities for group explanations of the content being covered, workbooks based on worksheets, fraction software that included the curricular flow associated with the six units, mathematical challenges demanding higher cognitive skills, game-based activities using cut-outs and concrete experiences with the content, and the operations software which included the flow of mathematical base knowledge that followed each child's work at their own individual pace. The only resource not associated with a greater increase in learning was presentation, which based the introduction of new material on everyday narratives.

In addition to this, a greater increase in student learning in the treatment group was also demonstrated at teacher level. Both knowledge of mathematics and technological proficiency were indicators associated with a greater increase in learning. Teachers who structured their classes with introduction, practice and review activities; followed the orchestration suggestions; and explained the material well instead of just covering the material quickly, were also associated with an increase in student learning. No positive or negative associations were observed between teacher feedback for students, group management, and management of digital resources in the classroom.

With regards to the school environment, only two variables showed a correlation: the type of computer present in the school and the average score on the 2012 SABER Test for 5th grade Math. The use of netbooks was directly and positively associated with a greater increase in learning. This may be due to the mobility of the technology in the classroom, the students' natural learning environment, without necessarily having to move somewhere else to work on computers. Finally, the significant correlation with the SABER Test scores may be due to better institutional management of the curriculum for student learning (http://www.icfes.gov.co/).

Finally, to respond to the last research question, "*When systematically implementing strategies that consider student learning pace, what type of impact does this have?"* we analyse issues related to the systematicity of resource use, paying close attention to the correlation reported by the use of the two software included in the strategy. Both software consistently reported a strong correlation between systematic use and an increase in student learning. This shows a positive association between the integration of curricular material and the material reviewed to address students' individual weaknesses, taking into consideration the different learning paces present in the classroom.

When analysing each software separately, the correlation of greater systematicity in the use of the fractions software, which covered curricular material, is 53%. This is an important figure when analysing each strategy component separately, as while the remaining resources also has a positive association it is to a lesser extent. This association could also be explained by the fact that the fractions software was designed based on the six units covered during the study's twelve-week period. In addition to this the pre- and post-tests measured knowledge of those six units. The operations software respected each student's learning pace, helping them to consolidate algorithms that are a basic element of mathematical thinking and key to acquiring new and more abstract, complex concepts. As a result, there was a 55% correlation between this software and the students that demonstrated a greater increase in learning. This demonstrates the importance when covering curriculum contents of not just working on standards defined by ministerial programs, but also addressing the mathematical deficiencies that students may present and, in doing so, better consolidating their new learning.

It is worth highlighting the importance of digital content in regards to this last question, continuing with NESTA's line of thought when they make a direct allusion to the use of technology rather than the technology itself (Luckin, Bligh, Manches, Ainsworth, Crook, & Noss 2012). The content of the hardware intended for student learning is also important and must be orchestrated or coordinated according to other learning experiences and ideally contain a component of work that is individually paced. By considering achievements and progress in relation to the individual student instead of set learning standards, this type of individual work can have an impact not just on learning but also on motivation.

The results from this study are similar to the results of a study carried out by BECTA (Somekh, et al., 2011). The main difference between the two lies in how the digital component in both studies addressed the students' and teachers' needs. In the BECTA study, the digital work only took into account the students' needs by allowing them to progress at their own rate. In our study, however, we also took into consideration the teachers' needs to advance through the curriculum with the students. Orchestration, which was not present in the BECTA study, was of fundamental importance to us as it took into consideration the duality of student vs. teacher needs in the classroom. This in turn allowed us to incorporate digital and conventional resources more coherently. Considering that our study compared groups that worked with and without orchestration, while the BECTA study looked at incorporating a digital component without orchestration and integrated support for the school community, which we did not, future studies should analyse the value added by orchestration in contexts such as the one in which BECTA carried out their study.

The findings discussed in this study suggest further investigation of orchestration and integration of curricular contents, as well as individual learning paces in the classroom. This should be done within two new frameworks. The first of these would be to conduct the study over a longer period of time, i.e., at least a full school year, which could cover learning associated with curricular contents for the whole grade level. In addition, the analyses could be fully reviewed with the systematicity of resource use maintained over time. Second, it would be interesting to analyse this experience in other areas of learning, expanding the scope to include other areas of the curriculum.

6. Conclusions and future work

6.1. Conclusions

The importance of the studies featured in this thesis stems mainly from the evidence that is produced and that can optimize the various efforts (both economic and social) currently being made by Chile and several other countries in terms of their investment in educational technology. The four papers that were developed based on orchestration analytically respond to the research questions set out in the introduction to this thesis.

It is worth highlighting that the inclusion of Chapter 4, which is not focused specifically on orchestration, looks to model a process for exploring elements that are implicit in the classroom with the aim of enriching the orchestration design. In this sense, progress is made by including relevant elements that curricular policies normally ignore, such as the teacher and students' motivations, interests and views.

6.2. Future work

In order to continue developing orchestration both conceptually and practically, it is important to revisit the main objective of this tool, which is "To organize and coordinate the different elements of the teaching-learning process within a classroom with technology, with the aim of guiding and enriching the teachers' actions". Faced with this objective, it is worth reflecting upon other critical elements that must be taken into consideration in order to strengthen classroom practices. There is a series of evidence that reveals the critical elements that must be taken into consideration in educational processes, with a look to the teachers providing a quality, constructivist and inclusive education.

Guzmán & Nussbaum (2009) suggest the need to consider six components within the process of training and empowering teachers to develop learning experiences where technology is used integrally, suitably and effectively. Although orchestration in itself does not represent a process of teacher training, it does look to empower the teachers in terms of what takes place in the classroom. These six components refer to aspects of methodology, curriculum, technology, attitudes, communication and assessment. The orchestration model developed in this thesis mainly addresses aspects of methodology and curriculum, including within its components the *what* and *how* of the pedagogy. Tangentially speaking, the orchestration also tackles components of attitude and communication, though it does not manage to include concrete actions regarding the technical knowledge that is required by the teacher in order to appropriate the technology. Furthermore, and with regards to the assessment component (in summative terms), although the orchestration suggests ways of monitoring progress, it does not include concrete instruments or criteria with which to do this. Integrally addressing these six elements is one of the most critical challenges, though it is possible to do so using orchestration.

In parallel to this, a census study conducted in Chile (Nussbaum et al., 2014) has identified the differences between students' curricular age and their actual grade level as a critical factor. This difference can be between one and four grade levels, as measured using a national standardized test. In this sense, orchestration designers are faced with the challenge of incorporating strategies that not only consider the curricular sequence in order to support the task of the teacher, but also provide opportunities to consolidate the prior knowledge that is needed in order to tackle the learning requirements for the students' grade level. The study of implementing orchestration in Colombia (Díaz et al., 2015 [Chapter 5 of this thesis]) included one activity each week where the technology was used to allow the students to work at their own pace, addressing each student's specific needs.

Another critical issue is the challenge of reducing the gap that exists between the teacher and students' views and objectives within a shared process such as the teaching-learning process (Penuel et al., 2010). This becomes particularly important when considering that the literature has revealed that schools are most effective when the educational process take their students' needs into consideration (Könings et al., 2014; Moradi & Sabeti, 2014). Chapter 5 of this thesis (Díaz et al., 2015) reveals that the teacher and students' points of view are not aligned when it comes to classroom objectives, student needs, the classroom environment, and the role that should be played by the family in the educational process. It also reveals that teachers are largely unaware of this gap and do not feel responsible for the issue. Further research has been carried out on the difference in opinions between teachers and students regarding different elements of the learning process. This has revealed a lack of consistency between the two groups with regards to different topics associated with the teaching-learning process (Zhu & Urhahne, 2014). In this sense, orchestration designers are faced with the significant challenge of explicitly including questions or comments that generate a bond between the teacher and the students. This bond could be generated and strengthened by questions that link the students' previous experiences with the curricular content; questions that can identify the students' needs when faced with new content; and questions that help teachers put themselves in their students' position in terms of their motivations and the significance of the curricular content to their lives.

Furthermore, given that grades affect students' perceptions of the schooling process and the amount of effort they make (Betts, 1997; Paredes, 2012), one of the most critical challenges for orchestration is to go beyond the formative questions that are suggested for the teacher to ensure the effectiveness of their assessments by incorporating instruments and criteria for summative assessment. Studies have highlighted the importance of assessing learning in order to deliver a quality education (OECD, 2013) in terms of its immediate importance and its importance for the future of the students (Muller et al., 1998; Shavit et al., 1998; Brown et al, 2013). In this sense, the literature regarding teaching practices has detected a lack of summative assessment strategies for teachers (Hume et al., 2009; Tyler et al., 2010). This translates into the use of point-scales instead of performance standards (Guskey, 2006; Urich, 2012) and into an alarming level of partiality when it comes to grading (Iacus, 2013; Sadler, 2013; Rauschenberg, 2014). One particular case to observe is that of New Zealand, where the national education system and its teachers have managed to come together and create a single school assessment system, based on criteria from active teachers (Nusche, 2012), i.e. managing the way that teachers assess through public policies. In this sense, although it is difficult to propose assessment tools from the outside (given the unique nature of each context in terms of language, time restrictions etc.), it is possible for orchestration designers to include an explicit indication of criteria for assessment and correction. This script would be similar to the one used by teachers in the classroom, though in this case it would have a specific function: to monitor the progress made by students in learning. As well as including assessment criteria within the orchestration, it would also be beneficial to include a timeframe for learning measurements in terms of progress and coverage of the orchestrated curricular content. The aim of this is to assess progress based on how much of the content is covered and not just how much of the school year has passed.

Finally, it is important to acknowledge that a policy for developing orchestrations that takes into consideration the curricular framework, local context, and the teacher's experience and knowledge is costly. In this sense, it becomes increasingly important to talk about developing skills within schools, something which is particularly relevant when it comes to educational policies and programs that look to be scaled up. The aim of developing skills among active teachers so that they can develop orchestrations is to empower them in their pedagogical decisions regarding how to prepare a series of classes based on student-centred practices for using conventional and digital resources that are well divided, suitable and effective. This division will be able to reflect the elements that are implicit in a classroom (such as interaction, visibility, question types etc.) and which are equally important as other, explicit elements (time, resources, contents etc.).

The development of skills among active teachers is proposed by following a methodology mediated by questions that look for the teacher to reflect and make pedagogical decisions, resulting in an orchestration. In other words, by taking said questions and an example of an orchestration, a school community is able to build its own orchestrations. These questions are presented on two levels: macro questions and micro questions. The macro questions directly reference the six dimensions of classroom teaching: subject/curriculum, time/frequency, purpose/objective, procedure/methodology, resources/organization and monitoring/assessment, and are detailed in Table 6—1. Micro questions are those that stem from macro questions and the answer to which produces the constituent elements of an orchestration. Both levels of questions precede the “Element” column from Table 1—1, as they are the ones that detect the need that is to be addressed and, therefore, orchestrates (or coordinates) the pedagogical actions.

Table 6—1 Questions that break up pedagogical planning and create an orchestration

Macro questions	Micro questions
Which subject and grade level will the orchestration address?	For which grade level am I going to make the pedagogical decision? For which subject am I going to make the pedagogical decision? For which specific topic am I going to make the pedagogical decision?
How often and for how long will the orchestration be implemented?	How much time do I really have to teach this topic? Which aspect of the topic will I cover in the first week, the second week, the third week, etc.? How am I going to divide the time I have available for class into different learning experiences? For which moment of the class will I prepare these learning experiences?
What is the pedagogical purpose of the orchestration?	On which cognitive skill will I focus the learning experiences of this class? Which learning objective do I hope my students will achieve by the end of this unit? What is the specific learning objective that my students must achieve after class 1, 2, 3, etc. in the first week, second week, third week, etc.? What prior knowledge do my students need so that the learning experiences I have designed will be useful based on the objective of the class?
Which pedagogical procedures does the orchestration include?	Which methodologies will my students follow for these learning experiences? What sort of consistency is there between these? How should my students work so that the learning experiences progress correctly? How should the space be organized in order to carry out the learning experiences? What specific instructions should I give my students regarding the use of resources (technological and conventional)? What instructions should I give my students so that they understand the learning experiences?
Which resources are used in the orchestration?	Which resources should I prepare so that the learning experiences can take place optimally? What sort of consistency is there between these?
Which monitoring procedures does the orchestration include?	How will I interact with my students as the learning experiences take place? And how can I promote interaction between my students as the learning experiences take place? How, how often, and which resources will I use to monitor my students’ progress?

	Which questions will I ask my students to make sure they understand every explanation I give and every example I show? How will I make sure my students are meeting the learning objectives set for class 1, 2, 3, etc. in the first week, second week, third week, etc.?

Based on this, it is of utmost importance for this thesis to suggest as future work the development of skills within schools for developing orchestrations. This can be achieved by analysing collaborative work processes between teachers regarding how to break down global processes into specific elements, which are not often elements that are made explicit in lesson plans. This will allow for an analysis of the feasibility of having teachers develop and implement orchestrations, thus facilitating the scalability of an educational policy or program of orchestration.

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APPENDIXES

APPENDIX 1: CRITICAL ISSUES WHEN IMPLEMENTING A NATIONAL ICT FOR EDUCATION POLICY

Abstract

A number of policies across the world are aimed at providing schools with technological resources to improve the quality of education. However, international evidence shows that there is a weak, null or negative relationship between the use of Information and Communication Technologies (ICT) at school and student performance. This study analyses the effect that Chile's ICT for Education policy has had on student learning, 20 years after it was first implemented. In order to do so, results were taken from a national census of ICT in education, as well as the scores on national standardized tests in Mathematics and Reading. Both the census and the standardized tests were administered in the same year and to students from the same year group and the same set of schools. To further analyse these results, a survey was also conducted with a representative sample of students from one of Chile's fifteen regions. The findings reveal that the indices for ICT Infrastructure and ICT Administration in schools are statistically significant and positive. This is reflected in the fact that students from schools that have better ICT infrastructure and administration perform better academically, thus reaffirming the importance of management teams within the school system. However, the Pedagogical Use of ICT index, directly related to classroom practices, turns out to be the only index without any sort of statistical significance. Further study also reveals that the vast majority of students state that they never use digital resources when studying Mathematics or Reading. This study therefore provides evidence that public policy has

failed to pay close enough attention to the pedagogical use of these new tools in the classroom.

Introduction

A number of policies across the world are aimed at providing schools with technological resources to improve the quality of education (UNESCO 2011a; Kozma et al., 2014; Schulte, 2014). Furthermore, there are a number of research papers that focus on the importance of developing strategies to empower teachers in their use of technology, taking full advantage of their pedagogical potential in order to enrich their own teaching practices (Hermans et al., 2008; Beetham & Sharpe, 2013; Suárez et al., 2013). However, various government programs only provide training for using basic productivity tools such as email and word processers, among others (Kozma, 2008). A large number of teacher development programs focus on the potential of new technology as being something separate from teaching practices (Jung, 2005), without providing a link between the development of technical and pedagogical skills (Mishra & Koehler, 2006; Shechtman & Knudsen, 2009; Prieto et al., 2011a).

International evidence shows that there is a weak, null or negative relationship between the use of ICT at school and student academic performance (Speizia, 2010; Tamim et al., 2011). In order to use technology in education appropriately, pedagogical, technological and curricular knowledge must be triangulated (Koehler & Mishra, 2009). In this sense, training programs that only focus on technology do not suffice as teachers also require knowledge on how to integrate its use into the curriculum and their teaching practices (Kozma, 2008).

One particular case is that of Chile, whose ICT policy was first implemented in 1992 with the aim of improving the quality of education and developing a digital culture (website of Enlaces). Thanks to this policy, by 2010 90% of students attending state-financed schools had access to computers, with 60% of these schools connected to the Internet. 110,000 teachers had also been trained in using computers and the country reached a national average of 9.8 students per computer in schools (Donoso, 2010). This training has mostly been focused on how to access and use ICT, without tackling the issue of acquiring skills for using ICT in a teaching-learning context (website of Enlaces). This is reflected in the fact that the majority of students are able to solve tasks related to the use of information as consumers and few as producers of information (Claro et al., 2012). Finally, an analysis of how technology is used in schools reveals that it is generally underused for supporting cross-curricular student learning. Instead, its use is related very specifically to only certain aspects of learning (Hinostroza et al., 2011).

Given that existing results focus on students' digital skills and identifying the ways in which teachers use technology in education, this paper is particularly interested in studying the effect that the ICT for Education policy in Chile has had on student learning. Therefore, the study's research question asks: "Is there any relationship between the efforts made by a public ICT for Education policy over 20 years and the children's learning achievements?"

Methodology

To answer our research question, the investigation features two stages. For the first stage, results were taken from a national census of ICT in education carried out in Chile in 2012 (website of the Index for Digital Development in Schools – IDDE in Spanish). These were combined with the scores on national standardized tests in Mathematics and Reading administered in the same year and to students from the same year group and same set of schools. These scores were taken from the System for Measuring the Quality of Education, or SIMCE (website of SIMCE). The data was analysed using regression analysis and by exploring explicative models of the effects of the census indices on the SIMCE indices. This analysis was carried out on a national level and for each of the country's fifteen regions.

In the second stage, a survey was conducted with a representative sample of students from one of Chile's regions. The aim of this was to provide further analysis of the results obtained in Stage 1. To choose a region that was representative of the indices on a national level when taking into account student-level data, a comparison was made between regions. Descriptive analysis was applied to the data from this survey to study the frequency of use of different technological resources as stated by the students. This was done in order to contrast said information with the effects of the Pedagogical Use of ICT index on learning (SIMCE scores) explored in this study. Each of the two stages is described in detail below.

i. Stage 1

The ICT in Education Census gathered data from 9,062 state-subsidized schools (98% of the total population), as well as a nationally-representative sample of 198 private schools. The information was obtained by surveying 5,384 school principals, 5,208 ICT coordinators, 20,006 teachers and 53,804 students (website of the Index for Digital

Development in Schools – IDDE in Spanish). Based on this information, three indices were measured for each school: ICT Infrastructure, ICT Administration and Pedagogical Use of ICT. ICT Infrastructure referred to the amount of equipment and connectivity relative to the number of students enrolled in the school. ICT Administration referred to actions taken by the school to adequately manage the available technology (e.g. producing timetables, maintaining the equipment, keeping an inventory, etc.). Finally, Pedagogical Use of ICT referred to the actions taken with regards to educational use of ICT for areas of the curriculum such as teaching classes, planning the use of the devices and educational management of these. These three indices were based on concepts used by ITU (ITU, 2011), with schools awarded a percentage score for each.

Learning achievement was assessed using the System for Measuring the Quality of Education (SIMCE). Specifically, this was done using the national standardized tests for Mathematics and Reading sat by 211, 594 10th grade students across the country in 2012 (Education Quality Agency, 2013). It was decided to use the scores achieved by students from the year group that had participated in the ICT in Education Census.

When analysing the relationship between the implementation of ICT policies and learning, it is important to distinguish between different types of schools. This is because there are contextual elements that could affect the extent of this relationship (Leithwood et al., 2004; Vanderlinde et al., 2014). In order to do so, two school-level characteristics were also included as control variables:

Administration type: determined by administration system and funding: i) Municipal schools (Managed by municipalities with state funding); ii) State-subsidized private schools (Privately run but with state funding); and iii) Private schools (Privately run and funded) (Drago & Paredes, 2011).

Location: determined by the distance from the school to the nearest urban boundary. A school is considered rural if it is located more than 5 kilometres from the aforementioned boundary; otherwise it is defined as urban (MINEDUC [Ministry of Education], Chilean legislation, 2006).

ii. Stage 2

A survey was designed for high school students (11th grade) in order to study the frequency of use of different types of digital resources at school. A single evaluator with previous training personally visited each of the schools in the sample. In order to develop this instrument, there was a review of the literature and a pilot process involving 200 students with similar characteristics to those in the final sample. These students were chosen at random and the aim of the pilot was to test both the format and wording of the survey. The questions included in the survey were based on a checklist to ask about how frequently each resource was used on a three-point scale (Never, Sometimes and Always). The resources that were chosen mostly corresponded to the Enlaces equipment provision policy, described below.

Computer programs: given that Enlaces has produced and distributed digital educational resources to support the teaching-learning process, students are asked how frequently they use educational software.

Search engines and Specific websites: given that school connectivity is one of the objectives of the Enlaces policy, students are asked about how often they use the Internet at school.

Social networks: while not part of national policy, it was decided to include social networks in the survey so as to see how much these have become part of the learning process for the students that were surveyed. Social networks provide the opportunity to share concerns, answer questions and discuss content (Ferguson & Buckingham, 2012).

Cell phone: although the Enlaces policy has not focused directly on mobile phones, these have been added to the list of resources to study. This is particularly relevant as the number of cell phones in Chile had reached 140% of the national population by December 2012 (website of Undersecretary of Telecommunications – SUBTEL in Spanish).

The students that participated in this stage of the study came from the Metropolitan Region, a region that was chosen for two main reasons. The first of these is based on the results of the multiple comparisons test. Tukey's Test is used to corroborate the homogeneity of a group when each group is to be compared with the others and there are a large number of groups (6 or more) (Jones & Tukey, 2000). The results of these comparisons revealed a lack of statistical differences between the Metropolitan Region (R13) and the other regions, suggesting that there is homogeneity (Table Appendix1-1). The second reason is based on the fact that the Metropolitan Region is the country's capital, with a concentration of 43.33% of the population (website of Ministry of Internal Affairs and Public Security, 2014).

Table Appendix 1—1 Results from the multiple comparison test between regions

Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2	1.00	---	---	---	---	---	---	---	---	---	---	---	---	---
3	1.00	1.00	---	---	---	---	---	---	---	---	---	---	---	---
4	1.00	1.00	0.73	---	---	---	---	---	---	---	---	---	---	---
5	1.00	1.00	1.00	0.96	---	---	---	---	---	---	---	---	---	---
6	1.00	0.32	0.19	1.00	0.06	---	---	---	---	---	---	---	---	---
7	1.00	1.00	1.00	1.00	1.00	1.00	---	---	---	---	---	---	---	---
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	---	---	---	---	---	---	---
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	---	---	---	---	---	---
10	0.67	0.15	0.10	1.00	0.02	1.00	0.85	0.58	1.00	---	---	---	---	---
11	0.10	0.04	0.02	1.00	0.05	1.00	0.27	0.27	0.68	1.00	---	---	---	---
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.23	---	---	---
13	1.00	1.00	0.76	1.00	0.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	---	---
14	1.00	0.84	0.44	1.00	0.82	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	---
15	1.00	1.00	1.00	0.00	0.11	0.00	0.03	0.01	0.01	0.00	0.00	1.00	0.00	0.00

****p=0 - 0.001; **p= 0.001 – 0.01; *p= 0.01 – 0.05; ºp= 0.05 – 0.1*
Pairwise comparisons using t test with pooled SD
Value adjustment method: Tukey

The sample was randomly selected and stratified by administration (Municipal Schools, State-subsidized Private Schools and Private Schools) and type (Science/Humanities or Initial Vocational Education and Training [IVET]) within the universe of students from 11th grade in the Metropolitan Region attending schools with a graduating class of at least 30 students. This particular year group was chosen as these were students for whom the learning indices were available (SIMCE test sat by 10th grade students in 2012). The parameters for the final sample contemplate a 3% margin of error and a 95% confidence interval. The sample included 1,221 students and their distribution by group from theoretical sample to final sample is shown in Table Appendix1—2.

Table Appendix1—2 Stage 2 sample

Type of school	Science/Humanities		Initial Vocational Education and Training (IVET)		Total	
	Theoretical	Final	Theoretical	Final	Theoretical	Final
Municipal Schools [a]	199	252	100	103	299	355
State-subsidized Private Schools [b]	419	415	210	283	629	698
Private Schools [c]	170	168	0	0	170	168
Total					1,097	1,221

[a] *Managed by municipalities with state funding*
[b] *Privately run but with state funding (state subsidy)*
[c] *Privately run and funded*

Results

The results of this study are presented separately for each of the stages described previously. Firstly, Stage 1 explores national data using the census and SIMCE indices. Secondly, Stage 2 looks at the data gathered by the aforementioned survey and describes the frequency with which students from one region in Chile state that they use digital resources to support their learning.

i. Stage 1 Results

The results that were obtained nationally and for the Metropolitan Region are shown in Table Appendix1-3 and table Appendix 1-4, respectively. Both tables also show the number of schools included in the analysis (N schools). In all of the regression models that were analysed, the SIMCE index is the dependent variable as it represents each school’s learning index. The tables therefore examine how the census indices and the contextual variables described above affect the SIMCE index.

In national terms, the Mathematics Model (Table Appendix1-3) reveals a significant relationship between the score on the Mathematics SIMCE and the ICT Infrastructure and ICT Administration indices. Specifically, each additional point in the census indices is reflected by a 30.13 and 20.13 point increase in the SIMCE test score. Unlike the other two indices, the Pedagogical Use of ICT index is not statistically significant, despite showing an 8.31 point decrease in the SIMCE score for each point on the census.

Furthermore, in the case of Reading, examined with the Reading Model (Table Appendix1-3), only the ICT Infrastructure index shows a statistically significant effect, with a 29.77 point increase in the SIMCE score for each point on the census. The ICT Administration index shows a positive effect of 7.90 points but it is not statistically significant. This is also the case for the Pedagogical Use of ICT index, which shows a 2.43 point increase in the SIMCE score for each point on the census, without being statistically significant.

Table Appendix1-3 National-level models

	Mathematics Model			Reading Model		
	Estimate	Std. Error		Estimate	Std. Error	
(Intercept)	182.23	8.71	***	204.04	6.63	***
ICT Infrastructure	30.13	9.77	**	29.77	7.44	***
ICT Administration	20.13	7.09	**	7.90	5.40	
Pedagogical Use of ICT	-8.31	9.18		2.43	6.99	
State-subsidized Private Schools [b]	42.59	2.52	***	30.01	1.92	***
Private Schools [c]	92.83	3.60	***	57.03	2.74	***
Location *(0: Rural; 1: Urban)*	17.40	4.08	***	7.06	3.11	*
Adjusted R-squared:		*0.32*			*0.24*	
p-value:		*0.00*			*0.00*	

******p=0 - 0.001; **p= 0.001 – 0.01; *p= 0.01 – 0.05; ºp= 0.05 – 0.1*

N schools: 1,694

[b] *Privately run but with state funding (state subsidy)*

[c] *Privately run and funded*

Within the Metropolitan Region, Table Appendix 1-4 (Metropolitan Region models) shows that the associations found for both Mathematics and Reading reveal similarities with the associations detected at a national level. The only difference in relation to the national-level model is that in the case of Mathematics the ICT Administration index loses statistical significance.

Table Appendix1-4 Metropolitan Region models

	Mathematics Model			Reading Model		
	Estimate	Std. Error		Estimate	Std. Error	
(Intercept)	170.49	15.53	***	187.44	12.22	***
ICT Infrastructure	46.60	15.00	**	39.99	11.81	***
ICT Administration	21.55	11.51	.	14.58	9.05	
Pedagogical Use of ICT	-13.93	15.60		-6.79	12.28	
State-subsidized Private Schools [b]	42.00	4.43	***	31.35	3.48	***
Private Schools [c]	89.83	5.57	***	58.36	4.38	***
Location *(0: Rural; 1: Urban)*	17.39	10.00	.	9.34	7.87	
Adjusted R-squared:		*0.31*			*0.23*	
p-value:		*0.00*			*0.00*	

****p=0 - 0.001; **p= 0.001 – 0.01; *p= 0.01 – 0.05; °p= 0.05 – 0.1*
N schools: 688
[b] *Privately run but with state funding (state subsidy)*
[c] *Privately run and funded*

ii. Stage 2 Results

The frequency with which students state they use each digital resource when studying Mathematics and Reading at school is shown as a percentage of the total number of students surveyed.

In the case of Mathematics (Table Appendix1-5), it can be observed that the most common response regarding the use of the various digital resources at school is Never (between 44% and 72%).

Table Appendix1-5 Frequency of use of digital resources when studying Mathematics, as stated by students

Frequency	Cell phone (%)	PC Software (%)	Search engine (%)	Website (%)	Social networks (%)
Always	16	5	14	6	15
Sometimes	40	23	25	21	21
Never	44	72	60	72	63
No answer	0	0	1	1	0

N students surveyed: 1,221

As was the case for Mathematics, for Reading (Table Appendix 1-6), it can be seen that digital resources are still not a regular feature in class for students. Between 52% and 72% state that they Never use the resources included in the list at school.

Table Appendix 1-6 Frequency of use of digital resources when studying Reading, as declared by students

Frequency	Cell phone (%)	PC Software (%)	Search engine (%)	Website (%)	Social networks (%)
Always	9	5	9	5	9
Sometimes	23	25	38	29	19
Never	68	69	52	65	72
No answer	0	0	0	1	0

N students surveyed: 1,221

Conclusions and discussion

Based on the results of this study, it is possible to answer our research question: "Is there any relationship between the efforts made by a public ICT for Education policy over 20 years and the children's learning achievements?" The relationship examined between the index for Quality of Education as measured by scores on the SIMCE tests and the indices for ICT Infrastructure and ICT Administration within schools is statistically significant and positive. This is reflected in the fact that as schools have better ICT infrastructure and manage their ICT more effectively, their students score higher on the SIMCE tests. This finding is consistent with the findings made by Díaz et al. (2014) regarding how infrastructure indices may be related to the administrative abilities of the management team. This is because these abilities impact directly on how they go about applying for and acquiring teaching tools and materials for their school. The changes and improvements in the student learning processes must be considered in direct association with each school's administrative process. The literature reveals the effects (both direct and indirect) of leadership on student learning, estimating that 25% of student progress may be due to the impact of the way in which the school is managed (Leithwood et al., 2004). In this sense, it could be suggested that it is not enough to simply have commitment from the teacher and to empower them to use technology in the teaching-learning process. Instead, it is also essential to have support from the management team as part of the project. It is also worth considering that, in general terms, the whole school benefits from using technology as the day-to-day running of a school can be improved by using ICT (Winthrop & Smith, 2012).

However, the Pedagogical Use of ICT index appears to be the only one of the three indices that were studied not to reveal any sort of statistically significant relationship (positive or negative) with the Quality of Education (SIMCE) index. This is examined in depth when, based on the students' learning experiences, we analyse the frequency with which the available resources are being used in teaching. In general terms, this frequency is low. The vast majority of students state that they never use digital resources when studying Mathematics or Reading. Given that this is the only index that is directly related to the teaching-learning process, this study provides evidence that public policy has failed to pay close enough attention to the pedagogical use of these new tools in the classroom.

Policies for providing schools with technological resources, such as Enlaces in Chile, should start to incorporate guidelines to help teachers understand the role expected of them when using technology. One example of such a guideline is orchestration (Nussbaum et al., 2013b). Studies have also analysed how teachers should be supported in their task of adding value to the learning process through the use of technology (Guzmán et al., 2009) by adequately administering logistics and social interactions in the classroom when using technological devices (Nussbaum & Díaz, 2013a).

Sharples (2013) reflected on the modern classroom becoming an increasingly complex and demanding place, where the teacher is not just responsible for preparing study plans, adapting official programs and managing both safety and discipline; they are also responsible for understanding and handling a variety of resources in order to improve the learning process. Faced with this range of demands, the author proposes adding orchestration to technology. For orchestration, the author understands it as being a second layer of technology that does not try to come between the teacher and the students; instead it acts as a personal guide for each of them. Furthermore, Prieto et al. (2011b) suggest that the presence of multiple forms of communication and access to information do not guarantee an improvement in learning unless the technology is accompanied by orchestration. In this case, orchestration is defined as the coordination of a teaching-learning event from the teacher's point of view. In this sense, orchestration tries to collaboratively manage (or subtly direct) the use of different resources and tools in the activities carried out in different educational contexts and social formats (group or individual work). The author adds that although often guided by a design (whether or not in the form of a script), orchestration can be modified with flexibility during the activity itself as different events occur (Prieto et al., 2011a). Similarly, the work by Perrotta & Evans (2013) considers that system-level factors have an influence on how technology is adopted in the context of learning. In this sense, orchestration would act as a metaphor for supporting the teachers' decisions by providing a guide for implementing educational strategies, technologies and practices. The work by the authors concludes that orchestration must be understood as being a cultural process that shows teachers how they can adopt innovative practices when integrating technology into their teaching.

Finally, if educational policy is focused on improving the quality of student learning, policymakers should consider experiences that allow teachers to develop the necessary skills to incorporate educational technologies. Furthermore, they should ensure that incorporating ICT in the processes of initial and continued development are considered as a priority, as has been the case in South Korea, Finland and Singapore (Falck et al., 2013).

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APPENDIX 2: EXAMPLE OF ORCHESTRATION

GUIDELINES FOR TEACHING TOPIC 2

Grade: 5th grade	**Area:** Mathematics	**Unit:** Fractions

Allocated time: 8 hours	**N° of Classes:** 8 classes

Topic: Types of fractions and ordering fractions.
Expected learning outcomes: Understand, represent, compare and order proper and improper fractions, mixed numbers and fractions equivalent to one whole.
Objectives: Read, write, represent, classify and order proper and improper fractions, mixed numbers and fractions equivalent to one whole.
Prior knowledge required for this activity: 1. The concept of fractions. 2. Parts of a fraction. 3. Reading and representing fractions. 4. The concept of wholes and sets.

CLASS 1: INTRODUCING THE CONTENT		
TIME	**TEACHER GUIDELINES**	**RESOURCES**
10 minutes	**<u>ACTIVITY 1</u>** **<u>OBJECTIVE:</u>** Recall prior knowledge with students to help them understand the new content that will be covered in class (Types of fractions and ordering fractions). **<u>EXPECTED OUTCOME:</u>** Students are expected to remember basic concepts related to fractions, with the aim of studying these in further detail later in the class. **<u>CLASSROOM DYNAMICS:</u>** Group activity (whole class) where the group will discuss the concepts, and the prior knowledge that emerges will be written on the board. **<u>OPENING:</u>** Start the class by explaining today's objective to your students: ***"We will learn about different types of fractions, we will classify them and order them according criteria".*** Then add that in order to meet said objective, they will start by recalling prior knowledge that will help them understand the new content. To recover the prior kno suggested at the beginning of the plan, the following questions are recommended: ○ ***Prior knowledge 1: "What are fractions?" (A number that expresses distribution or a part of something).*** ○ ***Prior knowledge 2: "What are the parts of a fraction?" (Numerator and denominator).*** ○ ***Prior knowledge 3: "What does each part of a fraction represent?" (The denominator shows the number of parts into which a whole is divided and the nu number of parts that we take from it).*** ○ ***Prior knowledge 4: "What examples of fractions can we think of?" (Invite some students to write examples of fractions on the board).*** ○ ***Prior knowledge 5: "How can we represent these fractions using wholes and sets?" (Suggest representing some as wholes, clarifying that first we divide the w number of parts indicated by the denominator and then we take the number indicated by the numerator. Then, follow the same procedure using sets).*** As well as recalling this conceptual element of fractions, it is also important to emphasize the use of fractions and how we use them in everyday life. Once this information has been recalled, invite your students to be introduced to the content: ***"Types of fractions and ordering fractions".***	- Whiteboard.

CLASS 1: INTRODUCING THE CONTENT		
TIME	**TEACHER GUIDELINES**	**RESOURCES**
30 minutes	**<u>ACTIVITY 2</u>** **<u>OBJECTIVE:</u>** Understand and classify types of fractions, as well as ordering them. **<u>EXPECTED OUTCOME:</u>** Students are expected to identify characteristics of, classify and compare proper and improper fractions, mixed numbers and fractions equivalent to a whole so that they can order them. **<u>CLASSROOM DYNAMICS:</u>** Group activity (whole class) where the content will be introduced. All of the students will be encouraged to participate by answering questions orally and in writing, making real examples using paper and comparing fractions. **<u>INSTRUCTION:</u>** Invite your students to take part of the presentation to be covered in class. The material introduces the content through a contextualized situation, where two swimmers talk about how they have an important competition for which they must prepare. An important part of this preparation consists of eating healthily. With this in mind, they reveal a recipe for the type of food they eat, in this case a "fruit salad". When introducing the recipe, the following questions are recommended: ○ ***What are the characteristics of this text? (It shows the ingredients and steps for making a fruit salad).*** ○ ***What ingredients do you need to make this recipe? (Those included in the power point).*** After introducing the recipe, a slide is shown which invites the students to recall previous classes. Give the students space to think about and recall what they are being asked Following this, show them the answers, which are written in red (this will be repeated throughout the whole presentation). Once they have identified that the ingredients are expressed as fractions, the students are invited to think about how these could be represented. The presentation includes box with phrases such as "try it in your exercise book" and "let's write some ideas on the board". The idea is that when these appear, you give the students a few minutes to do wh asked of them. All of the ingredients required for the recipe will be covered in this way, one by one. When it is time to represent the orange as a fraction, the students will realize that the nu Is greater than the denominator. At that moment, ask questions such as: ○ ***"What can we do in this case?" (We need more oranges).***	- Computer for the teacher with PPT *01. – Introduction_ (Types of fractions and ordering fractions).* - Projector. - Squares of paper. - Exercise books.

- ***"If the numerator says that I take seven pieces but the orange is divided into two, what can I do?" (Divide whole oranges in two until there are seven pieces to take).***

The idea is to guide the students to the conclusion that when the numerator is greater than the denominator, more than one whole is needed. Following this, a similar example is shown using the banana.
Given that they have already seen what happens with the orange, encourage the students to apply what they have learned.
Subsequently, a slide is shown explaining what the students have just observed. This time, it is revealed that the fractions that have been represented correspond to proper and improper fractions, as well as fractions equivalent to a whole. Read the definitions with your students, ask them to give other examples and then have them write these definitions in their exercise book
It is then time to represent the yoghurt as a fraction. This will be an ingredient that is expressed as a mixed fraction. When you show this, ask questions such as:

- ***"What characteristics does this number have?" (It has a whole number and a fraction).***
- ***"What do you think this represents?" (Encourage them to share any ideas they have regarding this).***

Following this, the presentation shows how this fraction (the yoghurt) can be represented. As with the previous cases, it is then explained that this type of fraction is called a "mixed fraction" as well as showing how they are read and represented. Show other examples of a mixed fraction, ask the students to read and then represent them. Finally, have them write the definition in th exercise books.
Once this way of classifying fractions has been explained, a series of fractions is revealed which the students must classify as proper, mixed or fractions equivalent to a whole. Invite your students to participate, comment on what their classmates are doing, whether they are right or wrong and why.
When the recipe has been shown and the fractions have been represented, the swimmers explain that they are now ready to compete. It is in this part of the presentation where, based on the competition, it is explained how to compare and order fractions.
The presenter of the competition will comment on how each swimmer is doing. In the beginning, he says that one of them has covered "one fifth", while the other has covered "one sixth"; asking which of them has swum further. In this part of the class, it is important for you to encourage your students to say what they think the answer is and to explain why. Then, an explanati is given of how to compare two fractions by representing them in picture form. In order to do so, ask the following question:

- ***"What characteristics must the wholes have in order to compare them?" (They must be equal).***

When the students answer this question, use the presentation to show how fractions are represented and compared using pictures. This exercise is repeated several times throughout the presentation as updates are given on the competitors' progress and the students must work out who is winning. At the same time, the students are shown how to represent numbers on a numb line. In order to do so, ask the following questions:

- ***"What is a number line?" (It is a line that is divided into equal parts, with each of these parts a number).***
- ***"What does each number on the number line represent?" (Each number represents a whole).***

Explain that, as with the previous case, in order to compare two fractions the wholes on the number line must be the same size and divided into the number of parts indicated by the denominator. With this, we can then take the number of pieces indicated by the numerator. Show other examples of representing fractions on a number line, so as to ensure that the students h understood the procedure. Then, tell the students to write down how to compare two fractions in their exercise books.
As the swimmers advance, the presenter indicates how much of the distance each one has covered. In one of his updates, he says that one of them has covered "three sixths" and the other "on half". The students are asked to represent said fractions in order to work out which swimmer is in front. By doing this exercise, the students will notice that they are tied and that the fractions represent the same thing. The presentation explains that such fractions are called equivalent fractions. You are recommended to stop for a moment in this part of the class in order to explain t type of fraction. Show some strategies for finding equivalent fractions, such as doubling both the numerator and the denominator. You could also clarify that when we want to see if two fractions are equivalent, we cross multiply them and if the numerators are the same, then the fractions are equivalent.
Suggest some fractions and invite the students to apply what they have learned by determining which fractions are equivalent.
Finally, the result of the competition is given and the students are asked to apply what they have learned in order to work out which of the swimmers has won.

CLASS 1: INTRODUCING THE CONTENT		
TIME	**TEACHER GUIDELINES**	**RESOURCES**
5 minutes	**ACTIVITY 3** **OBJECTIVE:** Show that the students have understood the main ideas of the class. **EXPECTED OUTCOME:** Students are expected to answer questions regarding the main ideas of the class, therefore showing they have understood the topic of "Types of fractions and ordering fractions". **CLASSROOM DYNAMICS:** Group activity (whole class), where questions will be asked that summarize and assess the work covered in today's class. Student participation must be encouraged so as to assess their learning. **CLOSING:** end your class by summarizing the main ideas of the class. In order to do so, you are recommended to ask questions such as : ○ ***"What did we do today?" (We watched a presentation that explained about types of fractions and how to compare them before ordering them).*** ○ ***"How useful is what we learned today?" (To understand the characteristics of a proper fraction, improper fraction, mixed number and equivalent fractions so that we know how to identify, represent, compare and order them).*** ○ ***"For which of the fractions do I only need one whole in order to represent them?" (For proper fractions and fractions equivalent to one whole).*** ○ ***"For which of the fractions do I need more than one whole in order to represent them?" (For improper fractions and mixed numbers).*** ○ ***"What are the steps for comparing two or more fractions?" (Draw a whole or a number line that is the same size, divide it into the number of parts indicated by the denominator and take the parts indicated in the numerator. Whichever covers more is the larger of the fractions).*** End the class by congratulating the students for the work they have done.	- Whiteboard.

APPENDIX 3: OBSERVATION SCHEDULE

1. Class details

School		Date	
Teacher		Group	
Class number		Observer	
Class type	Presentation	Practice	Application

2. Activity Record

Activity description		
	Period	
	Objective	
	Resource	
	Duration (mins.)	
	Support received	

Activity description		
	Period	
	Objective	
	Resource	
	Duration (mins.)	
	Support received	

Activity description		
	Period	
	Objective	
	Resource	
	Duration (mins.)	
	Support received	

Activity description		
	Period	
	Objective	
	Resource	
	Duration (mins.)	
	Support received	

Options for filling in Activity Record

Period		Objective		Resource		Support received	
1	Introduction	1	Introduction	1	XO	1	No support
2	Practice	2	Presentation	2	PPT or PDF	2	Teaching advisor
3	Wrap Up	3	Practice	3	Study guide		
4	Non-instructional	4	Test	4	Exercise book/Text book		
		5	Other	5	Other (record different software as distinct resources)		

3. Record of Observations

Class structure *(prepares the class, uses suggested resources, adequately defines periods throughout the class)*
Record of Observations:

Use of Planning*(Uses time organization strategies, suggested methodology and questions; Prepares suggested teaching resources)*
Record of Observations:

Integration of planning and resources during class
Record of Observations:

Content explanation
Record of Observations:

Feedback on content work (*Responds to questions, provides feedback, explains possible mistakes, positively reinforces the content learned)*
Record of Observations:

Group management strategy during activity *(Observes student behaviour, keeps attention focused on the activity, monitors student behaviour)*
Record of Observations:

APPENDIX 4: OBSERVATION CRITERIA

Class structure*(prepares the class, uses suggested resources and properly defines periods throughout class)*	
Ideal	The teacher explains the class objectives, develops activities consistent with the teaching objective and includes both an appropriate introduction and wrap up activity.
Good	The teacher explains the class objectives, develops activities consistent with the teaching objective and includes an appropriate introduction or wrap up activity.
Improvable	The teacher explains the class objectives, develops activities consistent with the teaching objective, but without including an appropriate introduction or wrap up activity.
Insufficient	The teacher does not distinguish between the different periods of class (introduction, practice, wrap up).

Use of Planning *(Uses time organization strategies, suggested methodology and questions; Prepares suggested teaching resources)*	
Ideal	The teacher uses all planning resources, time organization strategies, methodology suggestions and the use of questions to give continuity to the different class periods.
Good	The teacher uses all planning resources, methodological suggestions and the use of questions, but uses their own way of dividing class time rather than one set out in the planning.
Improvable	The teacher uses some of the planning suggestions during the development of the class.
Insufficient	The teacher does not use planning at all during class.

Integration of planning and resources during class	
Ideal	The teacher uses planning coherently with the established teaching objective and integrates **all suggested learning resources.**
Good	The teacher uses the planning guidelines and **integrates only some** of the suggested teaching resources.
Improvable	The teacher does not use the planning, but does use **some of the suggested teaching resources**.
Insufficient	The teacher does not use the planning or any suggested resource.

Content explanation	
Ideal	The teacher **clearly explains the characteristics and complexity of the content**, answers **questions about the content** and **raises questions suggested in the guidelines**.
Good	The teacher **explains the content to the students** and **links activities with the class objectives**.
Improvable	The teacher answers **questions about the content** (only when asked by the students).
Insufficient	The teacher provides no explanation or clarification regarding the content.

Feedback on content work *(Responds to questions, provides feedback, explains possible mistakes, positively reinforces the content learned)*	
Ideal	The teacher **is active in providing individual feedback** to students based on **direct observation and student demand**.
Good	The teacher **provides feedback** on work, based on **direct observation and student demand**.
Improvable	The teacher **provides feedback** on content work, attending to students only when they request assistance.
Insufficient	The teacher provides no feedback on student work, scarcely supervising at all.

Group management strategy during activity *(Observes student behaviour, keeps focused on the activity, monitors student behaviour)*	
Ideal	The teacher maintains **control and attention** of the entire class, **monitors** student work, **answers questions**, supports students, is proactive, **approachable** and **encourages student participation**.
Good	The teacher maintains **control of the group** during activities, **answers questions** and **helps** those students requiring support.
Improvable	The teacher maintains **control of the group**, attending to students only when they request assistance.
Insufficient	The teacher barely maintains control of the group, does not support the weakest students, has scarce or zero interaction with the class and is not dynamic.

APPENDIX 5: STUDENT SURVEY

Views of the teaching and learning process from the perspective of students and teachers from the Metropolitan Region

I. Information about the survey:

This survey is designed based on a recent review of the literature. It aims to give rise to indicators highlighting the perceptions of teachers and students about different components of the teaching and learning process.

II. How to answer:

- Select only one alternative for each question (mark with an X or shade the box).
- If answering "Other", please provide a reason *Which* or *Why*.
- Answers will be anonymous.

1	What would you like your **main** objective to be at school?
A	To learn according to my learning pace and learning style.
B	To develop myself fully in line with my peers.
c	To learn what is appropriate at my level, at the same time as the rest of the class.
d	Other, What?

2	What is the **main** condition you need to adequately fulfil your objective?
a	A group of peers that behave appropriately so that the teacher can teach the subject effectively.
b	Have different moments to: cover new material, and work on what **I** find most difficult.
c	Have materials that allow for different learning styles.
d	Other, What?

3	Is the condition that you chose in Question 2 being met?
a	Yes
b	No

4	What motivates you to achieve your objective at school?
a	It is obligatory.
b	Because I like the school environment.
c	I enjoy what I do.
d	Other, What?

.

5	Do you think your teacher understands your needs?
a	Yes
b	No

.

6	What is your main need in the educational process?
a	To be more motivated to learn.
b	To be able to learn at my own pace without the teacher moving on to new material too quickly.
c	For my teachers to have other ways of teaching that help me understand the subject better.
d	Other, What?

.

7	Do you think that the necessary conditions are present for you to be able to study effectively in the classroom?
a	Yes
b	No
*	Why?

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8	Do you think that there are differences among the students in your class?
a	Yes
b	No
*	If you answered **<u>Yes</u>** please proceed to Question **<u>9</u>**, if you answered **<u>No</u>** please move on to Question **<u>10</u>**.

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9	Where is this most notable?
a	Different cultures.
b	Different families.
c	Different economic backgrounds.
d	Different learning paces.
e	Other, What?

.

10	Do you think it is necessary for your family to play a role in the educational process?
a	Yes, because I would like my family to be involved in educational activities at school and to help me understand at home what my teacher teaches me at school.
b	A little, I would like that my family were kept up to date with what is happening at school, but parent/guardian meetings should be enough.
c	Not really, I do not think my family has anything to do with my learning process.

11	What do you think society expects of the teachers at you school?
a	That they teach and support us with whatever we need.
b	That they teach me to be a professional.
c	That they educate and guide me in my personal behaviour.
d	Other, What?

12	What do you think **people outside school** expect of you as a student?
a	To build strong and lasting social connections.
b	To learn so that following school I can continue to study and become a professional.
c	To learn how to behave properly.
d	Other, What?

13	What do you think your **teacher** expects of you?
a	To build strong and lasting social connections.
b	To learn so that following school I can continue to study and become a professional.
c	To learn how to behave properly.
d	Other, What?

14	What do you expect of your teacher?
a	That they teach and support us with whatever we need.
b	That they teach me to be a professional.
c	That they educate and guide me in my personal behaviour.
d	Other, What?

APPENDIX 6: TEACHER SURVEY

Views of the teaching and learning process from the perspective of students and teachers from the Metropolitan Region

I. Information about the survey:

This survey is designed based on a recent review of the literature. It aims to give rise to indicators highlighting the perceptions of teachers and students about different components of the teaching and learning process.

II. How to answer:

- Select only one alternative for each question (mark with an X or shade the box).
- If answering "Other", please provide a reason *Which* or *Why*.
- Answers will be anonymous.

1	What do you feel is your **main** objective within the educational process?
a	To respect the learning pace of each individual student.
b	To support the overall development process of the group of students under my responsibility.
c	To closely follow the national curriculum as set out by the Ministry of Education with the whole class.
d	Other, What?

.

2	What is the **main** condition you require in order to effectively fulfil your objective?
a	To have a well behaved class that allow me to teach new material.
b	Have different times to: cover new material from the curriculum and work on my students' areas of weakness.
c	To draw from a wide variety of resources that allow me to diversify the learning experience.
d	Other, What?

.

3	Is the condition that you chose in Question 2 being met?
a	Yes
b	No*

..

4	What motivates you to achieve your objective at school?
a	This is a job.
b	Because I like the school environment.
c	I enjoy what I do.
d	Other, What?

.

5	Do you feel you know what your students' needs are?
a	Yes
b	No
*	If you answered **<u>Yes</u>** please proceed to Question **<u>6</u>**, if you answered **<u>No</u>** please move on to Question **<u>7</u>**.

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6	From your point of view what are your students' needs?
a	Greater stimulation to motivate them in the learning process.
b	To learn at their own pace.
c	To learn according to their own learning style.
d	Other, What?

.

7	Do you think that the necessary conditions are present for your students to be able to study effectively in the classroom?
a	Yes
b	No
*	Why?

.

8	Do you think the make-up of your class is heterogeneous?
a	Yes
b	No

*	If you answered **Yes** please proceed to Question **9**, if you answered **No** please move on to Question **10**.

.

9	Where is this most notable?
a	Different cultures.
b	Family background.
c	Different socio-economic backgrounds.
d	Different learning paces.
e	Other, What?

.

10	What do you perceive the role of the family within the educational process to be?
a	The family should have an active participation within the educational process ***(Role: to be involved in the school's educational activities, to act as a teacher at home, etc.)***
b	The family should be kept up to date at specific moments, such as parents/guardians meetings, appointments, etc. ***(Role: to be informed about the teaching and learning process of their pupils)***
c	Family participation is irrelevant in the students' learning process.

.

11	What expectations do you think society has about the role of teachers?
a	To satisfy the students' educational and welfare needs.
b	To academically shape future careers.
c	To educate and guide the students in their personal behaviour.
d	Other, What?

.

12	What expectations do you think society has about school students?
a	To build strong and lasting social connections.
b	To learn so that following school they can continue to study and become a professional.
c	To learn how to behave properly.
d	Other, What?

.

13	What expectations do you have of your students?
a	To build strong and lasting social connections.
b	To learn so that following school they can continue to study and become professionals.
c	To learn how to behave properly.
d	Other, What?

14	What expectations do you think your students have of you?
a	That we satisfy their educational and welfare needs.
b	That we shape them academically so that they can go on to become professionals.
c	That we educate and guide them in their personal behaviour.
d	Other, What?