PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE
ESCUELA DE INGENIERIA

A STUDY OF THE MOOC-BASED BLENDED LEARNING APPROACH FROM STUDENT'S PERSPECTIVE

JOSEFINA MARÍA HERNÁNDEZ CORREA

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

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Santiago, Chile, August, 2021

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To my husband, parents, and sister, for always being there for me. To my children, Amparo and Rafael, who came along the way. To Mar, for always guiding me.

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Hace cinco años y medio decidí estudiar un doctorado sobre tecnologías educativas. Buscando alternativas de programas, conocí a Mar, mi supervisora y ahora amiga. Por ende, me gustaría comenzar por agradecerle a ella todo su esfuerzo y dedicación en mi proyecto de tesis. Por aguantarme e incentivarme en mis ideas, y por siempre darme ánimo, ver lo positivo y ayudarme a avanzar. Más aun, me gustaría agradecerle su amistad, compañerismo, y constante entusiasmo e inspiración durante todos estos años. Mar, has sido una gran tutora y guía, pero, sobre todo, has sido una gran amiga. Al fin terminamos este primer proyecto, pero estoy segura de que seguiremos siempre encontrando nuevos desafíos juntas.

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RESUMEN

Lo que los adultos de hoy en día aprendieron en la escuela y en la universidad hace veinte, treinta o incluso sesenta años, no es muy diferente a lo que se enseña hoy en clase, aunque el mundo actual es muy diferente al mundo en que crecimos nosotros. Además, los estudiantes de hoy son nativos digitales, una generación que se caracteriza por estar expuesta a las tecnologías de la información y a los medios digitales desde una edad muy temprana, mayor que la de cualquier generación anterior. Por lo tanto, el sistema educativo debe adaptarse a estos cambios y replantearse las metodologías de enseñanza, para cambiar las clases tradicionales basadas en conferencias unidireccionales, a enfoques de aprendizaje centrados en el alumno. En particular, esta tesis se centra en el modelo de aprendizaje mixto (Blended Learning) basado en MOOCs, que se caracteriza por el uso de tecnologías en el proceso de aprendizaje, que ha ido en aumento en los últimos años. Existe una necesidad urgente de profundizar en el conocimiento del impacto de la metodología Blended Learning con MOOCs en la literatura actual.

Esta tesis doctoral propone un estudio en profundidad de la metodología de aprendizaje Blended Learning con MOOCs, para entender el impacto de este modelo de enseñanza en estudiantes de educación secundaria, postsecundaria y superior. Ampliamos la literatura actual en el área mediante la realización de tres estudios de caso y un posterior estudio multicaso que cruza los tres casos individuales en una propuesta de investigación integral. En concreto, exploramos el Blended Learning con MOOCs desde la perspectiva del estudiante, analizando su adopción de la metodología de enseñanza y sus resultados de aprendizaje en estas experiencias. Finalmente, presentamos afirmaciones que resumen los principales hallazgos y resultados de este estudio. En primer lugar, concluimos que la metodología de aprendizaje Blended Learning con MOOCs puede ser adoptada con éxito por los estudiantes, y es un método eficaz para la enseñanza y el aprendizaje de los contenidos del curso. Los estudiantes rinden igual o mejor en las evaluaciones del curso con esta metodología que en una experiencia de aprendizaje tradicional, y perciben que aprenden los contenidos del curso con mayor eficacia que en los enfoques de aprendizaje tradicionales. Además, afirmamos que interactuar consciente y eficientemente con un MOOC en una experiencia de aprendizaje Blended Learning está significativamente relacionado con mejores resultados de aprendizaje. Finalmente, concluimos que una vez que los estudiantes adoptan la metodología de aprendizaje Blended Learning con MOOCs, cambian su paradigma de aprendizaje, se comprometen con los MOOCs y se hacen conscientemente responsables de su propio proceso de aprendizaje, mejoran significativamente sus resultados de aprendizaje.

Palabras Claves: Aprendizaje Mezclado, Cursos Online Masivos y Abiertos (MOOC), Aprendizaje Centrado en los Estudiantes, Adopción, Resultados de Aprendizaje, Métodos Mixtos de Análisis, Educación Secundaria, Educación Postsecundaria, Educación Superior, Estudio de Multicasos.

ABSTRACT

What today's adults learned in school and college twenty, thirty or even sixty years ago, is not much different than what is taught today in class, even though today's world is very different than the one we grew up in. Moreover, today's students are Digital Natives, a generation characterized by being exposed to information technology and digital media from a very young age, greater than that of any prior generation. Therefore, the educational system must adapt to these changes and rethink the teaching methodologies and shift from the traditional lecture-based class, to student-centered learning approaches. In particular, this thesis focusses on the MOOC-based blended learning model, which is characterized by its use of technology in the learning process and has been on the rise in the past years. However, there is an urgent need for a deeper understanding of the effectiveness of the MOOC-based blended learning methodology in current literature.

This doctoral thesis proposes an in-depth study of the MOOC-based blended learning methodology, to understand the impact of this teaching model in secondary, post-secondary and higher education students. We extend current literature in the area by conducting three case studies and a subsequent multicase study that cross-analyses the three individual cases into one integral research proposition. Specifically, we explore MOOC-based blended learning from the student's perspective, analyzing their adoption of the teaching methodology and their learning outcomes in these experiences. Finally, we present assertions that summarize this study's main findings and results. First, we conclude that the MOOC-based blended learning methodology can be adopted successfully by students, and it is an effective method for teaching and learning course contents. Students perform the same or better in course assessments with this methodology than in a traditional learning experience, and they perceive they learn course contents more effectively than in traditional learning approaches. In addition, we affirm that interacting consciously and efficiently with a MOOC in a MOOC-based blended learning experience is significantly related to better learning outcomes. Finally, we conclude that once students adopt the MOOC-based blended learning methodology, change their learning paradigm, engage with the MOOCs, and consciously become responsible for their own learning process, they significantly improve their learning outcomes.

Keywords: Blended Learning, Massive Open Online Course (MOOC), Student-centered Learning, Adoption, Learning Outcomes, Mixed Method, Secondary Education, Postsecondary Education, Higher Education, Multicase Study.

1. INTRODUCTION

1.1 Motivation

"If Rip Van Winkle were to wake up today after sleeping for 130 years, the only thing he would recognize would be the typical school classroom"

- *G. Dryden, 2000* [1]

What today's adults learned in school and college twenty, thirty or even sixty years ago, is not much different than what is taught today in class, even though today's world is very different than the one we grew up in. We received education in a world without internet, which was just beginning to open up to globalization, with limited sources of information and more conventional paradigms. The future (today's present) seemed much more predictable than what it turned out to be. What about today's students? Even though we now know their future is far from imaginable, and that "*the combination of the Internet, smart phones, and Google allows nearly any question to be answered immediately* [2]", is it ok to give them the same education we received?

Today's college students are what is known as Generation Y [3], the Net Generation [4] or Millennials [5]. They are the generation born between 1980 and 1995 more or less. Today's middle and high school students are known as Generation Z [6], [7], born between 1996 and 2010. These two generations are characterized by being exposed to information technology and digital media from a very young age, greater than that of any prior generation [8]. They are accustomed to 24/7 information connectedness, multitasking [9] and collaborative experiences [8]. Therefore, for the purpose of this study we will combine them in the term Digital Natives (DN) [10].

As students, Digital Natives bring new challenges to the educational community. Particular knowledge is not as important anymore as the ability to acquire new skills, information, and talents [11]. For example, Digital Natives have a certain affinity for seeking information through videos: you will most likely find a Generation Y or Z student learning how to make lasagna by watching someone prepare it in a YouTube video rather than reading a recipe from a cooking book or web page [7].

A report from the U.S. Department of Commerce in 2003 revealed that education is ranked as the least technology-intensive enterprise among 55 U.S. industry sectors [12], [13]. Therefore, the educational system must adapt to these changes and rethink both the teaching methodologies and the contents that are being taught. There is an urgent need to shift from a teacher-centered paradigm [8], where the teacher is responsible of communicating knowledge to the students, generally in a unilateral lecture format [14], to a student-centered learning paradigm [8], where the students must build their own knowledge through actions and their experiences in the world, as “architects” of their learning process [14].

There are many student-centered teaching methodologies that help create innovative learning experiences, rather than memorization of knowledge and facts. In particular, the learning approach called Blended Learning (BL) is characterized by its use of technology in the learning process, and therefore, engages Digital Native learners. Depending on the technology and the pedagogical methodology, teachers have thousands of alternatives to choose from to adopt blended learning in their teaching experiences.

Moreover, the MOOC-based blended learning model has been on the rise in the past years [15]. MOOCs are Massive Open Online Courses. *Massive*, because one course can have unlimited registered students at the same time. O*pen*, because they are available to everyone, without prerequisites, and the access to the educational resources is free of charge. O*nline*, because the course is done remotely via the Internet and does not require physical attendance at a classroom. C*ourse*, because they have a course-like structure, with learning objectives to be achieved by students after certain activities within a given period of time, and assessments to evaluate the knowledge acquired by students.

MOOCs present new opportunities for teaching and learning [16]. The literature reports many ways of reusing and integrating MOOCs into formal education, and institutions are exploring and experimenting with blended learning methodologies that aim at integrating MOOCs in the formal curriculum [17]–[19]. To positively impact students through a MOOC-based blended learning experience, they must successfully adopt this teaching methodology, and it must affect or at least maintain their learning outcomes when comparing to a traditional lecture.

Current literature offers thousands of comparisons between classes with technological interventions and classes without technology since the 1980s, from kindergarten to graduate school. Each analyses provides a valuable piece of information, focusing on specific questions such as subject matter, grade level, type of technology, etc., but no single one is capable of answering the overarching question of the overall impact of technology use on student achievement [20], [21] . Moreover, no studies were found in the literature that analyze the effectiveness of the MOOC-based blended learning model in students across different educational grade-levels.

Additionally, in 2020 the Coronavirus Pandemic has caused a huge rise in technology-supported learning worldwide [22]. Therefore, there is an even more urgent need to provide teachers and educational institutions’ staff members with a better understanding of the different blended learning methodologies and their effectiveness as a reference for future designs.

This doctoral thesis proposes an in-depth study of *blended learning with MOOCs from student's perspective*, to understand the impact of this teaching methodology in secondary, post-secondary and higher education students. Specifically, we extend current literature in the area by conducting three case studies and a subsequent multicase study that cross-analyses the three individual cases into one integral research proposition. We explore MOOC-based blended learning from the student's perspective, analyzing their adoption of the teaching methodology and their learning outcomes in these experiences. Finally, we present ten assertions regarding this approach, which will help future teachers, students, educational institutions and educational researchers in designing, implementing and assessing future blended learning experiences.

1.2 Scope

This study adopts many of the current terms and concepts in the literature. To facilitate the readability of this work and better understand its main contributions, the following subsections introduce and define the main concepts and how they are employed in the context of this dissertation.

1.2.1 Blended & hybrid learning: concepts and definitions

"Our world is also blended, and it is blended so much that we hardly see the individual components of the blend any longer." [23].

Due to the COVID Pandemic, the term "Hybrid Education" has become very popular the last year. Even though hybrid and blended learning are similar and often used interchangeably to discuss the mix of in-person and online learning, they describe different learning models [24].

Hybrid Learning has many definitions depending on the context and time span. However, the world's recent educational changes due to the Coronavirus have brought consensus over the definition of Hybrid and the differences with Blended Learning. In this work we will refer to Hybrid Learning as an educational approach where some individuals participate in person and some attend a class virtually (online) at the same time using technologies such as video conferencing [25]. For example, an instructor can stream live in-person lectures for students to tune in from home, and/or a recording of that lecture can be shared for students to review or watch later if they could not attend class synchronously [24].

On the other hand, Blended learning requires physical in-person class time between instructors and students [24]. In BL, instructors and facilitators combine in-person instruction with online learning activities, and learners complete some components online and others in a face-to-face model [25].

In summary, both types of learning involve a mix of in-person and online learning, but in hybrid learning, the in-person learners and the online learners are *different* individuals, while in blended learning, the *same* individuals learn both in person and online [25].

In this thesis we will refer to a Blended Learning methodology, because all our students participate both in the face-to-face and technological experiences. BL has been defined in many ways in the literature [26], therefore, in this work we combine several of these descriptions to define blended learning as *the combination of face-to-face activities with technology-supported activities* [27], [28] *in student-centered learning environments* [29] *where the teacher's main role is to create learning experiences that encourage students to* *be active seekers of their own knowledge* [30] *instead of spoon-fed learners* [29]. This definition will be used throughout this entire dissertation.

Most studies on blended learning indicate that there is no ultimate formula for blending the distance and face-to-face learning components [31]. To the contrary, designers of blended learning must adjust their BL teaching model to each learning context. In current literature one can find blended learning models that range from 30 to 79% of the content delivered outside the classroom [32], [33]. Also, Graham et al [34] proposes distinguishing blended learning models according to the predominance of the technology supported activities, as is illustrated in Figure 1-1.

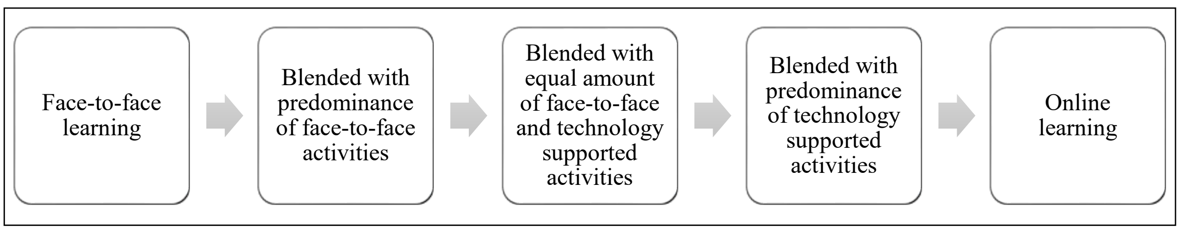

Figure 1-1: Types of blended learning models (Adapted from Graham et al [34])

In addition, [23] analyzed all the sources in two meta-analyses conducted by Barbara Means [35], [36] and identified thirteen different blending techniques, which are labelled as: laboratory assessments, online instruction, e-mail, class web sites, computer laboratories, mapping and scaffolding tools, computer clusters, interactive presentations and e-mail, handwriting capture, evidence-based practice, electronic portfolios, learning management systems, and virtual apparatuses.

Particularly, educational institutions are exploring and experimenting blended learning models with MOOCs [37], [38]. Current literature provides different approaches to BL design with MOOCs. For example, [39] proposes five models based on the relevance for the institution, shifting the scope from delivery to purpose. Also, [40] documented six blended learning models for integrating MOOC technologies with face-to-face instruction.

Therefore, each instructor must design or decide on a blended learning model that best fits their learning situation [31], [41], learners' characteristics and/or the context's external factors and limitations. Regarding learners' characteristics, computer competence, self-regulation skills, family and social support, age and student's workload are some of the factors that should be taken into account [42]. Some of the external factors and limitations that need to be considered are: distant vs. face-to-face maximum or minimum support times [42], time to implement, technology access, content's appropriateness [41], institutional effort and curriculum alignment [37], [38].

1.2.2 Impact of MOOC-based blended learning

"There is such thing as Quality, but that as soon as you try to define it, something goes haywire. You can't do it"

Robert M. Pirsig, 1974 [43]

"Is blended learning effective?" is a question continually asked by researchers, practitioners, and policy makers all around the world for the last forty years [12]. In the literature, one can find many studies addressing this question and answering it for a specific subject matter, grade level, and type of technology. Then, a few prominent authors have performed meta-analyses and even second-order meta-analyses to understand the impact of blended learning and its relationship with student's learning outcomes [23]. Specifically, Robert Bernard et al. [21], [44], Barbara Means et al. [35], [36], Zhao et al. and Tamim et al. [20] have contributed with important meta-analyses, where they measure effectiveness in terms of achievement gains, and analyze the "effect sizes" between a treatment (technology-supported) group and a control group that has a traditional face-to-face learning experience [12]. Each of these studies has found small to moderate positive effect sizes in favor of blended learning [23]. Even so, student's grades are only *part* of what constitutes a learning experience. Its effectiveness, therefore, depends on how well it helps teachers and students achieve the desired instructional goals [12].

Therefore, even though "mean comparison" studies contribute with important information, they could under-represent potentially meaningful contributions to improving education [12], [45] if not complemented with other aspects, such as the goals of instruction, teacher effectiveness, subject matter, age level and fidelity of technology implementation [20].

As a result, in this work we will say that a MOOC-based blended learning strategy has been effective or has caused an *impact* on students when they successfully **adopt** the teaching methodology and it improves or at least maintains their **learning outcomes**. In the following section we discuss what students' adoption and learning outcomes mean in the context of this dissertation.

1.2.2.1 Student's adoption

In the literature, there are multiple definitions of adoption, along with metrics and instruments for measuring it. Adoption is also confused with (or considered a synonym of) engagement. However, engagement is not necessarily the same as adoption. Engagement in educational technology is defined in the literature as the learners' involvement with the course content and with the tools available within the learning environment [46], [47]. Meanwhile, with adoption we refer to the adoption of a learning methodology that uses educational technology. In this study we have defined adoption as: *a paradigm shift* *regarding a learning process that integrates new methodologies and/or elements in the educational practice* [48]–[51].

Extensive research has been carried out on student engagement in face-to-face courses and online courses, but there aren't many studies proposing models or methods to measure students' adoption in MOOC-based blended learning contexts [52].

Qualitatively, many studies measure adoption through self-reported surveys or questionnaires that cover different dimensions, such as attitude, beliefs and abilities towards a new technology [53]. The Technology Acceptance Model (TAM) is one of the most famous self-reported questionnaires that explains and predicts the attributes that affect a user's adoption and their behavior when exposed to a new technology [54]–[56]. The problem with TAM though, is that it does not take into consideration the use that the person is giving the technology, nor the practice it is intended for. For measuring adoption of an educational technology, the Technological Pedagogical Content Knowledge (TPACK) [57] has been applied as an analytical instrument to understand a teacher's abilities and knowledge necessary to integrate technology in their classrooms [58]. This instrument is also a self-reported questionnaire, and is only intended for teachers, not students.

Quantitative studies, on the other hand, have used clicks as the proxy for measuring adoption, but this method is also controversial. For example, the 2019 EDUCAUSE Horizon Report states that "*clicks are not necessarily translatable to what students have learned… since looking at (or clicking on) something is not a proxy measure of learning*". Moreover, it says that "*the focus on measuring learning remains a trend that will drive technology adoption… but there are major obstacles to scaling and adopting technology solutions in education*" [59].

When using MOOCs in a blended learning environment, not much is proposed in the literature about how to measure student's adoption of the BL methodology. Many studies report either on student's engagement in face-to-face courses or their engagement in online courses, but when it comes to student's adoption in a BL context with MOOCs, very little research has been found [52]. In this study we contribute to current literature with a novel method to measure and analyze student's adoption of blended learning, according to our definition. This procedure combines qualitative and quantitative data in a mixed method analysis.

1.2.2.2 Student's learning outcomes

Blended Learning has been known to improve or at least maintains students' learning outcomes when compared to traditional teaching methodologies [60]–[64]. Both qualitative and quantitative instruments can be used to measure Blended Learning's impact in students' learning outcomes. Quantitative instruments can be: (1) pre and post exam results on the specific contents of an experiment; (2) a complete courses' evaluations results (tests, quizzes, homework, etc.); (3) a courses' final grade; and (4) a third person's evaluation on students' learning outcomes [62], [64]. However, these types of measurements are very complex to collect because of all the external factors that could affect the results. Therefore, there are very few studies that report evidence based on quantitative instruments [65]. Most measurements are based on qualitative instruments, such as: (1) self-assessment of an activity through a questionnaire about the perceived improvement in skills, goal achievement, learning outcomes or confidence in their skills and/or knowledge; (2) self-assessment through pre and post experiments, using instruments that measure perception or motivation; and (3) a third person's evaluation of his/her perception of improvements in student's learning outcomes. According to [63], 77% of studies use self-reported information about peoples' perceptions, like questionnaires or surveys, to evaluate the effectiveness of an experiment [66].

This work proposes measuring student's learning outcomes through a mixed method that combines both qualitative and quantitative data, to obtain a holistic understanding of their entire learning process. We recollected their scores in the different course and technological assessments, along with their perceptions of their performance and of their learning outcomes and combined all this data to truly understand how and what they learned in each blended learning experiences.

1.2.3 Objects of study

"Today's students are no longer the people our educational system was designed to teach."

- *Marc Prensky (2001)* [10]

Prior research has investigated the impact of MOOC-based blended learning in different educational contexts, but when looking for literature about the different age levels, a void in the state of the art was found. To our knowledge, no studies were found that analyze the effectiveness of the MOOC-based blended learning model in students across different educational grade-levels.

A second-order meta-analysis on forty years of research in blended learning [20] found only five studies that included elementary, secondary and postsecondary papers in the same investigation. Of the five studies [67]–[70], one was from 1988 and another from 1991 [67], leaving them partly outdated; a third study [70] was specifically focused on a word-processing tool for writing instruction; and the other two can be considered as part of the state of the art of this investigation. In particular, [69] says: "*For the grade-level variable, there was no significant difference of mean Effect Size (ES). However, the small ESs associated with secondary school subjects may have occurred because different instructional approaches were used for these students as compared to other students. More studies need to be conducted to clarify this variable*".

Therefore, prior work emphasizes on the need to study MOOC-based blended learning from student's perspective, specifically in different educational levels. As a result, through this doctoral thesis we propose a thorough investigation on MOOC-based blended learning in secondary, postsecondary and higher education. Then by contrasting comparable methodologies and results, we will contribute to current literature with a holistic understanding on MOOC-based blended learning in these three educational levels.

1.3 Objectives and research questions

This study proposes the following General Research Objective: **To study the impact of MOOC-based blended learning from student's perspective.** In consideration of the above, the following research questions are addressed:

- **RQ#1: How do students engage with the MOOC(s) and adopt the MOOC-based blended learning methodology?** This question aims at understanding the adoption of students of the MOOC-based blended learning methodology, shifting from a teacher-centered paradigm to a student-centered paradigm, where students must become responsible of their learning process.
- **RQ#2: What is the impact of MOOC-based blended learning in students' learning outcomes?** This question aims at understanding if the MOOC-based blended learning methodology affects student's performance in the course or experience in any way.

- **RQ#3: Is there a relationship between students' adoption of the MOOC-based blended learning methodology and their learning outcomes?** This question aims at understanding how students assimilate and integrate the MOOC-based blended learning methodology in their learning process and if this paradigm shift affects their performance in the course or experience.

1.4 Methodology

To answer the research questions addressed in this work we propose analyzing three case studies conducted in three Chilean educational centers in secondary education, postsecondary education, and higher education. The case study methodology was selected as the main methodology for this thesis because it allows the exploration of a context, delimited by time and space, through the collection of large amounts of data by multiple techniques and sources of information [71] with the purpose of obtaining a deep comprehension of the case in question. Moreover, case studies provide valuable information regarding the influence of technology in a particular context [72] when the evaluation involves human-related real experiences [73].

Quantitative and qualitative data will be collected in the three case studies and triangulated using Mixed Methods. The complexities of applying technology to education suggest the need for research evidence that is more than simply quantitative indicators of "effects" on isolated outcome measures [12]. Also, subjective (i.e., "qualitative") impressions as the only evidence are also not sufficient. Therefore, the mixed method has been chosen as the beset model because it combines both quantitative methods—to yield data on effects or impacts—and qualitative methods—to yield data on the implementation processes and other contextual factors potentially influencing those impacts [12], [74].

The three case studies will allow answering RQ#1, RQ#2 and RQ#3 through a cross-analysis of the findings of these three case studies in a multicase study adjusted to our research purposes. A multicase study allows a cross-analysis of individual case study findings. This methodology enriches the understanding of the main research question and provides multiple perspectives of the same proposition for a stronger and more robust validation of the model [75].

We propose three case studies: secondary education, postsecondary education, and higher education. All three cases are with Chilean students, in their normal educational contexts.

1.5 Contributions

This work has the following contributions:

- Three case studies, each answering the research question "what is the impact of MOOC-based blended learning" in different educational grade-levels and specific learning contexts.
- A multicase study answering the same research question at a broader level, considering the results from the three independent case studies mentioned above.

So far, this PhD work has contributed with the following publications:

- Hernández, J., Pertuzé, J., Hilliger, I., Sanagustín, M. (2019). Students' adoption and learning outcomes in a MOOC-based flipped course. *EC-TEL Practitioner Proceedings 2019.* Vol 2437. http://ceur-ws.org/Vol-2437/paper6.pdf
- Hernández, J., Rodríguez, M.F., Hilliger, I., Sanagustín, M. (2018). MOOCs as a complement: Students' adoption and learning outcomes. *IEEE Transactions on Learning Technologies.* Vol 12-, Issue N°1, pp 133-141. DOI: 10.1109/TLT.2018.2830373
- Rodríguez M.F., Hernández Correa J., Pérez-Sanagustín M., Pertuze J.A., Alario-Hoyos C. (2017) A MOOC-Based Flipped Class: Lessons Learned from the Orchestration Perspective. *Lecture Notes in Computer Science (EMOOCS 2017).* Vol 10254. DOI: 10.1007/978-3-319-59044-8_12
- Pérez-Sanagustín M., Hernández Correa J., Gelmi C., Hilliger I., Rodriguez M.F. (2016). Does Taking a MOOC as a Complement for Remedial Courses Have an Effect on My Learning Outcomes? A Pilot Study on Calculus. *Lecture Notes in Computer Science (ECTEL 2016).* Vol 9891. DOI: 10.1007/978-3-319-45153-4_17
- Hernández Correa, J., Pérez-Sanagustín M., (2021) A MOOC-based experience in secondary education for student inclusion. *IEEE-RITA Revista Iberoamericana de Tecnologías del Aprendizaje.* Accepted.

and has one pending paper to yet be published:

- Hernández Correa, J., Pertuzé, J., Pérez-Sanagustín M., (2021*) Adoption and learning outcomes in an engineering MOOC-based flipped course in higher education.

1.6 Structure

This thesis is structured into six main chapters. Along with the thesis introduction described in chapter 1, chapters 2, 3, and 4 present the three case studies, including their contexts, research questions, participants, data gathering techniques, results, and conclusions.

Chapters 2, 3 and 4 are presented according to the order in which the case studies took place. First, chapter 2 presents the postsecondary education case study which took place in January, February and March of 2016. Then, chapter 3 presents the higher education case study, which was implemented the second semester of 2016 and the second semester of 2017. Finally, chapter 4 presents the secondary education case study, which took place the second semester of 2018. Chapter 5 presents the multicase study which was worked on during 2020, and finally, chapter 6 presents the final conclusions of this thesis.

2. POSTSECONDARY EDUCATION

This chapter presents a pilot study with postsecondary education students that had just been accepted in the School of Engineering of Pontificia Universidad Católica de Chile, and had to take a Calculus Diagnostic Exam in the summer of 2016. This chapter answers to two research questions, from the perspective of postsecondary education students that must take their Diagnostic Exam and are offered a MOOC to voluntarily study from: (RQ#1) what is the impact of a MOOC-based blended experience in terms of students' learning outcomes? And (RQ#2) how do students adopt the MOOC-based blended learning experience, and how does this adoption affect their learning outcomes?

The main results of this chapter are published in [17], [19].

2.1 Context

UC-Engineering accepts over 700 freshmen students every year by conducting a rigorous selection process. To get accepted in this program, students have to achieve outstanding results in a national admission exam. This exam evaluates their knowledge in math, science, and language (Spanish). Additionally, they have to be in the top positions of their high school rankings and have obtained excellent high school grades. Even so, the new students have very different backgrounds on basic calculus concepts to successfully address the calculus courses that are imparted in the first year. Consequently, most of the students struggle during their first semester to pass their courses. The average fail rate of the first semester math courses (Calculus I and Algebra) is over 30% in each.

To address this problem, UC-Engineering freshmen have been required to take a calculus diagnostic exam since 2014. The DE is divided into 4 modules: Functions and Modelling (M1), Trigonometry (M2), Polynomials and Complex Numbers (M3), and Progressions and

Summations (M4). Students must pass each module separately. There are three different instances of this exam. The first instance (DE-Instance 1) is right after they are informed that they have been admitted in engineering (about two months before classes start). After DE-Instance 1, students who fail in a specific content may take a 2-day intensive traditional course on each of the failed modules where professors reinforce main theoretical topics and facilitate students' learning with guided exercises. This course is voluntary. After undertaking traditional courses, students have a second opportunity to take the diagnostic exam (DE-Instance 2). Either if they choose not to take the remedial courses or if they fail one or more modules, students are given a third opportunity to take the diagnostic exam in the modules they have not passed, right before classes begin (DE-Instance 3).

2.1.1 MOOCs' structure and components

To help students study for the diagnostic exams, the school decided to produce 4 MOOCs. There is one course for each module as a complementary support, but they do not follow the same structure than the remedial courses offered in January. The MOOCs were produced by 3 teaching assistants and were deployed in the Open EdX platform as part of the UC-Engineering online initiative (Ingeniería UC Online: http://online.ing.uc.cl/). These courses were produced as MOOCs and not SPOCs in order to make them available to everyone. Nonetheless, all the contents of the MOOC were designed to align with the learning objectives and topics addressed in the diagnostic exam. All the MOOCs are self-paced, so no restrictions or deadlines were proposed.

The four MOOCs are Functions and Modelling (M1), Trigonometry (M2), Polynomials and Complex Numbers (M3), and Progressions and Summations (M4). The different resources available in the MOOCs are videos, readings, example exercises, exercises and GeoGebra

Interactive Modules. The videos are recordings of teachers explaining different concepts, as if they were teaching a class. The readings are lectures or texts that explain a concept, like a chapter in a book. The example exercises are problems with their resolutions step by step. The exercises consist in problems that the students must solve and respond in the platform. Once they submit their answers, they get immediate feedback as if to whether they got it right or wrong. All the assessments are multiple choice (quizzes and exams). Finally, the course includes exercises designed with GeoGebra, a software for studying algebra and geometry capable of representing geometric figures, functions and charts. It also allows the user to create geometric constructions and insert equations and algebraic formulas to show on a graph. These graphs can be embedded in MOOCs in the Open EdX platform as an exercise, so students can interact with the figures and functions in real time. Each MOOC has different assessments depending on their structure.

Tables 2-1 through 2-3 show in detail how each MOOC is structured, their chapters and sub-chapters, how many videos (V), readings (R), example exercises (EE), exercises (E) and GeoGebra Interactive Modules (GG) they have, and finally, each MOOCs' assessments.

Table 2-1: MOOCs' Structures

MOOC	**Chapters**	**Sub-Chapters**
Functions and Modelling (M1)	Chapter 1: Foundations	1.1. Introduction
		1.2. Mathematical Vocabulary
		1.3. Applications
		1.4. Sequence of real numbers
		1.5. Real numbers
		1.6. Equations
		1.7. Inequalities
	Chapter 2: Functions	2.1. What is a function?
		2.2. Function charts
		2.3. Obtain information from the function charts
		2.4. Function transformation
		2.5. Function combination

		2.6. Inverse functions
Trigonometry (M2)	Chapter 1: Rectangular triangles	1.1. Introduction and angles
		1.2. Trigonometric proportions
		1.3. Trigonometric proportions and notable angles
	Chapter 2: Trigonometric functions of real numbers	2.1. The unitary circumference
		2.2. Trigonometric functions in the unitary circumference
		2.3. Reduction of trigonometric functions
		2.4. Arbitrary triangle areas
	Chapter 3: Trigonometric functions' charts	3.1. Basic trigonometric functions' charts
		3.2. Transforming trigonometric functions' charts
	Chapter 4: Inverse trigonometric functions	4.1. Inverse trigonometric functions
		4.2. Trigonometric equations
		4.3. Compound trigonometric functions
	Chapter 5: Trigonometric identities	5.1. Simplification of trigonometric expressions
		5.2. Demonstration of trigonometric identities
		5.3. Addition and Subtraction formulas
		5.4. Addition and Subtraction formulas' applications
		5.5. Applications to complex numbers
Polynomials and Complex Numbers (M3)	Chapter 1: Polynomials	1.1 Quadratic functions and models
		1.2 Polynomial functions and their charts
		1.3. Polynomial division
		1.4. Polynomial real zeros
	Chapter 2: Complex numbers	2.1. Complex numbers
		2.2. Complex zeros and fundamental algebra theory
Progressions and Summations (M4)	Chapter 1: Successions and summation notations	1.1. Succession concept
		1.2. Summation concept
		1.3. Telescopic property
		1.4. Review activities
	Chapter 2: Arithmetic Successions	2.1. Definition and characteristics
		2.2. Partial sums of arithmetic successions
		2.3. Review activities
	Chapter 3: Geometric successions	3.1. Definition and characteristics
		3.2. Partial sums of geometric successions
		3.3. Review activities
	Chapter 4: Mathematical inductions	4.1. Understanding induction
		4.2. Applicating in demonstrations
		4.3. Review activities
	Chapter 5: Binomial theorem	5.1. Binomial theorem
		5.2. Binomial coefficients
		5.3. Review activities

Table 2-2: MOOCs' Contents

MOOCs	V	R	EE	E	GG
Functions and Modelling (M1)	20	20	28	26	6
Trigonometry (M2)	17	11	13	51	5
Polynomials and Complex Numbers (M3)	3	9	18	15	0
Progressions and Summations (M4)	8	9	23	16	0

Table 2-3: MOOCs' Assessments

MOOC	Assessments	Questions	% of course grade
Functions and Modelling (M1)	Chapter 1 Quiz	9	50%
	Chapter 2 Quiz	15	50%
Trigonometry (M2)	Chapter 1 Quiz	6	10%
	Chapter 2 Quiz	5	15%
	Chapter 3 Quiz	5	15%
	Chapter 4 Quiz	6	15%
	Chapter 5 Quiz	8	20%
	Exam	18	25%
Polynomials and Complex Numbers (M3)	Exam	11	100%
Progressions and Summations (M4)	Chapter 1 Quiz	6	15%
	Chapter 2 Quiz	5	15%
	Chapter 3 Quiz	5	20%
	Chapter 4 Quiz	3	10%
	Chapter 5 Quiz	6	15%
	Exam	12	25%

2.1.2 Description of the pilot study

The case study took place at UC-Engineering between December 27th, 2015 and March 1st, 2016. Students were required to take a diagnostic exam to assess their prior knowledge and skills in calculus, and they were given 3 instances to pass it or they would fail a first semester calculus requisite. Table 2-4 shows a timeline of the different milestones in this case study.

Table 2-4: Pilot study timeline

Dates	Activity/Milestones
Dec. 27th, 2015 – Jan. 10th, 2016	Dissemination effort via e-mail, web-page and flyers to potential engineering students
Jan. 11th	Publication of the Admission Results (00:00 hours) Presentation session of the accepted students and registration to the platform.
Jan. 13th	DE-Instance 1: diagnostic exam instance 1
Jan. 14th	Publication of exam results
Jan. 18th – Jan. 29th	M1 F2F course (2 days); M2 F2F course (3 days); M3 F2F course (2 days); M4 F2F course (2 days)
Jan. 20; 25; 27; 29	DE-Instance 2: diagnostic exam instance 2. The exam was distributed in 4 different days depending on the module, starting from M1 to M4.
Feb. 29th	DE-Instance 3: diagnostic exam instance 3
March 1st	Classes begin

2.1.3 MOOC integration proposal

The MOOCs were available before the students knew that they had been admitted in UC-Engineering. MOOCs were announced by e-mail and flyers a week before releasing the admission results to all those that had manifested their interest in studying at UC-Engineering. Additional outreach to students involved posting in the official Engineers' web page, so all prospective students were informed that they could register on the platform and take the MOOCs. Once accepted, all freshmen were registered in the MOOC provider platform during the admission day, so all of them could access the 4 MOOCs.

Students had 2 days to study for DE1 since they were notified that they had been accepted, and all the dissemination activities suggested to study from the MOOCs as much as possible. For DE2, UC-Engineering offered the students remedial face-to-face (F2F) courses from 9 am to 5 pm. During this period, the MOOCs were promoted through flyers and emails. Additionally, two teacher assistants were available from 5 pm to 8 pm every day on campus in a classroom, hoping the students would go study there after the remedial course. In average, they received around 10 students each day.

Finally, students had one month to study for DE3. During this time, we did not provide any extra support other than the online MOOCs.

2.1.4 Curricular alignment

The MOOCs were created to help students study for the diagnostic exam. Therefore, everything that is taught in the MOOCs is asked in the DE.

2.2 Research questions

Since participating in the MOOCs was voluntary, this study analyzes the impact of this initiative in terms of students' adoption and learning outcomes. Specifically, two research questions were addressed:

- **What is the impact of a MOOC-based blended experience in terms of students' learning outcomes?** This question aims at understanding whether using the online platform gives students a better chance of passing the diagnostic exam and/or helps them perform better in the assessment.
- **How do students adopt the MOOC-based blended learning experience, and how does this adoption affect their learning outcomes?** This question aims at understanding how students assimilate and integrate the MOOC-based methodology in their learning process.

2.3 Participants & data sample

The population of this study was 771 students, the total amount of new freshmen UC-Engineer students in 2016. Of these students, 98% (N=752) took the diagnostic exams on Instances 1, 2 and/or 3, representing the sample for the quantitative data analysis of this study.

Particularly, the School of Engineering has an inclusion program that admits low socioeconomic status students into the career [76]. This program selects students with admission test scores below asking, but that show remarkable high school grades, proving to be in disadvantage due to a lack of opportunities to prepare the admission tests, but have potential to be great students if given the opportunity. Of the 752 students that took the diagnostic exams in this study, 95 correspond to the inclusion program.

Table 2-5 describes the number and percentage of students who passed (Students passing) and failed (Students failing) in each diagnostic exam instance.

Table 2-5: Number and percentage of students that passed (SP) and failed (SF) the different modules in each Diagnostic Exam instance

		Course			
		M1	**M2**	**M3**	**M4**
DE - Instance 1	Students Passing	547 (82%)	185 (28%)	275 (41%)	323 (52%)
	Students Failing	121 (18%)	483 (72%)	393 (59%)	345 (48%)
	Total	**668**	**668**	**668**	**668**
DE - Instance 2	Students Passing	78 (75%)	247 (72%)	260 (92%)	128 (44%)
	Students Failing	26 (25%)	94 (28%)	23 (8%)	101 (56%)
	Total	**104**	**341**	**283**	**329**
DE - Instance 3	Students Passing	66 (72%)	86 (33%)	101 (61%)	128 (58%)
	Students Failing	26 (28%)	177 (67%)	64 (39%)	94 (42%)
	Total	**92**	**263**	**165**	**222**

In addition, we classified the students into "active" and "non-active" depending on their interaction with the MOOC courses. Table 2-6 shows the percentage of active and non-active students per module in each of the three periods explained in Section 3.3.

Table 2-6: Number and percentage of students that were active and non-active in the MOOCs during different periods

		Course			
		M1	**M2**	**M3**	**M4**
Before DE-I1	**Active**	96 (13%)	135 (18%)	57 (8%)	104 (14%)
	Non-Active	656 (87%)	617 (82%)	695 (92%)	648 (86%)
Before DE-I2	**Active**	47 (6%)	65 (9%)	31 (4%)	42 (6%)
	Non-Active	705 (94%)	687 (91%)	721 (96%)	710 (94%)
Before DE-I3	**Active**	37 (5%)	83 (11%)	39 (5%)	51 (7%)
	Non-Active	715 (95%)	669 (89%)	713 (85%)	701 (93%)

164 students were invited via e-mail to participate in the interviews. From this population, 34 students had used at least one of the MOOCs during the first year of study; 11 students attended the F2F remedial courses; and 119 students registered at least one entry in one of the MOOCs. From these 164, 8 students agreed to participate in the semi-structured interviews: 1 from the group that had used at least one of the MOOCs during the first year of study; and 7 students that had registered at least one entry in one of the MOOCs.

2.4 Data collection and analysis

To address the two research questions, we used a mixed method approach. Quantitative and qualitative data was collected and analyzed in parallel to better understand students' adoption and learning outcomes.

Concerning quantitative data, we worked with the students' scores in the 3 instances of diagnostic exams (ScoresDEX-MY; where X goes from 1 to 3 and corresponds to the diagnostic exam instance, and Y goes from 1 to 4 and corresponds to the module). All diagnostic exams contemplate a 0-100% scale, where a 100% score would mean that they got every question right. Students pass the exams if they get a score of 60% or higher.

The students' prior knowledge was determined by analyzing the students' scores in the Chilean university admission system composed by: Math (MAT), Science (CIE), and Language (LEN) scores in the national university admission exams, along with a score associated to their high school grades (NEM) and class ranking (RKG). All these individual scores have a scale from 0 to 850. Finally, the admission score (PING) is computed as: 20% NEM, 20% RKG, 10% LEN, 35% MAT and 15% CIE. This datum was taken as a reference for students' prior knowledge and skills.

To classify the students into “active” and “non-active” depending on their interaction with the MOOC courses, we worked with Open EdX MOOC Platform Movement Logs in each MOOC for each month that the experiment took place. We analyzed the students’ movements in the MOOCs in three separate periods:

- **BDE-I1**: Before DE-Instance 1
- **BDE-I2**: After DE-Instance 1 and before DE-Instance 2
- **BDE-I3:** After DE-Instance 2 and before DE-Instance 3

Active students (A) are the ones who have registered any movement in a module of the MOOC. Non-active students (NA) are the ones who either did not register in a module or registered without conducting any interaction or movement.

To collect qualitative data, we conducted telephonic semi-structured interviews to go into detail about certain topics the researchers wish to analyze. In this case, the main objective was to gain more information about the actual usage students were giving the MOOCs, beyond passing the DE. The semi-structured interviews included questions about two main topics: Adoption and Learning. The interviews were carried out because in our prior work we identified that students had a positive adoption of the initiative, but we did not understand the reasons. Concerning adoption, the goal was to get to know the students that used the platform; the time they spent on the courses; and why they used the MOOCs (for example before a diagnostic exam, before a class, for homework, etc.). Regarding learning, we included questions to find out if the courses helped students remember or formalize some concepts; if the courses contributed to their academic performance; and if students perceived that their performance improved after interacting with the course.

2.4.1 Data analysis

Both quantitative and qualitative data was used to answer the two research questions. Quantitative data was analyzed through statistical methods and qualitative data extracted from the semi-structured interviews was transcribed and analyzed using an open coding technique supported by NVivo 11 software. The predefined nodes for the analysis were Adoption and Learning. Also, an emerging category about students' adoption was identified: Opinion about Resources. We cross-analyzed this both types of data using triangulation methods to answer the research questions.

To address RQ#1 about the students' learning outcomes, we conducted several statistical analyses in Stata/IC 14.0. First, we performed Welch t-tests to determine whether the average scores of active students were higher than the ones of non-active students in the different DE instances. Second, we conducted a Chi-squared test to determine whether there's an association between active and non-active students' approval rates. Third, we performed propensity score matching to create comparable active and non-active groups of students based on students' prior knowledge, to estimate the effect of students' MOOC use on their performance in the diagnostic exams. NEM (high school GPA score), MAT (mathematics score), CIE (science score), and RKG (ranking score) were considered the covariates. As the treatment, we used the categorical variables on students' activity in a MOOC module. Students' scores in the different DE instances were defined as the outcome variables. We paired the nearest neighbors with a caliper of 0.1, besides evaluating the balance of covariates between active and non-active students before and after the matching. The results of the statistical analysis were also complemented with data from the semi-structured interviews to understand the students' learning benefits from using these courses.

To address RQ#2 about the students' adoption of the MOOC initiative, we conducted a detailed analysis of the daily movements in each MOOC during the entire study period to understand the activity patterns in the different periods of the study. Additionally, we analyzed the students' interactions with the videos, readings and the exercises (quizzes and other activities). We used this data to get an idea about whether the students used the MOOC for reviewing theoretical concepts through videos, readings or for exercising. Finally, we performed linear regressions between active students' movements in the MOOCs, and their performance in the DEs. The results of this analysis were cross-analyzed with qualitative data to extract conclusions about how students used the MOOCs and their main reasons.

2.5 Results

This section reports on the results obtained from the analysis to address the two research questions.

2.5.1 Effects of the MOOC initiative on students' learning outcomes

Table 2-7 shows the results about the effects on Learning Outcomes based on the quantitative and qualitative data.

Table 2-7: Learning outcomes results

	Finding	Data Sources
1.1	1-I. When no other institutional support was available, studying with the MOOCs helped students obtain better scores in the DEs, and this result is not related to their prior knowledge.	MOOCs' Movement Logs; Students' scores in DE; Student's prior knowledge (scores in the Chilean university admission system). Interview 4; Interview 5; Interview 6; Interview 8
1.2	1-II. When no other institutional support was available, studying with the MOOCs gave students better chances of passing the Diagnostic Exam, and this result is not related to their prior knowledge.	MOOCs' Movement Logs; Students' scores in DE Interview 4; Interview 5; Interview 6; Interview 8

Finding 1.1 says that **when no other institutional support was available, studying with the MOOCs helped students obtain better scores in the DEs, and this result is not related to their prior knowledge.** This is supported by four partial results. First, in DE-Instance 1, active users in the MOOCs obtained statistically significant higher scores in average than the non-active users for all four exam subjects. Second, in DE-Instance 3, active users in M2 and M4 obtained significantly higher scores in average than those who were non-active in the respective MOOCs. In particular, in DE-Instance 3, M2 and M4 reported four and two times more movements than M1 and M3.

Table 2-8 shows the results of the Welch t-tests that proves that active users obtained higher average scores than those who were non-active in DE Instance-1 and in M2 and M4 of DE Instance-3

Table 2-8: Welch t-test results to compare average scores in DE between active and non-active students

Course	**Group**	**N**	**Score Mean**	**SD**	**P-value (* < 0.05)**
ScoreDE1-M1	Non-active	572	74%	0.158	**0.0131***
	Active	96	78%	0.152	
ScoreDE1-M2	Non-active	533	38%	0.270	**0.0000***
	Active	135	51%	0.221	
ScoreDE1-M3	Non-active	611	59%	0.196	**0.0086***
	Active	57	65%	0.185	
ScoreDE1-M4	Non-active	564	57%	0.263	**0.0003***
	Active	104	66%	0.238	
ScoreDE2-M1	Non-active	101	71%	0.188	0.6625
	Active	13	68%	0.211	
ScoreDE2-M2	Non-active	296	68%	0.166	0.3550
	Active	46	69%	0.179	
ScoreDE2-M3	Non-active	262	81%	0.141	0.5440
	Active	23	80%	0.139	
ScoreDE2-M4	Non-active	202	62%	0.194	0.9850
	Active	28	52%	0.221	
ScoreDE3-M1	Non-active	66	66%	0.149	0.9490
	Active	26	59%	0.199	

ScoreDE3-M2	Non-active	186	44%	0.18	**0.0001***
	Active	77	53%	0.17	
ScoreDE3-M3	Non-active	131	60%	0.20	0.2601
	Active	34	63%	0.21	
ScoreDE3-M4	Non-active	178	57%	0.224	**0.0451***
	Active	44	64%	0.241	

Third, when comparing groups with similar prior knowledge through Propensity Score Matching, the effects of studying with the MOOCs is still statistically significant in all four exam subjects of DE-Instance 1 and in M2 of DE-Instance 3.

Finally, in the interviews, students mentioned how much they used and learned from the trigonometry MOOC (M2) course: "In school I was taught the basic calculus concepts, but I only knew a little trigonometry so I studied with the MOOC for the diagnostic exam". Finally, active users during BDE-I3 in M4 also obtained significantly higher average scores than those who were non-active in the MOOC.

Finding 1.2 says that **when no other institutional support was available, studying with the MOOCs gave students better chances of passing the Diagnostic Exam, and this result is not related to their prior knowledge.** This is supported by three partial results. First, in DE-Instance 1, students that were active users in the MOOCs reported significantly higher approval rates than the non-active users for all four exam subjects. Second, M2 reports the highest activity of the four modules for DE-Instance 3, and the group of students who were active in the M2 module BDE-I3 reported significantly higher approval rates than the non-active users.

Table 2-9 presents the results of the Chi-square test ($\chi 2$) that shows the association between students' activity in a MOOC module and the approval rates.

Table 2-9: Approval rates of students who were classified as active (A) and non-active (NA) MOOC users ($\chi 2$ results)

Course	A (n)	NA (n)	X^2	P-value (* < 0.05)
DE1-M1	90% (86)	81% (461)	4.478	**0.034***
DE1-M2	39% (53)	25% (132)	11.300	**0.001***
DE1-M3	54% (31)	40% (244)	4.496	**0.034***
DE1-M4	62% (64)	50% (281)	4.826	**0.028***
DE2-M1	75% (9)	75% (69)	0.0000	1.000
DE2-M2	65% (30)	74% (217)	1.387	0.239
DE2-M3	87% (20)	92% (240)	0.810	0.368
DE2-M4	46% (13)	57% (115)	1.160	0.282
DE3-M1	58% (15)	77% (51)	3.5275	0.060
DE3-M2	46% (35)	27% (51)	8.0488	**0.005***
DE3-M3	59% (20)	62% (81)	0.103	0.748
DE3-M4	66% (29)	56% (99)	1.530	0.216

Finally, in the interviews the students reinforced that they had learned from the MOOCs: “The MOOCs clarified many concepts that I did not know or had forgotten”; “I learned from the MOOC; everything in there was new to me”; “I learned a few methods and definitions”; “I think it helped me remember many things. Thanks to the MOOC I was much more prepared for the calculus and algebra first semester courses”.

2.5.2 Student’s adoption of the MOOC initiative and its relationship with their learning outcomes

Table 2-10 shows the summary of the mixed method results for RQ#2.

Table 2-10: Results on students' adoption of the MOOC initiative

	Finding	Data Sources
2.1	2-I. Students are not yet prepared to adopt MOOCs for remedial studies if they are not mandatory.	MOOCs' Movement Logs
2.2	2-II. Students study from the MOOCs preferably right before each DE, instead of gradually throughout the entire available study period.	MOOCs' Movement Logs
2.3	2-III. Student's activity in the different MOOCs allows detecting prior knowledge gaps.	MOOCs' Movement Logs Interview 4; Interview 5; Interview 8
2.4	2-IV. Of the students that used the MOOCs for studying for their DEs, the more the students interacted with the MOOCs, the better scores they obtained (and vice-versa).	MOOCs' movement logs; DE scores
2.5	2-V. Students from the school's inclusion program studied more from the MOOCs than regular admission students.	MOOCs' movement logs

Finding 2.1 says that **students are not yet prepared to adopt MOOCs for remedial studies if they are not mandatory.** This is supported by the fact that between 4% (the minimum) and 18% (the maximum) of the students were active in the MOOCs under study during the case study period, reaching its peak for DE -Instance 1.

Finding 2.2 says that **students study from the MOOCs preferably right before each DE, instead of gradually throughout the entire available study period.** This is supported by the fact that students interacted with the MOOCs much more the three days before each DE than the rest of the study period. The average number of interactions per day per MOOC the three days before the DE's v/s the rest of the corresponding study periods are detailed in Table 2-11.

Table 2-11: Average number of interactions per day per MOOC

	Three days before the DE's	Rest of the study period
DE-Instance 1	591	49
DE-Instance 2	154	58
DE-Instance 3	130	38

In addition, Figure 2-1 shows the number of daily interactions with each MOOC during the entire study period. The diagnostic exams were on January 13th, January 20th- 29th, and February 29th.

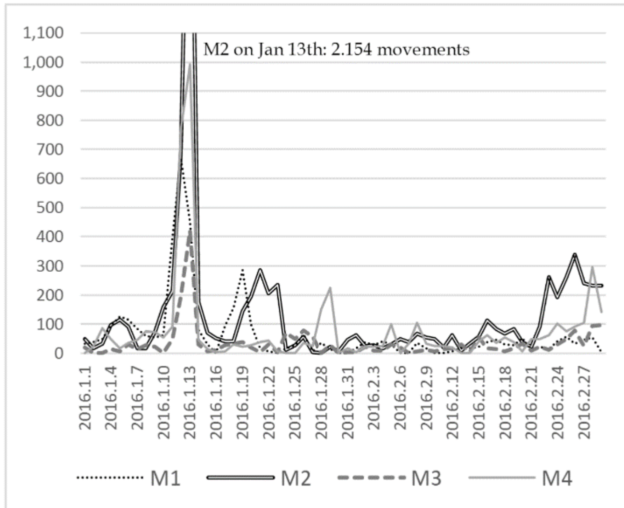

Figure 2-1: Daily movements in the 4 MOOCs during the case study period

Finding 2.3 says that **student's activity in the different MOOCs allows detecting prior knowledge gaps,** and this is supported by two partial results. First, M2 has the most activity during the case study period, reaching 8.211 movements in total, followed by M4 with 4.619 movements, then M1 with 4.316 and finally M3 with 2.082. Second, M2 topics were not necessarily studied in high school, and the national admission test does not evaluate trigonometry. In the semi-structured interviews, students indicated that they used M2 more frequently because these topics were not studied in high school: "*Trigonometry was the hardest for me, because I had not seen it in school* (Interview 4)"; "*I took the M1 and M2 MOOCs because there were many concepts I had not studied in school* (Interview 5)".

Finding 2.4 says that **of the students that used the MOOCs for studying for their DEs, the more the students interacted with the MOOCs, the better scores they obtained (and vice-versa),** and this is supported by three partial results. First, in DE-Instance 1 the amount of movements in the MOOCs significantly predict student's scores in the respective DE, for M1, M2 and M4, which are the MOOCs with the highest number of interactions and active students in DE-I1:

- **DE-I1 M1:** N = 96, Movements = 2.629
  - ß = 0.002, t = 2.63, P>|t| = 0.010
- **DE-I1 M2:** N = 135, Movements = 3.734
  - ß = 0.003, t = 3.04, P>|t| = 0.003
- **DE-I1 M4:** N = 104, Movements = 2.338
  - ß = 0.003, t = 2.37, P>|t| = 0.020

Second, In DE-Instance 2, the amount of movements in the M2 MOOC significantly predicts student's scores in the respective DE. This is the MOOC with the highest number of interactions and active students for DE-I2:

- **DE-I2 M2:** N = 26, Movements = 719
  - ß = 0.005, t = 2.10, P>|t| = 0.046

Third, In DE-Instance 3, the amount of movements in the MOOCs significantly predict student's scores in the respective DE for M2 and M4, which are the MOOCs with the highest number of interactions and active students for this instance:

- **DE-I3 M2:** N = 87, Movements = 3.758
  - ß = 0.001, t = 2.16, P>|t| = 0.033
- **DE-I3 M4:** N = 50, Movements = 2.133
  - ß = 0.003, t = 2.44, P>|t| = 0.018

Finally, finding 2.5 says that **students from the school's inclusion program studied more from the MOOCs than regular admission students**. This is supported by the fact that 77% of the students from the inclusion program were active users in the MOOCs, while only 34% of regular admission students were active during the pilot study.

2.6 Discussion and limitations

The lessons reported in this section were obtained from reflecting on the results from both the student's adoption and learning outcomes. To highlight those aspects of the study that could be applied to other contexts, we analyze the issues that emerge from this work as future work and report the limitations that would deserve further study.

First, students are not yet enough prepared to adopt MOOCs for remedial studies if they are not mandatory. Considering how the online initiative was promoted within the students, these percentages are less than what was expected. This result means we must improve the promotion of the initiative for future interventions. For future work, we would like to better understand how students self-regulate in these types of courses and what type of support they need to encourage future freshmen students to use the MOOCs and obtain better results in the diagnostic exam and remedial courses.

Second, students that used the MOOCs before the diagnostic exam had significantly more chances of obtaining better scores and of passing this exam than students who did not study from the MOOCs. By comparing students with similar prior admission scores, we observed that students who used any of the four MOOCs during BDE1 had better chances of passing the DE and would obtain better results than non-active users. In this extension, we were also able to show that, during BDE3, students who were active in M2 also obtained better scores and had a better probability of passing DE-Instance 3 than students who did not study from the MOOC. Although these results expand current knowledge on MOOCs' effects, the lack of randomization limits the external validity of these findings. In order to test the effect of a remedial MOOC in other educational setting, variables that signal prior knowledge should be identified for each particular context in order to build comparable groups of students.

Third, students tend to be active in the MOOCs more intensively before the exams, especially in M2. Most of the movements in the courses were registered before the diagnostic exams. In addition, differences were observed on the activity patterns in each of the courses. Course M2 registered more movements than the other 3, followed by M4, then M1 and finally M3. Since all the courses were prepared by the same teachers and used the same resources, we sustain that this difference can be due to the needs of the students on the different course topics. For example, the national admission test does not evaluate trigonometry (M2), a branch of mathematics that is required for succeeding in engineering calculus courses. Therefore, the availability of M2 might have raised student awareness of the importance of this topic for succeeding not only in the diagnostic test, but also in their first year of college. Further research on MOOCs used as a complement for remedial postsecondary education should be addressed. But on the other hand, this difference could simply be due to the quality of the MOOCs.

Fourth, service MOOCs should be designed for diversifying learning activities and exercises. A curriculum narrowing effect has emerged from the fact that the national admission test is not evaluating trigonometry, a branch of mathematics that is required for succeeding in engineering calculus courses. Therefore, the availability of M2 might have raised student awareness of the importance of this topic for succeeding not only in the diagnostic test, but also in their first year of college. Further research on MOOCs used as a complement for improving academic preparation for college should be addressed. Future work includes obtaining quantitative data about the student's perception of their adoption through questionnaires, to make certain generalizations that cannot be made with the interviews and focus groups.

This chapter has shown that offering students different MOOCs as a complement study resource for an on-campus diagnostic exam is a complex process that involves many variables and dimensions that need to be considered for the students to use the MOOCs and learn from them. However, the benefits of this effort give those students better chances of succeeding in the corresponding exams and getting them more involved in their own learning process.

3. HIGHER EDUCATION

This chapter presents a quasi-experiment with higher education students from the School of Engineering of Pontificia Universidad Católica de Chile that were taking a mandatory "Organizational Behavior" course in 2017. This chapter answers to two research questions, from the perspective of higher education students that were either in a control group with traditional lecture-based classes, or in an experimental group exposed to a flipped class teaching methodology with MOOCs. The research questions are: (RQ#1) what is the impact of a MOOC-based flipped classes in terms of students' learning outcomes? And (RQ#2) how do students adopt the MOOC-based flipped class experience, and how does this adoption affect their learning outcomes?

The main results of this chapter are published in [77], [78].

3.1 Context

The "Organizational Behavior" is a mandatory undergraduate course of the School of Engineer of Pontificia Universidad Católica de Chile, usually organized into two sections per semester with an average of 150 students each. Given the sections' size, it has resulted very difficult for the course's teacher to promote class participation. To address this problem, during the second semester of 2017, the teacher of the course decided to flip one of the two sections to evaluate if this teaching methodology encourages class participation and communication, and if it promotes a student-centered learning environment. For the flipped model, the teacher used an existing MOOC called "Gestión de Organizaciones Efectivas", which he had created and launched a year earlier in Coursera. A private session [79] of the MOOC was created to include specific contents for the face-to-face course, and to monitor student's progress. The private session of the MOOC was completely aligned with the course's content. The study lasted an entire semester, from August 21 to November 17 of 2017.

The proposed intervention is considered a quasi-experiment because: 1) the goal was to analyze the causal impact of an intervention, and 2) the target population was not randomized [80]. Instead of randomization (which was not possible due to the university's course selection system), the control group was as similar as possible to the experimental group (students in sections 1 and 2). Moreover, this study worked around this limitation by creating comparable groups in both sections through the statistical analysis. Therefore, given these conditions, a quasi-experiment allows us to conclude what would have been the outcomes of the experimental group if the intervention had not taken place [80].

The quantitative and qualitative gathered data was analyzed using a mixed method approach to report our findings in student's adoption and learning outcomes of the MOOC-based flipped-class teaching methodology. The mixed method research approach was chosen because it aims at maximizing the strengths of both quantitative and qualitative methodologies [4].

3.1.1 Course's instructional design

The course had three 80-minute sessions per week: Mondays, Wednesdays and Fridays. Monday and Wednesday were reserved for face-to-face sessions (from 10:00 to 11:20 for the control group and from 11:30 to 12:50 for the experimental section), and Fridays were either (1) Seminar Days, where both sections would join in the same classroom and the teacher would invite guest speakers from outside the university to give a lecture; or (2) Test Days, in which both sections took the same test at the same time.

The course's instructional design had the objective of maintaining an equivalence between both sections in terms of workload, contents, exercises, and assessment activities, which resulted in a sequence of activities for before, during and after each face-to-face session. The contents and learning objectives for the experimental and control groups were the same and only differed in the order they were taught throughout the week, given the different methodological approaches.

Figure 3-1 illustrates both section's instructional design. Regarding the experimental group, before Monday's class students had to read a case related to the class's subject-matter and watch a video lecture in the MOOC explaining the subject-matter of that day's class (a). During class (b), sessions were structured into two parts. First, a 5-minute graded quiz to evaluate student's work before class; and then students worked in groups, debating and analyzing the case and/or video-lectures they had read and/or seen before class, proposing a final analysis. Later, after class (c) students had to review the weekly work performed by their groupmates through online co-evaluations. Before Wednesday's class (d), students had to read a text related to the class's subject-matter. There were four possible texts, so students were separated in groups and were assigned one of the four readings. During class, sessions were structured just like Monday's classes (e). Finally, after class (f) students had to turn in a group assignment that reflected their work in class, due every Friday, and they had to review the weekly work performed by their class-groupmates through online co-evaluations. Regarding the control group, before Monday's class (g), students had to read a text related to the class's subject-matter. There were four possible texts, just like in (d), so students were separated in groups and were assigned one of the four readings. During class (h), the teacher taught that day's subject-matter through a traditional expository methodology, promoting class participation by asking questions related to the lecture. After class (i), (j) Students had to read a case related to the class's subject-matter (the same case the experimental group read before Monday's class) and were given an individual assignment regarding the case and the class's subject matter. This assignment was due before Wednesday's class. Wednesday's class (k) followed the same structure as Monday's lecture. Finally, after Wednesday's class (l) students had to revise their classmates' individual assignments through a peer review process, due before next Monday's class. Each student revised two classmate's work using a specific rubric created by the teacher. The final grade was calculated by averaging both peer review revisions.

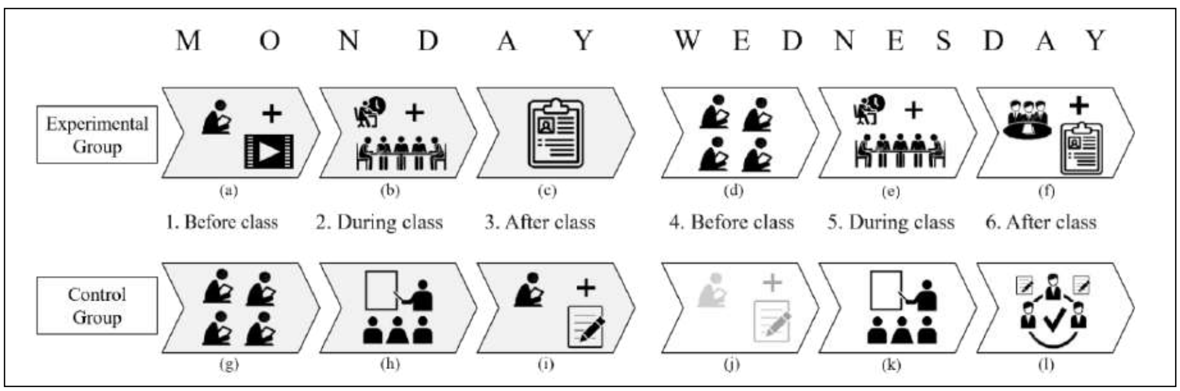

Figure 3-1: Control and Experimental groups' instructional design

3.1.2 Course topics and evaluations

The course was divided into 12 topics, which were taught in one or two weeks, depending on the subject. Table 3-1 explains the twelve course contents, along with the teaching methodology for the control and experimental groups. In addition, Table 3-1 shows the tentative weight each topic has on the final course grade. Given that each student's final course grade considers different assessments (due to the optional exam, and the election of 7 out of 9 FC and IP grades), these percentages are an average reference.

Table 3-1: Course contents

Topic ID	Class Week(s)	Subject	Control Group Teaching Method	Experimental Group Teaching Method	Weight in course grade
0	1	Course introduction	Traditional	Traditional	-
1	2	Organizational environment	Traditional	Semi-Traditional**	5%
2	3	Organizational strategy	Traditional	Flipped	9%
3	4	Organizational design	Traditional	Flipped	9%
4	5*	Organizational development	Traditional	Flipped	9%
5	6, 7	Heuristics and cognitive biases	Traditional	Semi-Traditional**	8%
6	8	Group processes	Traditional	Flipped	9%
7	9, 10	Leadership and teamwork	Traditional	Flipped	7%
8	11*	Conflict and negotiation	Traditional	Flipped	9%
9	12	Motivation	Traditional	Flipped	8%
10	13	Significance of people's work	Traditional	Traditional	3%
11	14	Culture and organizational ethics	Traditional	Flipped	13%
12	15*	Sustainability	Traditional	Traditional	6%

* *Fridays of these weeks were Test days.*
** *These topics were covered in the MOOC with videos-lectures, but the face-to-face classes did not follow a flipped model. Students did not have in-class quizzes nor a group project.*

The course's assessments resulted in 12 different grades that were weighted to result in the final course grade. All grades are in a grading scale from 1.0 to 7.0, where 7.0 is the highest possible value. First, there were three tests and one final optional exam, which was taken only by those who wished to replace a test grade with the exam grade. In the experimental group there were nine Flipped Class grades (1 per week) which consisted in the weighted average of the in-class quizzes (30%), the co-evaluation grades (20%) and the Group Projects grades (50%). Alternatively, the control group had nine Individual Project grades. Of the nine grades, only the seven best were considered in the final course grade, in both sections. Finally, there was a Class Participation grade. Table 3-2 describes the course's assessments, the topic they were related to, and each ponderation in the final course grade.

Table 3-2: Course evaluations and grades

Description **[Q: Questions]**	**Evaluated topics (ID) per question or project**	**Weight in course grade**	**Section**
Test #1: [Q1 - Q4]	[1, 2, 3, 4]	20% (each question ~ 5%)	Both
Test #2: [Q1 - Q5]	[5, 5, 6, 7, 8]	20% (each question ~ 4%)	Both
Test #3: [Q1 - Q6]	[9, 10, 11, 11, 11, 12]	20% (each question ~ 3.3%)	Both
Exam: [Q1 - Q9]	[1, 2, 3, 4, 5, 6, 8, 9, 11]	Replaces worst test grade (each question ~ 2.2%)	Both
Individual Projects: [IP1 - IP9]	[2, 3, 4, 6, 7, 8, 9, 11, 12]	35% (7 best grades: 5% each)	1 (Control)
Flipped Class: [FC1 - FC9]	[2, 3, 4, 6, 7, 8, 9, 11, 12]	35% (7 best grades: 5% each)	2 (Exp.)
Class Participation	-	5%	Both

3.1.3 MOOC's structure and components

All the contents in the private version of the MOOC were designed to align with the learning objectives and topics addressed in the "Organizational Behavior" course at the School of Engineers of Pontificia Universidad Católica de Chile. The different resources available in the MOOCs are video-lectures, supplement readings (cases), exercise quizzes and graded in-class quizzes. The video-lectures are recordings of the course teacher explaining different concepts, as if students were in class. The supplement readings included business cases presented as texts in the MOOC (e.g. a chapter in a book). The exercise quizzes are formative assessments the students can optionally respond to help them study. The graded in-class quizzes are summative assessments the teacher published at the beginning of every class, for the students to respond online when they entered the classroom, in approximately 5 minutes. This evaluation instrument was important to induce students to come prepared to class. The grades were submitted automatically through Coursera, liberating the teacher and teacher assistants from having to grade 170 quizzes twice a week. All the assessments in this MOOC are multiple choice. Table 3-3 shows in detail how the MOOC is structured in modules according to the course's topics, how many video-lectures (V) and supplement readings (R) it has, and how many assessments in exercise quizzes (EQ) and graded in-class quizzes (GQ) it has in each module.

Table 3-3: MOOC's resources and assessment items

Course Topic	MOOC module name	[V]	[R]	[EQ]	[GQ]	Total
0 - Introduction	Welcome to the MOOC.	1				1
1 - Organizational Environment	People-centered organizational management.	6	1	1		8
2 - Organizational Strategy	The organization's strategic project.	7	1	1	5	14
3 - Organizational Design	Effective organizational design.	11	1	1	5	18
4 - Organizational Development	The keys to Organizational Development.	6	1	1	5	14
5 - Heuristics and Cognitive Biases	Our mental system's performance and memory and rationality's limits.	5				5
6 - Group Processes	Group dynamics, social influence and their impact in teamwork.	4	1		5	10
7 - Leadership and teamwork	How to assemble and manage successful teamwork.	8	1		5	14
8 - Conflict and Negotiation	Power and political dynamics in organizations.	6	1	1	5	13
9 - Motivation	Motivating and encouraging people.	6	1		5	12
11 - Culture and Organizational Ethics	Dealing with ethical dilemmas at personal and organizational levels.	7	1		5	13
12 - Sustainability	What is the impact of Corporate Social Responsibility and how can you define a strategy in that direction?		1		1	2
Total		**67**	**10**	**5**	**41**	**124**

3.2 Research questions

This study's research questions are:

- **RQ#1: What is the impact of a MOOC-based flipped course in terms of students' learning outcomes?** This question aims at understanding if the MOOC-based flipped class methodology affects student's performance in the course in any way.
- **RQ#2: How do students adopt MOOC-based flipped methodologies, and how does this adoption affect their learning outcomes?** This question aims at understanding how

students assimilate and integrate the MOOC-based flipped class methodology in their learning process.

3.3 Participants & data sample

The number of students that were considered for the study is 312, where 145 (46%) were in the control group (section 1) and 167 (54%) were in the experimental group (section 2). Students were 21 years old in average, coursing their third year of Engineering at Pontificia Universidad Católica de Chile, and in different majors according to their study plans. All students considered in the sample completed all the evaluations of the course, in accordance to the course's program.

3.4 Data collection and analysis

Both qualitative and quantitative data was gathered throughout the semester to fully comprehend the adoption of the flipped class teaching methodology, and how it affects students' learning outcomes. The quantitative data gathered throughout the semester is:

- **MOOC Log-files:** MOOC's log-files that registered all the interactions the students in the experimental group made in the Coursera MOOC throughout the semester, over each available resource.
- **Course Load questionnaire:** An auto-reported course load questionnaire was conducted weekly in both sections. It had two questions on a three-point Likert scale, and one open-response question. The first two were "I have a clear understanding of this week's class goals and how to implement them" and "I consider my assistance to the face-to-face lectures beneficial". The third question asked the students to indicate how many hours they dedicated to the course the past week.
- **Grades:** Student's grades in each course assessment.
- **GPA:** Student's Grade Point Average up until the semester before taking this course.

- **BL abilities questionnaire:** Auto-reported questionnaire about students' competences for blended learning, taken at the beginning and the end of the semester by both sections. The questionnaire measures six dimensions on students' abilities to face a BL course. The dimensions are responsibility, proactivity, collaborative learning, organization, time management and oral communication. The questionnaire had 42 questions (items) about these abilities, and students had to rate each on how characteristic they were for them on a labeled 5-point scale. The individual score for each dimension was computed by averaging the ratings of the corresponding items. The instrument's internal validity was first validated through an exploratory factorial analysis and then through a confirmatory factorial analysis. The measures of each dimension had high reliability with Cronbach's α of at least 0.63 (Cronbach's α for Responsibility: 0.7; Cronbach's α for Collaborative Learning: 0.87). This questionnaire is available in https://es.surveymonkey.com/r/8T25GJQ.

The qualitative data gathered throughout the semester is:

- **Focus Group:** Two focus groups with students from the experimental group with a total of 7 students.
- **Teacher Evaluation Survey:** Every semester, students evaluate the teachers they had that semester in each of their courses. This is an institutional survey where students must point out all the positive and negative aspects of the course and/or of the teacher's role in the course.

3.4.1 Data analysis

To respond our first research question about students' learning outcomes, we analyzed and compared the control and the experimental groups' Course Load replies, their grades, GPA, BL abilities questionnaire responses and the Teacher Evaluation Survey results.

For the learning outcomes analysis, we analyzed students' grades in each assessment of the course. Given that the grade point average (GPA) is one of the best predictors of success in education [81], student's GPA up until the semester before taking this course was considered as a measure of their prior knowledge. The sample's Grade Point Average (GPA) mean was 5.06 with a standard deviation of 0.43. In section 1, the GPA mean is 4.95 and in section 2, it is 5.15. This difference is statistically significant with a 95% confidence interval (ρ-value < 0.001). Students chose which section they preferred to be in before knowing the difference in the teaching methodology; they only decided based on schedule. However, those with better GPA have preference on selecting their schedule than those with lower GPA, which could have generated the observed differences of GPA between the two groups. In order to minimize the effect of the GPA between the two sections, we conducted the analysis of the data by performing Propensity Score Matchings to compare grades between both sections. This method allows comparing groups of students with similar characteristics, in this case, with similar GPA.

The comments in the Teacher Evaluation Survey were analyzed and categorized according to the topics in study. The course load questionnaire was analyzed by averaging the weekly results for in each section, in each of the three questions. Finally, the BL abilities questionnaire was analyzed by calculating each student's results in the six dimensions in both the pre and posttest. T-Student tests were performed to compare experimental and control group's results in both instances (pre and post).

To answer our second research question about student's adoption of the MOOC-based flipped class methodology, we analyzed the experimental group's MOOC log-files, their grades, focus groups and the teacher evaluation survey results.

To analyze the MOOC's log-files that registered all the interactions the students in the experimental group made in the Coursera MOOC, we define a "movement" by making the following distinctions:

- A new session is considered every time a student interacts with the MOOC 10 or more minutes after the previous interaction.

- All continuous interactions of the same student with the same resource in the same session are considered as one movement.
- Interactions of the same student with different resources in the same session are considered different movements.

A total of 29.317 movements are registered in the MOOC during this study in the 12 topics of the course. The number of movements in the MOOC from the beginning to the end of the study were registered to understand the activity patterns in the different topics. The quantitative part of the adoption analysis of the flipped class methodology was done by performing linear regressions in STATA between student's movements in the different sections of the MOOC, and their performance in the course's assessments.

Finally, the transcriptions of both focus groups were analyzed using the NVIVO Software, by categorizing them in 4 main nodes, and 10 sub-nodes. The main nodes were: adoption of the methodology (referring to expressions about the student's taking on of the methodological approach), learning of the courses' contents (references to learning outcomes), blended learning abilities (aspects related to the competences and abilities perceived by the students) and class logistics and organization (aspects related to the logistics of the course). A total of 40 references were found for blended learning abilities, 45 for adoption, 31 for learning of the courses' contents and 34 for class logistics and organization.

3.5 Results

This section addresses the two research questions after an analysis of the gathered data, reporting 3 main findings regarding adoption and 5 main findings regarding learning outcomes. Subsection 4.1 reports on the results of student's adoption of the MOOC initiative in the experimental group and how this affected their learning outcomes. Subsection 4.2

presents the results about the effects on students' learning outcomes when compared with the control group.

3.5.1 Experimental groups' adoption of the flipped class methodology

To study student's adoption of the MOOC-based flipped class methodology, we considered their interactions in the MOOC, their perceptions of the experience (through the focus groups and course's evaluation) and student's grades in the course's tests and Flipped Class grades. Table 3-4 shows the summary of the findings on students' adoption of the learning approach, including the data sources.

Table 3-4: Findings regarding student's adoption

	Findings	Data Sources
1.1	Students interacted with the video-lectures much more than the rest of the resources in the MOOC, and these interactions are significantly related with their learning outcomes.	MOOC log-files, Course grades
1.2	Students adopted the MOOC-based flipped class methodology gradually throughout the semester in a successful manner.	Focus Groups, Teacher Evaluation results, MOOC log-files, Course grades
1.3	Students greatly valued and successfully adopted the activity patterns of the flipped classes, and their performance in the before, during and after activities is significantly related with the movements in the MOOC.	Focus Groups, Teacher Evaluation Results, MOOC log-files, Course grades

Finding 1.1 indicates that **students interacted with the video-lectures much more than the rest of the resources in the MOOC, and these interactions are significantly related with their learning outcomes.** This finding is supported by two different partial results. First, movements in the video-lectures significantly predicted student's final grade in the course ($ß = 0.17$, $t = 2.32$, $P>|t| = 0.022$) and student's final grade in the flipped classes ($ß = 0.215$, $t = 2.82$, $P>|t| = 0.005$). Second, movements in the exercise quizzes also predicted student's final grade in the course ($ß = 0.19$, $t = 2.22$, $P>|t| = 0.028$), and student's average grade in the course tests ($ß = 0.198$, $t = 2.32$, $P>|t| = 0.022$). Table 3-5 shows student's total

movements in each type of resource available in the MOOC: video-lectures, exercise quizzes, graded in-class quizzes and supplement readings.

Table 3-5: Movements in MOOC's resources

Resource	**Total movements throughout the semester**
Video-Lectures	20.456
Exercise quizzes	1.742
In-Class quizzes (graded)	5.544
Supplement Readings	1.575
Total	**29.317**

Finding 1.2 indicates that **students adopted the MOOC-based flipped class methodology gradually throughout the semester in a successful manner**. This finding is sustained by two partial results. The first partial result is supported by Table 3-6, Table 3-7, and Figure 3-2, which shows the movements in the MOOC in each topic and month of the semester. During August and September, students interacted very much with topics 2, 3 and 4. Even so, these interactions were not related with student's scores in Test#1, nor their grades in Topics 1, 2, 3 or 4, in any way. However, from Topic 5, this behavior changed. The sum on movements in topics 5, 6, 7 and 8 significantly predict student's scores in Test#2 ($ß = 0.17$, $t = 2.28$, $P>|t| = 0.024$), and the movements in the exam's topics significantly predict student's scores in Test#4 ($ß = 0.32$, $t = 4.46$ $P>|t| = 0.000$). In addition, movements in topics 6 and 7 significantly predict students' grades in the corresponding flipped classes, and these movements also predict students' grades in the in-class graded quizzes and coevaluations (part of the flipped class grades of each week's work). The results of these regressions are presented in Table 3-6. Finally, movements in topics 7, 8 and 9 significantly predict student's final course grade ($R2 = 0.13$, $F(11,152) = 2.12$, $Prob>F = 0.02$) as can be seen in Table 3-

7. The second partial result is extracted from student's perceptions and comments in the Focus Groups. Students declared that at first, they had a hard time understanding the rhythm of the course, sometimes forgetting to do the before-class activities or leaving them for the last minute. However, throughout the semester they incorporated these tasks in their routine, and eventually completed them without a problem. For example, one student stated: "*at the beginning I arrived at class and was like "oops, I forgot I had to read!" or on Sundays at 10 pm I remembered I had to watch the videos... but after a while I got used to writing it down and made it part of my weekly routine. At first it was hard for me though*".

Table 3-6: Regressions predicting flipped class grades in topics 6 & 7

Predictor	**Predicted variable**	**ß**	**t**	**P>|t|**
Movements in topic 6	Flipped class grades in topic 6's FC	0.16	2.11	0.04
Movements in topic 6	Monday's quiz grades in topic 6's FC	0.16	2.03	0.04
Movements in topic 7	Flipped class grades in topic 7	0.24	3.17	0,00
Movements in topic 7	Monday's quiz grades in topic 7's FC	0.20	2.57	0.01
Movements in topic 7	Wednesday's quiz grades in topic 7's FC	0.23	3.02	0.00
Movements in topic 7	Wednesday's coevaluation grades in topic 7's FC	0.24	3.18	0.00

Table 3-7: Multivariate regression predicting final course grades through movements in topics 1 through 12

Final course grade	t	P>t	Beta
Movements Topic 1	-0.03	0.975	-0.002
Movements Topic 2	-0.71	0.482	-0.126
Movements Topic 3	0.91	0.366	0.158
Movements Topic 4	-0.10	0.920	-0.007
Movements Topic 5	0.35	0.727	0.036
Movements Topic 6	0.54	0.587	0.063
Movements Topic 7	2.23	**0.027***	0.266
Movements Topic 8	1.90	**0.059***	0.144
Movements Topic 9	-2.91	**0.004***	-0.306
Movements Topic 11	0.76	0.449	0.086
Movements Topic 12	-0.20	0.844	-0.016

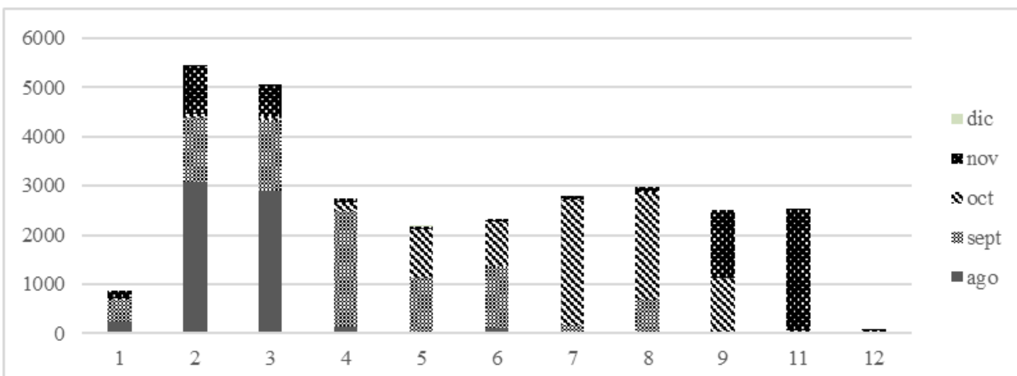

Figure 3-2: Total movements by topic and month

Finding 1.3 indicates that **students greatly valued and successfully adopted the activity patterns of the flipped classes, and their performance in the before, during and after activities is significantly related with the movements in the MOOC**. This finding is supported by three partial results. The first is that in the focus group students agreed that the weekly work made learning easier, and that watching the video-lectures in the MOOC helped their memory retention, making it easier to understand definitions and key concepts of the course than in a lecture-based class. Then, when discussing the contents in class with their group members, they reinforced the important topics, increasing their learning outcomes and performance in the course. The second partial result is that in the course evaluations, many comments emphasized how much they appreciated the before, during and after class activities. They agreed that studying the contents before class and discussing it in class makes learning much more fun and easier. For example, one student said: "*I loved the flipped class methodology because it made the course much more fun and applying the subject-matters in class made it easier to understand and remember the contents*". This coincides with the third partial result, being that student's interactions in the MOOC successfully predict their flipped class grades ($ß = 0.16$, $t = 2.05$, $P>|t| = 0.04$).

3.5.2 Control vs. experimental groups' learning outcomes

Table 3-8 shows the summary of findings on students' learning outcomes, including the data sources.

Table 3-8: Findings regarding student's learning outcomes

	Findings	Data Sources
2.1	In average, learning outcomes resulted the same in both sections.	Course grades, GPA.
2.2	During the period when students in the experimental group were adopting the flipped class methodology, their performance in the course grades was affected. Meanwhile, students in the control group obtained better results than the experimental group in the corresponding evaluations. However, towards the end of the semester, both groups performed equally.	Course grades, GPA.
2.3	In the experimental group, students greatly value the before, during and after class activities, while the control group values going to class, but students don't see much value in their after-class activities (IP). Moreover, performance in the FC assessments is significantly better than the control group's performance in the IP's.	Course grades, GPA, Course Load, Focus Groups, Course evaluations
2.4	Students in the experimental group dedicated more weekly hours to the course than students in the control group, due to difficulties in organizing the group projects.	Course load, Focus Groups, Course evaluations.
2.5	Throughout the semester, students that participated in the flipped class methodology developed two skills that the control group students did not: responsibility and collaborative learning	BL abilities questionnaire

Finding 2.1 indicates that **in average, learning outcomes resulted the same in both sections**. This finding is supported by two partial results shown in Table 3-9. The first partial result is that when comparing the course's final grade, considering student's GPA to create comparable groups from both sections, the difference in these grades is not significant. The second is that when performing the same statistical analysis with the average in the four tests, the difference is also non-significant. This suggests that in average, neither groups were in advantage in their class methodologies. Even so, in the focus groups a few students said they perceived that students in their section had obtained better scores than the control group, due to the flipped class methodology that allowed them to better comprehend the course's contents.

Table 3-9: Course evaluations' general means and Propensity Score Matching (PSM) Results

	GPA Mean		Final course grade mean	Std. Error	Test means	Std. Error
Control Group	4.95		5.43	.047	4.89	0.046
Experimental Group	↑5.15		↑5.61	.036	↑4.98	0.041
PMS Results by GPA	**Coef.**	**Std. Error**	**z**	**P > | z |**	**[95% Conf. Interval]**	
Final course grade control v/s exp.	0.067	0.063	1.06	0.289	-0,057	0.192
Average test grades control v/s exp.	-0,062	0.08	-0,77	0.439	0,219	0.095

Finding 2.2 states that **during the period when students in the experimental group were adopting the flipped class methodology, their performance in the course grades was affected.** Meanwhile, students in the control group obtained better results than those in the experimental group in the corresponding evaluations. However, towards the end of the semester, both groups performed equally. This finding is supported by different partial

results. Table 3-10 and Table 3-11 show Propensity Score Matching results between the control and experimental groups for test grades and grades associated to the course's topics. The first partial result is in relation to student's results in Test #1 and Test #2. In Test#1, students in the experimental group obtained significantly higher grades than students in the control group. However, in Test#2 the opposite occurs: the control group obtains better grades. The second partial result is that in topics 6, 7 and 8, (evaluated in Test #2) the control group obtained significantly better results than the experimental group, as can be seen in Table 3-11. If we recall finding 1.I, for Test #2, students in the experimental group displayed successful adoption of the flipped class methodology. These results suggests that in the period where students were struggling to better adopt the teaching methodology in the experimental group, students in the control group outperformed them in the corresponding test, because they did not need to change their study habits for this exam. Finally the third partial result is that this phenomenon is no longer repeated throughout the rest of the semester (Test #3 and Test #4 do not show significant differences between the groups), which suggests that once students manage to adopt the flipped class method, they perform well in the corresponding course's evaluations.

Table 3-10: Individual test means for control and experimental group and Propensity Score Matching (PSM) results

	Test #1 mean	Std. Error	**Test #2 mean**	Std. Error	**Test #3 mean**	Std. Error	**Test #4 mean**	Std. Error
Control	4.11	0.075	↑4.83	.096	5.00	0.082	4.82	0.094
Experimental	↑4.51	0.073	4.51	.069	↑5.17	0.083	↑4.90	0.077

PSM Results by GPA	**Coef.**	**Std. Error**	**z**	**P > | z |**	**[95% Conf. Interval]**	
Test #1: control v/s exp.	0.284	0.107	2.64	0.008	0.073	0.496
Test #2: control v/s exp.	-0.508	0.128	-3,96	0.000	-0.759	-0.256

Table 3-11: Control and experimental group means obtained in each topic and Propensity Score Matching results summary

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
Control	4,9	5,2	5,1	5,2	5,0	↑5.9	↑5.4	↑5.3	5.4	4.6	5.1	5.0
Experimental	5,0	5,0	5,2	5,2	5,2	5.6	5.1	5.1	↑5.7	4.9	5.1	5.3
P > | z | (PS-matching with GPA)	non-sig.	non-sig.	non-sig.	non-sig.	non-sig.	0.000	0.010	0.012	0.027	non-sig.	non-sig.	non-sig.

Finding 2.3 indicates that **in the experimental group, students greatly value the before, during and after class activities, while the control group values going to class, but students don't see much value in their after-class activities (IP).** Moreover, performance in the FC assessments is significantly better than the control group's performance in the IP's. This finding is supported by different partial results. The first partial result is that in the course evaluations, students from the control group greatly criticized the individual projects, saying they did not contribute to their learning in the course, in contrary to the experimental group's great appreciation to their class methodology, as was reported in Finding 1.2. The second partial result is that experimental student's performance in the FC grades is significantly better than the control group's performance in the IP grades, as can be seen in Table 3-12.

Table 3-12: Flipped Class (FC) or Individual Project (DI) means and Propensity Score Matching Results

	FC/DI mean	Std. Error
Control Group (DI)	5.64	0.055
Experimental Group (FC)	5.94	0.028

PSM Results for control v/s experimental groups by GPA	Coef.	Std. Error	z	P > | z |	[95% Conf. Interval]	
	0.225	0.062	3.59	0.000	0.102	0.348

Finding 2.4 indicates that **students in the experimental group dedicated more weekly hours to the course than students in the control group, due to difficulties in organizing the group projects.** This is supported by two partial results. First, there is a statistically significant difference between student's perception of their weekly hours of dedication to the course between the control and experimental group. The experimental group indicated that they dedicated an average of 11 hours a week to the course, while the control group reports only 9 hours a week, in average, as can be seen in Figure 3-3. The second partial result is that in the focus groups and course evaluations, students in the experimental group agreed that the group projects were too much work for such little time a week. They said that "*it was very hard to organize eight people in a couple of days to create and turn in a project, every week*" and that "*if the projects could have been turned in a few days later (Sunday or Monday for example), then it would have been easier to plan the work, but since the due date was always Friday, they lost a great deal of time in the organization process of the task*".

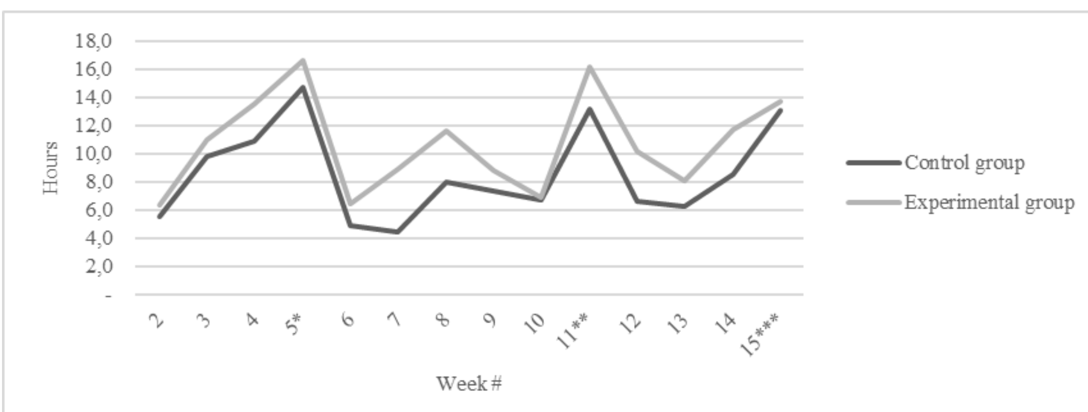

Figure 3-3: Students' perceptions of their weekly hours of dedication to the course

* Test#1 on Friday of this week, ** Test#2 on Friday of this week, *** Test#3 on Friday of this week

Finding 2.5 says that **throughout the semester, students that participated in the flipped class methodology developed two skills that the control group students did not: responsibility and collaborative learning**. This finding is supported by one main analysis. Table 3-13 shows the control and experimental groups' means in the BL abilities questionnaire's dimensions, and the T-Student results when comparing control v/s experimental group's pre results, control v/s experimental group's post results, experimental group's pre v/s post results and control group's pre v/s post results. In the pre-test, there are no statistical differences between the control and the experimental group in any of the six dimensions. Neither are there statistical differences in the control group's results between the pre and post-test. However, the experimental group's results in responsibility and collaborative learning are statistically different (better) than the same group's results in the pre-test and statistically different (better) than the control groups' post-test results. This finding suggests that students in the MOOC-based flipped class methodology perceive they develop responsibility and collaborative learning abilities, while students in the traditional class do not.

Table 3-13: Blended learning abilities questionnaire results

**RESP = responsibility; CL: Collaborative learning; ORG: organization; TM: time management; OC: oral communication; PRO: proactivity.*

		RESP	CL	ORG	TM	OC	PRO
Group Means	Control - Pre	3,71	3,73	3,29	3,35	3,67	3,71
	Experimental - Pre	**3,76↓**	**3,72↓**	3,17	3,44	3,64	3,71
	Control - Post	**3,70↓**	**3,71↓**	3,42	3,45	3,74	3,76
	Experimental - Post	**3,91↑**	**3,90↑**	3,30	3,45	3,79	3,87
T-Student P-Values	Control v/s experimental group's pre results	0,34	0,91	0,29	0,34	0,65	0,94
	Control v/s experimental group's post results	**0,00***	**0,02***	0,43	0,98	0,62	0,22

Control group's pre v/s post results	0,88	0,78	0,35	0,32	0,39	0,55
Experimental group's pre v/s post results	**0,03***	**0,03***	0,33	0,93	0,10	0,06

3.6 Discussion and limitations

The lessons reported in this section were obtained from reflecting on the results from student's adoption of the blended learning methodology and their learning outcomes. One of the main advantages of quasi-experiments over other forms of interventions is that if the results of a quasi-experiment show differences in outcomes between the experimental and control groups, these differences can be attributed to the experiment in question [80]. Therefore, aspects of the study that could be applied to other contexts are highlighted, and the issues that emerge from this study as future work, are reported as limitations that would deserve further analysis.

Regarding the experimental student's adoption, the results show that students first struggle with the new teaching methodology and manage to adopt it successfully as the course evolves. They end up appreciating the new methodology, and even preferring it over a traditional one in some cases. This conclusion coincides and reaffirms other studies found in current literature. One particular author, Ghadiri et.al., describes this process as an evolution with three stages of acceptance during a BL course using MOOCs: 1) the initial resistive stage, where students complained about the extra time they had to dedicate to the course; 2) the skeptic stage, when students began to realize that this methodology could be beneficial; and 3) the receptive stage, where students finally adopted and engaged with the BL course [82]. Therefore, students in the experimental group of this quasi-experiment behaved as could have been expected, embracing and adopting the MOOC-based flipped course successfully according to the expected stages of a process of this nature.

To promote an even easier adoption of the flipped class methodology, students would benefit if this teaching strategy was presented to them in their first semester as college students. Also, students could have a few sessions to adapt and realize that it is a different course structure.

Regarding student's learning outcomes, the first general conclusion that can be reported in this work is that, in average, students in the experimental group obtained the same grades than the control group. Nevertheless, it is important to point out that the class tests were not adapted for the flipped class and followed the same structure and question's style that the course had presented in previous years, in order to have comparable results with the control group. Moreover, students in the experimental group complained about the form of the tests, saying they expected them to be "more practical and to require less memory".

Therefore, of all the grades in the course, we consider that the Flipped Class grades and the Individual Projects grades are a better representation of student's learning outcomes in each methodology. This is sustained by the fact that the Flipped Class grades evaluate student's hands-on learning through peer collaboration in an active learning environment. Meanwhile, the Individual Project grades evaluate student's individual understanding of the traditional teacher-centered lecture format of the class. Therefore, given that performance in the FC assessments is significantly better than the control group's performance in the IP's, we believe that students in the experimental group gained a deeper and more profound understanding of the course's contents than students in the control group. Nevertheless, a deeper analysis of the assessments and the obtained grades is needed to be able to conclude this objectively.

Finally, a very interesting emerging result that was not intended is that students that participated in the flipped class methodology developed responsibility and collaborative learning skills throughout the semester, while students in the control did not. This finding suggests that blended learning encourages students to take responsibility over their learning process and to collaborate, which are essential skills for the 21st century [83]. In particular, related works suggest that the flipped class methodology provides more opportunities for students to develop these, and other, vital skills than the traditional teacher-centered lecture, given that it promotes in-class discussion and hands-on learning activities during class time [84]. Therefore, this study contributes with successful results in this research area.

In the face of the successful results presented in this study, we still have many questions that we would like to be addressed in future work. For example, the data showed that the control group says they benefitted more from class attendance than the experimental group, despite the lecture-based methodology. Maybe this was because students in the control group did not feel responsible for their own learning process and therefore, valued the lecture-based classes more, but this is only a hypothesis that we would like to investigate in future interventions.

Another important issue that deserves much more investigation is how to assess in flipped classrooms and in BL in general. Throughout the semester, we were constantly struggling to create assessments that were consistent with the class methodology, but we are not sure if we achieved this completely. Therefore, in future versions of this course we would like to have more time to prepare the courses' assessments and make sure they are truly measuring what we believe students should learn in the BL course.

This chapter has shown that students in a MOOC-based flipped course greatly value the new teaching strategy and get successfully involved in their own learning process. This work enhances the research in current literature on flipped courses with MOOCs, and the presented results are aligned with prior research in this area which also conclude that MOOC-based flipped course in higher education are an effective teaching methodology. Moreover, the findings are encouraging and beneficial for future higher education institutions that wish to implement flipped courses.

4. SECONDARY EDUCATION

This chapter presents a pilot study with secondary education students that took place in 2018. The experience was conducted with eleventh graders from Colegio Eliodoro Matte Ossa, from the Sociedad de Instrucción Primaria Foundation, in Santiago, Chile. Students were coursing Accountability, and were presented with a MOOC-based blended learning methodology.

This chapter answers two research questions, from the perspective of secondary education students. The research questions are: (RQ#1) what is the impact of a MOOC-based flipped classes in terms of students' learning outcomes? And (RQ#2) how do students adopt the MOOC-based flipped class experience, and how does this adoption affect their learning outcomes?

The main results of this chapter have been accepted to be published in IEEE RITA.

4.1 Context

This chapter presents a pilot study of a MOOC-based blended learning experience conducted in a Secondary Education School located in a peripheral district of Santiago, Chile. This school is characterized by the vulnerability of its population, with low socio-economic income, and is part of the Sociedad de Instrucción Primaria (SIP) Foundation. The school was built in 2008 and started operating with students in 2009.

In relation to socioeconomic status (SES), in [85], the National Board of Student Support and Scholarships defined the concept of *socioeconomic vulnerability* (called "índice de vulnerabilidad", IVE) as a dynamic condition which results from the interaction between multiple risk and protection factors and which manifests itself in minor or major acts of social, economic, psychological, cultural, environmental or biological risks producing a comparative disadvantage between subject, families and communities. Therefore, IVE is considered an official and accurate indicator of SES. The school's student's average vulnerability index is 92%, which indicates that most of the students of this school live in extreme poverty conditions and have a high risk of scholar failure [86].

As part of the curriculum, the school offers a technical degree in one of three areas: accounting, telecommunications, and logistics. Technical degrees consist in 2 years of differentiated studies for those students that are interested, during their junior and senior years. In Chile, high school technical degrees are a very effective mechanism to either help vulnerable students continue to higher education studies related to their technical degrees, or give them better job opportunities since they may not be able to go to college because of their economical situations [87]. This school started its first technical degree programs in 2018 with the school's first generation of 11th graders, offering limited vacancies for each specialty for which students had to apply the previous year.

Given the school's vulnerability index, students came from many different backgrounds and living situations. Some have academic support from their families, but other learners do not, and are therefore, in disadvantage regarding personal study time at home, study tools, technologies, and/or even physical space. In order to address these differences, the school was eager to create an innovative curriculum for the technical degrees that lessened this gap. Specifically, the school proposed incorporating digital resources as part of the face-to-face lectures for changing the traditional lecture-based teaching methodology for a more blended experience in which students could advance and evolve at their own pace. As a test, the school chose the Accounting course for running a pilot study, run by one of the teachers more open to technological innovations. The pilot took place from October 16 to November

12 of 2018. A MOOC was created especially for the course, addressing two specific topics, which were taught through a MOOC-based blended learning approach instead of a traditional lecture.

4.1.1 MOOC design

For the course design, the initial idea of the teacher was to reuse existing content. However, after a systematic revision of all Spanish MOOCs on accounting topics in 7 MOOC platforms (see Table 4-1), only twenty-nine MOOCs partially covered the selected contents of the course, but no MOOC covered the topics completely. This was mostly due to that the course's topics respond to specific Chilean banking and commercial laws, so most foreign MOOCs contained misleading information. In consequence, the teacher decided to create a MOOC specially designed for the course, following the school's curriculum.

Table 4-1: Selected and revised MOOCs in each platform

MOOC Platform	Search Phases		
	Phase 1: Language and Indexation	**Phase 2**: Title and Description	**Phase 3:** MOOC Contents
Class Central	174	0	0
Coursera	188	42	11
EdX	46	13	4
Miriada X	44	17	12
EMMA	54	0	0
Mexico X	17	1	1
Iversity	2	1	1
MOOCs after each revision	**525**	**74**	**29**

From the Accounting course, two topics were selected to be taught through the MOOC: banking documents and mercantile documents. Banking documents has the following contents: checks, bank vouchers, fixed deposits and debenture notes. Mercantile documents includes the following contents: VAT, invoices, credit notes, debit notes, and purchase and sales records.

The MOOC was designed as a Massive Open Online Course with 8 sessions (to be completed self-paced). The OpenEdX platform from the School of Engineers of Pontificia Universidad Católica de Chile was used for hosting the course, and anyone can enroll in the following link and take the course if interested (http://online.ing.uc.cl/courses/course-v1:PUC+DB001+DB001_18/about). For this study, the MOOC was taken as the main resource of the course and, therefore, considered as a Small Private Online Course (SPOC). However, the course was designed from the beginning as a MOOC, with a video-lectures and exercises that anyone can do without the support of a teacher. Then, the teacher wanted to include the MOOC as a resource in the course, as other studies have previously reported [37]. Therefore, and since the course was designed as a MOOC, we prefer keeping the term MOOC instead of SPOC throughout the rest of the chapter.

The video-lectures' contents, presentations and scripts were generated by the teacher. However, the videos were recorded by two students selected by the teacher. The idea was to motivate students to watch the videos and to make the learning process more participative. Figure 4-1 shows an example of one of the generated videos.

Given the contents of theoretical, mathematical and practical nature, the assessments were constructed by three different types of problems to best fit each topic: Multiple Choice, Numerical Input, and Drag and Drop. Multiple choice was used to assess on the theoretical concepts and a few mathematical exercises, and each problem weighed 1 point. Numerical input problems were used for mathematical exercises. Each problem could contain between one and four mathematical exercises, and each exercise weighed 1 point. Drag and Drop was used for the practical problems of completing or "filling in" the different documents. Each Drag and Drop problem had between 15 and 20 items to be "dragged", and each item weighed 1 point.

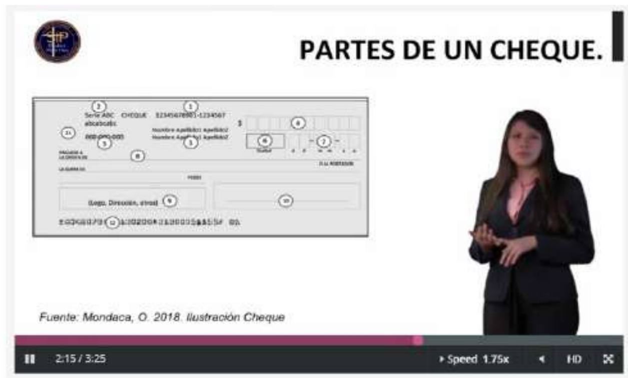

Figure 4-1: MOOC video-lecture with students as protagonists

Table 4-2 shows in detail how the MOOC is structured according to the course's contents, number of video-lectures (VL), and how many assessments in Multiple Choice (MC) problems, Numerical Input (NI) problems and Drag and Drop (D&D) problems it has in each topic. The table also shows how many points each type of problem has, since the Numerical Input and Drag and Drop problems could have many exercises. At the end of the MOOC, there was a final review with 57 Multiple Choice questions covering all the topics.

Table 4-2: MOOC's resources and assessment items

	ID	Contents	VL	MC (Prob/pts)	NI (Prob/pts)	D&D (Prob/pts)
Banking Documents	1	Checks	3	19/19	0	9/60
	2	Bank vouchers	1	14/14	0	0
	3	Fixed deposits	1	7/7	0	2/15
	4	Debenture notes	1	5/5	0	2/26
Mercantile Documents	5	VAT	1	30/30	20/20	0
	6	Invoice, credit and debit notes	1		0	7/127
	7	Purchase and sales records	1		36/140	0
		Final MOOC review	0	57/57	0	0
		Totals	**9**	**132/132**	**56/160**	**20/228**

4.1.2 A blended learning approach for integrating the MOOC content

In this school not all students have personal access to a computer or tablet and stable internet connection in their homes, so working in the MOOC outside the classroom was not an option. For this reason, the proposed teaching methodology was to integrate the MOOC in the classroom, taking advantage of the autonomy it gave students in their learning process, and at the same time, giving all the students "equal footing".

Eight classes were taught through the MOOC, and each class lasted 90 minutes. At the beginning of each class, the teacher proposed a goal for that session, to give students an idea of how much they should advance during the class.

During class, students reviewed the course's contents online individually through the MOOC's video-lectures and completed the exercises in the platform at their own pace. The key advantage of this methodology is that the teacher's role during class was to attend students with more difficulties individually and help them work through the subjects each one struggled with more. Also, students helped each other with simple doubts and could work in groups to solve exercises if they preferred.

Before these eight sessions, students took a pre-test on the accounting contents covered in the MOOC. After the 8 sessions, they took the same test to measure their learning gains. Also, a few sessions after the post-test, students took the Superior Logic Intelligence Test (TILS) and Motivated Strategies for Learning Questionnaire (MSLQ), explained in section IV of this chapter. The detail of each session is presented in Table 4-3.

Classes took place in one of the school's computer rooms, with enough room for all students and internet connection capabilities for a massive number of people.

Table 4-3: Session summary

Session	Date	Proposed Class Activity	Attendance
1	Oct 19	Pre-Test	17
2	Oct 22	MOOC: Introduction & Checks	17
3	Oct 24	Bank vouchers, fixed deposits and debenture notes	18
4	Oct 26	Banking documents review	15
5	Oct 29	VAT & Invoices	19
6	Oct 31	Credit and debit notes & Purchase and sales records	20
7	Nov 05	Mercantile documents review	17
8	Nov 09	Final MOOC review	15
9	Nov 12	Personal study session	18
10	Nov 14	Post Test	17

4.2 Research questions

The main objective of this study was to gain insights on how a MOOC-based blended learning activity was used to deal with the classroom diversity by analyzing its impact in terms of students' adoption and learning outcomes. Two research questions were defined:

- RQ#1. **What is the impact of a MOOC-based blended experience in terms of students' learning outcomes**? This question aims at understanding if the MOOC-based blended learning methodology affects student's performance in the course in any way.
- RQ#2. **How do students adopt the MOOC-based blended learning experience, and how does this adoption affect their learning outcomes**? This question aims at understanding how students assimilate and integrate the MOOC-based blended learning experience in their learning process.

4.3 Participants & data sample

Twenty seventeen-year-old students participated in the study. There were 11 girls and 9 boys. However only 17 students, who conducted all the assessment activities were selected as the data sample.

4.4 Data collection and analysis

Both qualitative and quantitative data was gathered throughout the semester to fully comprehend the adoption of the blended learning teaching methodology, and how it affects students' learning outcomes. The quantitative data gathered throughout the semester was:

- **MOOC Log-files**: MOOC's log-files that registered students' interactions with the MOOC's assessments.
- **Pre and Post Accounting test grades**: an accounting assessment was created by an accounting expert external to the school that did not participate in the pilot experience. This expert constructed the instrument only based on the MOOC's contents. Students took the same test before and after the 8 class sessions, as can be seen in Table 4-3. The pre and post versions of the assessment had the same questions in different order.
- **Superior Logic Intelligence Test (TILS)** [88]. Students took the Superior Logic Intelligence Test, a one-dimensional instrument created in Chile that scales the differential scores according to age and type of school (regarding administrative support). The TILS instrument has shown a positive and meaningful correlation between logical intelligence and overall academic performance, especially in the area of mathematics [89], [90]. Therefore, student's scores in this questionnaire were considered as a measure of their general intelligence. This instrument is normalized and tested.
- **Motivated strategies for learning questionnaire (MSLQ)** [91]**:** Students responded the MSLQ, a self-reported instrument designed to assess students' motivation and learning strategies. The MSLQ gives information about the students in three dimensions: motivation for studying, their learning strategies, and their anxiety during assessments. This information was important to understand if student's adoption and/or learning outcomes were being influenced by external personal factors or motivations, and not just the new teaching methodology. This instrument is normalized and tested.

The qualitative data gathered throughout the semester is:

- **Focus Group**: Two focus groups were performed to obtain the entire class's perspective on this teaching methodology regarding their adoption, learning outcomes and general appreciation. The focus groups were performed by an external expert that had not participated in the pilot study, so that students would feel free to say whatever they wanted about the intervention. The Focus groups had six questions regarding adoption in three sub-topics: understand the use of the MOOCs' resources, student's autonomy and the teaching methodology. Also, it had four questions regarding learning outcomes: student's perception of their personal learning process, the teacher's roll in their learning, courses' contents and types of exercises.

- **Teacher Interview**: a semi-structured interview was performed to the teacher of the class by an external expert, to obtain her perspective on the student's adoption of this teaching methodology and their learning outcomes, especially regarding its utility in diminishing the learning gap between students and favoring student inclusion. The interview had five questions regarding adoption in three sub-topics: understand the use of the MOOCs' resources, student's autonomy and the teaching methodology. Also, it included four questions regarding learning outcomes: student's perception of their personal learning process, the teacher's roll in their learning, courses' contents and types of exercises. The interview had two questions regarding her perception of her workload and student's workload during the experiment.

4.4.1 Data analysis

The quantitative and qualitative data gathered was analyzed using a Mixed Method approach to report the main findings. The mixed method research approach was chosen because it aims at maximizing the strengths of both quantitative and qualitative methodologies [4].

Also, given the class's reduced size of only 20 students, 17 of which are the experimental sample, the statistical results of this work are bound to be insignificant and will only suggest general tendencies.

First, both MSLQ and TILS questionnaires were used to establish a comparative baseline between students in terms of their general intelligence and personal motivations that could affect the results of this study.

To respond our first research question about students' learning outcomes, we analyzed and compared the student's results in the pre and post accounting assessment, their scores in the TILS and MSLQ, the focus group conclusions and the teacher interview results.

First, we analyzed students' grades in the pre and post assessment by performing T-Student tests to compare student's results in both instances. The TILS results are normalized by the student's age and the type of school administration (which strictly relates to the school's vulnerability). Correlations and linear regressions were performed between the post-test scores and student's TILS scores to discard that student's scores in the post test respond to their general intelligence and not the MOOC-based blended learning approach.

Regarding the MSLQ, correlations and linear regressions were performed between the pre and post-test scores and student's scores in the MSLQ, to discard that student's performance responds to their motivation, learning strategies or (reversely) to their anxiety, and not the MOOC-based blended learning approach.

Finally, the Focus Groups and Teacher's interview results related to learning outcomes were considered for cross-analyzing them with the quantitative data.

To respond our second research question about student's adoption of the MOOC-based flipped class methodology, we analyzed student's grades in the post test, the MOOC log-files, the MSLQ scores, the focus group conclusions and the teacher interview results.

The MOOC log-files contain students' final scores in each of the assessment items, and the number of times they attempted to respond each one before obtaining the final score.

Therefore, the quantitative part of the adoption analysis of the blended learning methodology was done by performing correlations and linear regressions in STATA between student's movements in the different sections of the MOOC, and their performance in the post test.

Also, correlations were performed between student's movements and their scores in the MSLQ, to analyze if their engagement in the MOOC responds to their motivation or learning strategies.

Finally, the Focus Groups and teacher's interview results related to adoption were considered for cross-analyzing them with the quantitative data.

4.5 Results

This section reports the results obtained from the analysis to address the two research questions. First, we present the results about the effects on students' learning outcomes. Then we present an analysis of student's adoption of the MOOC initiative and its effect on their learning outcomes.

4.5.1 Student's learning outcomes

Table 4-4 shows the summary of findings on students' learning outcomes, including the data source(s).

Table 4-4: Findings regarding student's learning outcomes

	Findings	**Data Source(s)**
1.1	Student's knowledge on banking and mercantile documents increased significantly after the fourth week	Pre & post accounting test scores; Focus Groups; Teacher interview
1.2	Disadvantaged students, with lower levels of prior knowledge, were equalized it terms of their learning outcomes in mercantile documents.	Pre & post accounting test scores; TILS scores
1.3	Disadvantaged students, with lower motivation, fewer learning strategies and more anxiety during assessment, were equalized in terms of their learning outcomes in mercantile documents.	Pre & post accounting test scores; MSLQ scores

Finding 1.1 states that **student's knowledge on banking and mercantile documents increased significantly after the fourth week,** as can be seen in Figure 4-2**.** This finding is

supported by three partial results. First, students obtained significantly better final scores in the post-test than the pre-test. The pre-test average score is 43.4 points whereas the post-test average score is 67.0 points, and this difference is statistically significant (*P-Value*: 0.00006).

Second, in the focus groups students stated that “we learned more with the MOOC than in a traditional class because we worked at our own pace and could revise the video-lectures as many times as we wanted”. Also, they said “the videos don’t change, while a teacher can explain something twice in a completely different manner, which can be more confusing than helpful”. Students also greatly valued the immediate feedback from the exercises, stating that this helped them learn greatly. For example, one student said that “you learn from your own mistakes thanks to the automatic corrections. In a normal class, if you don’t check your answers with the teacher, you don’t know if you solved a problem correctly or not. Therefore, this system is more efficient. Another student stated “that the system would check your answer automatically was excellent. This way, I never stayed with the wrong answer thinking it was correct”.

Finally, the teacher said, “I think the learning outcomes were the same as would have been in a traditional class, but they gained a great learning experience”.

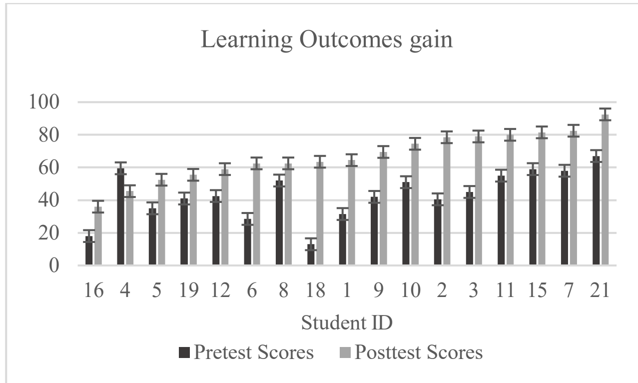

Figure 4-2: Students' pre and post test scores

Finding 1.2 reveals that **disadvantaged students, with lower levels of prior knowledge, had an equal footing in terms of their learning outcomes**, given that their learning outcomes of banking and mercantile documents were not related to their profile captured by the TILS. The TILS scores go from 16 points, which corresponds to percentile 12, to 42 points, which corresponds to percentile 96. This shows a huge gap between a small group of students from the same class, that have been learning from the same teacher in the same manner in the past. Despite this gap, the regression results between student's post-test scores and their TILS scores are not significant (R = 0.1545). Also, the regression results between student's difference between the pre and post-test scores and their TILS scores are not significant either (R = 0.3607). This finding suggests that this learning methodology has positive effects in social inclusion for disadvantaged learners [92]. Figure 4-3 illustrates this relationship.

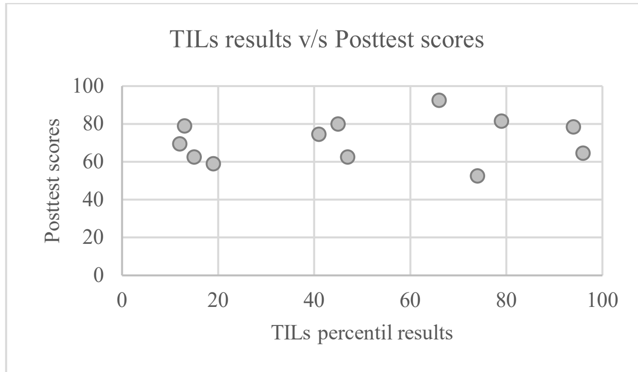

Figure 4-3: Students’ TILs percentile results v/s posttest scores

Finding 1.3 reveals that **disadvantaged students, with lower motivation, less learning strategies, and/or more anxiety during assessments, had an equal footing it terms of their learning outcomes.** On a scale from 1.0 to 7.0, students’ motivation results go from a score of 5.34 the lowest, to a 6.75 the highest; the learning strategies go from 4.13 to 6.30; and the test anxiety scores go from 3.6 to 6.0. The gaps between students shows disadvantages for those with high anxiety, low motivation, or scarce learning strategies in relation to students with the opposite characteristics. Even so, no strong correlation was found between student’s scores in any of the MSLQ’s dimensions, and their performance on the pre and post-test, nor the difference between these scores. Figure 4-4 illustrates this relationship.

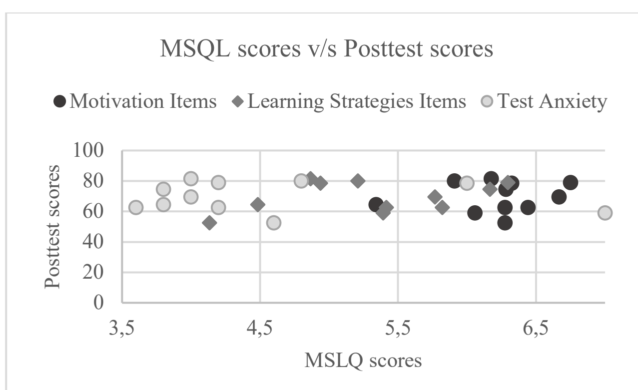

Figure 4-4: Students’ MSLQ results v/s posttest scores

In conclusion, these three findings suggest that the MOOC-based blended learning experience has a positive effect in student's learning outcomes. Students were able to learn the contents of the course as was expected, by performing well in the post-test in comparison to the pre-test. In addition, this significant increase in their learning was not related to their general intelligence nor personal motivations or study habits, which in turn, have been known to be related to learners' disadvantages given their vulnerable contexts [93].

4.5.2 Student's adoption of the blended learning methodology

Table 4-5 shows the summary of the findings on students' adoption of the learning approach, including the data source(s).

Table 4-5: Findings regarding student's adoption

	Findings	Data Source(s)
2.1	Students' scores in the exercises of the MOOC's final review section are significantly related to their final learning outcomes.	MOOC log-files; Post-test scores
2.2	Students that answered the MOOC's exercises randomly did not learn as much as those that took the exercises seriously and answered systematically.	MOOC log-files; Post-test scores; Focus Groups
2.3	Disadvantaged students, with lower motivation, less learning strategies and/or more anxiety during assessment, had an equal footing it terms of their adoption of the blended learning methodology.	MSLQ scores; MOOC log-files, accounting test scores
2.4	Students greatly valued the learning methodology and advancing on their own pace.	Focus Groups; Teacher interview
2.5	The MOOC-based blended learning experience was greatly appreciated as an effective methodology to deal with students' diversities and/or disadvantages.	Focus Groups; Teacher interview

Finding 2.1 indicates that **students' scores in the MOOC's final review are significantly related with their final learning outcomes.** The MOOC's final review consisted on 57 multiple choice questions covering all the contents of this study. This finding is supported by two different partial results. First, the correlation between the post-test scores and the

final review scores is strong (R = 0.66). Second, this correlation is statistically significant (ß = 0.2, t = 3.43, P>|t| = 0.004, Prob>F = 0.0037).

Finding 2.2 indicates that **students that answered the MOOC's exercises randomly did not learn as much as those that took the exercises systematically**. A group of students opted to answer randomly in the MOOC's assessments until they got the right answers, registering more attempts than those students that tried to solve the problems before answering. We found through this study that those who made more attempts in the MOOC's assessments did not learn as much as those that made fewer attempts. This finding is supported by three different partial results. First, there is a negative correlation between the post-test scores and the attempts the students made on the assessments (R = -0.55). Second, this negative correlation is statistically significant (ß = -0.243, t = -2.55, P>|t| = 0.022, Prob>F = 0.022). Finally, the teacher stated that "it was very effective that the students could see where they were making mistakes in the exercises. When we take a test, students have to wait a long time before they can know what they understood and what they didn't. Here they could immediately see what they were getting wrong".

Finding 2.3 reveals that **disadvantaged students, with lower prior knowledge, lower motivation, less learning strategies, and/or anxiety during assessments were equalized in terms of their adoption of the blended learning methodology**. This finding is supported by the fact that no strong correlation was found between student's scores in any of the MSLQ's dimensions nor their TILS results, and their completion of the different sections of the MOOC, as can be seen in Figure 4-5 and Figure 4-6. Given the difference between students' scores in the MSLQ and TILS reported in Findings 1.2 and 1.3, disadvantaged students are not undermined with this methodology.

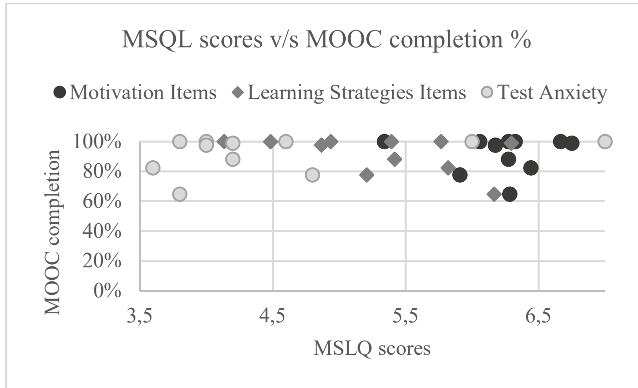

Figure 4-5: Students' MSLQ scores v/s their MOOC completion percentage

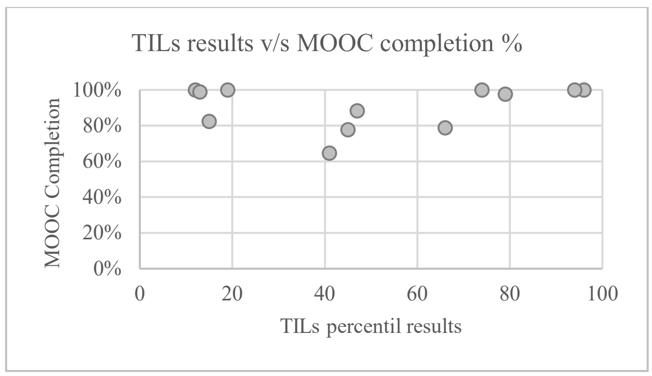

Figure 4-6: Students' TILs percentile results v/s their MOOC completion percentage

Finding 2.4 says that **students greatly valued the learning methodology and advancing on their own pace**. In the Focus Groups, there was consensus in this matter. For example, one student said that "in class, some people get lost and those that understand faster are the only ones able to keep up. This generates a gap between us. But here everyone advanced at their own rhythm, so it gave us equality". Another student said, "there is no reason to bother the entire class when you don't understand something, because it's all in your videos". Also, someone stated that "we don't have to worry about interruptions. In normal classes, if something is misbehaving the teacher has to stop the entire lecture. Here we don't get distracted. Everyone is listening to their videos with their earphones and you can't hear when somebody is misbehaving".

Finally, the teacher stated that “this methodology helped student’s self-control, because in class you must be shushing them, telling them to sit, to do this or to not do that. Meanwhile here they were protagonists of their own learning, so they had to control themselves and concentrate in the video-lectures”.

Finding 2.5 suggests that **the MOOC-based blended learning experience was greatly appreciated as an effective methodology to deal with students’ diversities and/or disadvantages, promoting educational inclusion.** In the Focus Groups, there was consensus in this matter. One student said “when I couldn’t attend class one day, the teacher took her time and helped me catch up. This never happens in a normal class”. Other comments were “the teacher can stay with those students that need help the most…we can ask for help at any moment during the class…sometimes you felt as if you had the teacher all for yourself, whenever you wanted”. In addition, they compared this methodology with a traditional lecture, stating that “in a traditional lecture the teacher does not have time to explain the contents to those that don’t understand so fast…in a traditional lecture, you can’t rewind, and many times the teacher doesn’t have the time for everyone”. Finally, the teacher said “those students that always have a harder time understanding were the ones that had the most questions during this experience, and I could help them much more than normal.”

These findings suggest that students successfully adopt the MOOC-based blended learning methodology and it is a good alternative to promote diversity and social educational inclusion. First, it allows a more personalized education, by having students advance at their own different learning rhythms. Second, students can exercise with immediate feedback, which increases their performance. Finally, the teacher has time to help disadvantaged students individually.

4.6 Limitations

A limitation of this study is that the N in this experience is very small. Even so, statistically significant findings have been reported which suggests that certain results could be expandable to other similar scenarios.

Another limitation is that we do not know for sure if students discussed and/or memorized their answers from the pretest when responding the posttest. Therefore, the results of the post-test should be considered only as a reference for evaluating knowledge improvement.

4.7 Conclusions and discussions

Each finding presented in this work contributes to current literature regarding specific topics of discussion. Moreover, when trying to understand the greater impact of MOOC-based blended learning in secondary education, we must combine the findings to understand them as a whole.

Concerning the impact of a MOOC-based blended experience in terms of students' learning outcomes, our findings suggest that this learning methodology positively affects their performance in the course. Regarding adoption, our findings suggest that students successfully assimilate and integrate the MOOC-based blended learning experience in their learning process. Finally, both suggestions are complemented with the fact that student's disadvantages are not reflected nor related with the results in any way (Finding 1.2, 1.3 and 2.3).

Therefore, through this pilot study we can aggregate to current literature by concluding that a MOOC-based blended learning experience promotes inclusion of vulnerable students with learning gaps, favoring an "equal footing" between classmates.

Talented children who live in a vulnerable socioeconomic context are strongly affected by the lack of adequate opportunities and instruments to meet their specific educational needs [93], [94]. In fact, governmental data has shown that a school's index of vulnerability (IVE) is negatively correlated to students' cognitive abilities [93].

With this work we aimed at evaluating whether a MOOC-based blended learning experience is a good method for students with a high vulnerability index, who are not usually exposed to technology-enhanced learning settings nor used to learning at their own learning pace. The results of this work show that these students adopted this method successfully and valued it positively. We hope that this work serves as a first step to working for the inclusion and promotion of learning equity of disadvantaged secondary students through MOOCs-based blended learning.

5. MULTICASE STUDY

5.1 Context

To address the research questions of this thesis, we have presented in the previous chapters three contributions of MOOC-based blended learning experiences: a 2-month pilot study in secondary education, a 3-month pilot study in postsecondary education [17], [19], and a quasi-experiment in higher education [77], [78]. All these activities were designed, implemented, and evaluated in authentic learning situations. To present a deeper comprehension of the impact of MOOC-based blended learning, the next step is to cross-analyze these three learning blended learning experiences in a multicase study adjusted to our research purposes.

A multicase study is a methodology typically employed by educational researchers to study experiences of cases in real situations [95]. They have been successfully applied as an instrument for studying the effects of a technology in context [96] when the evaluation involves human-related real experiences [97]. Multicase studies comprise different case studies of similar interventions in different contexts. The final goal is to comparatively analyze the case findings in order to conclude cross-case **assertions** about the main aspects under evaluation (what is called the *quintain*). The quintain is defined as the ultimate evaluation goal that is common to multiple experiences comprising a multicase study [95], [96].

This chapter adapts the multicase methodology according to the proposal by Hernández-Leo et al [96] and also applied in Pérez-Sanagustín et al [75] to facilitate the cross-analysis of the findings in the three case studies presented in chapters 2, 3, and 4. The strength of using this methodology relies on enriching the understanding of the main research question and providing multiple perspectives of the same proposition for a stronger validation.

5.2 *Quintain* and research questions

We structured the multicase study as shown in Figure 5-1. We started from the main research aim as the umbrella of the study, responding to what "we seek to understand", and then, we defined three research questions that guided the evaluation and cross-case analysis. The research aim of this work is to *study the MOOC-based blended learning approach from student's perspective.* The research questions under this umbrella are (1) How do students engage with the MOOC(s) and adopt the MOOC-based blended learning methodology, (2) What is the impact of MOOC-based blended learning in students' learning outcomes? And (3) is there a relationship between students' adoption of the MOOC-based blended learning methodology and their learning outcomes? In addition, two emerging research questions appeared during the cross-case analysis: (I) Is there a relationship between the blended learning model and student's adoption of the MOOC-based blended learning methodology, and (II) How does a MOOC-based blended learning methodology promote socioeconomic inclusion and equal educational opportunities for disadvantaged students?

Each case study has previously responded similar research questions (or *issues;* to distinguish from the research questions of the multicase study) in each context, through a mixed method analysis considering quantitative and qualitative data. Figure 5-1 summarizes what has been presented in Chapters 2, 3 and 4 under the umbrella of the quintain and research questions under study.

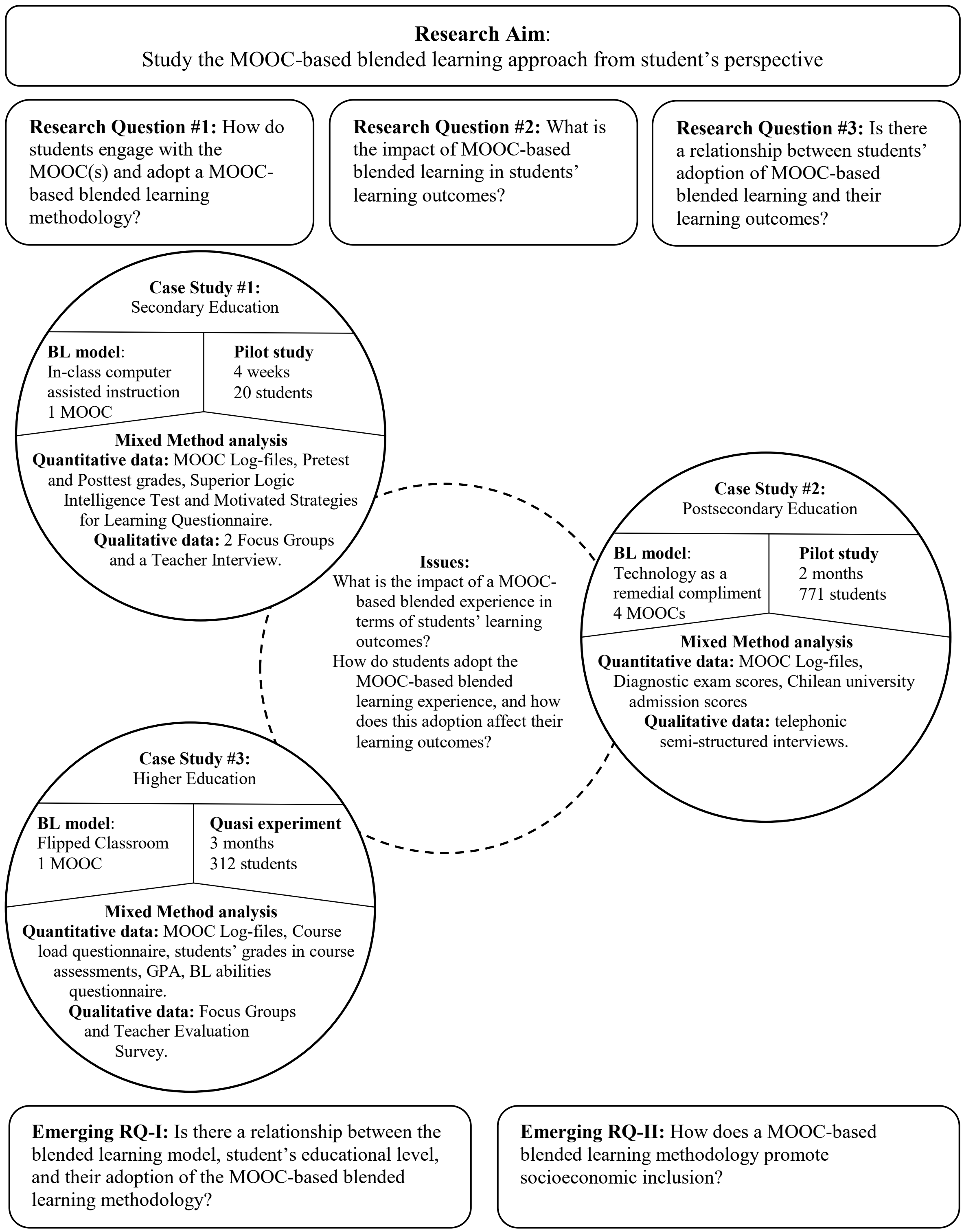

Figure 5-1: Multicase study summary

5.3 Data collection and analysis

The first step to carry out a cross-analysis consists in analyzing the data of each case separately, guided by its issues, and extracting the findings for each case. In a second step, the findings of each case are organized according to the main research questions to which they provide answers. The findings of a case give the perspective of the research questions from a particular activity and context. Treating all findings together allows extracting contrasted results about the research questions based on evidence, which correspond to the data behind each finding.

5.3.1 Case studies

We aim at understanding each case considering its context. The method employed to collecting data integrates quantitative and qualitative data gathering techniques. Quantitative data allows detection of general trends, while data obtained through qualitative techniques allows the evaluators to understand these trends better by introducing contextual issues and considering participants' perspective.

The quantitative data that is available for the three cases are: (1) student's grades or scores in course assessments related to the contents of the study, (2) movements in the MOOCs under study, and (3) a "prior knowledge" measurement for each student. The qualitative data that is available for the three cases are focus groups and/or semi-structured interviews with students. In addition, each case study recollected more quantitative and qualitative data according to the specifics of each blended learning design, such as perception or abilities questionnaires for students, semi-structured interviews with the teacher, etc., as was detailed in Figure 5-1 above.

Table 5-1 shows a summary of each case study regarding the analysis that was carried out to respond the following issues in each context:

- **Issue #1:** What is the impact of a MOOC-based blended experience in terms of students' learning outcomes?
- **Issue #2:** How do students adopt the MOOC-based blended learning experience, and how does this adoption affect their learning outcomes?

Table 5-1: Data analysis carried out to respond the issues in each Case Study

Case Study		How/what was analyzed to respond Issue #1	How/what was analyzed to respond Issue #2
Case #1: Secondary Education 20 students in the same class	Quantitative Analysis	Mean-comparison tests between students' grades in the pre and post assessment. Correlations and linear regressions between the post-test scores and student's TILS (prior knowledge) scores. Correlations and linear regressions between the pre and post-test scores and student's scores in the MSLQ	Correlations and linear regressions between student's movements in the different sections of the MOOC, and their performance in the post test. Correlations between student's movements in the MOOC and their scores in the MSLQ.
	Qualitative Analysis	The Focus Groups and Teacher's interview were transcribed and analysed using an open coding technique. Results regarding learning outcomes were cross analysed with the quantitative data.	The Focus Groups and Teacher's interview were transcribed and analysed using an open coding technique. Results regarding adoption were cross analysed with the quantitative data.
Case #2: Post-Secondary Education 752 students (295 active; 457 non-active)	Quantitative Analysis	Mean-comparison tests and Chi-squared test between active and non-active student's scores in the DEs and their approval rates. Propensity score matching based on students' prior knowledge between active and non-active students, estimating their performance in the diagnostic exams.	Linear regressions between active students' movements in the MOOCs, and their performance in the DEs. Detailed analysis of daily movements in each MOOC.
	Qualitative Analysis	The semi-structured interviews were transcribed and analysed using an open coding technique with a predefined node for learning outcomes. Results regarding learning outcomes were cross analysed with the quantitative data.	The semi-structured interviews were transcribed and analysed using an open coding technique with a predefined node for adoption, and an emerging category about students' adoption: Opinion about Resources. Results regarding adoption were cross analysed with the quantitative data.

Case #3: Higher Education 312 students (167 experimental group; 145 control group)	Quantitative Analysis	Propensity Score Matchings to compare course grades between control and experimental groups. T-Student tests to compare experimental and control group's results in pre and post BL abilities questionnaire.	Linear regressions between experimental student's movements in the different sections of the MOOC, and their performance in the course's assessments.
	Qualitative Analysis	The comments in the Teacher Evaluation Survey and the transcriptions of the focus groups were analyzed by categorizing them in 4 main nodes, and 10 sub-nodes. The main nodes regarding learning outcomes were: (1) learning of the courses' contents, and (2) blended learning abilities (aspects related to the competences and abilities perceived by the students). A total of 40 references were found for blended learning abilities and 31 for learning of the courses' contents.	The comments in the Teacher Evaluation Survey and the transcriptions of the focus groups were analyzed by categorizing them in 4 main nodes, and 10 sub-nodes. The main nodes regarding adoption were: (1) adoption of the methodology (referring to expressions about the student's taking on of the methodological approach), and (2) class logistics and organization. A total of 45 references were found for adoption and 34 for class logistics and organization.

5.3.2 Cross-case analysis

The purpose of a cross-case analysis is not to revise the common relationships across cases, but to understand the commonality and differences across manifestations of the main research aim. The objective is to make assertions about the main objective and specifically about the derived research questions.

The evidence that leads to the assertions needs to be indicated through the case findings. Therefore, the strategy adopted to formulate assertions consists of rating each case finding as to its importance for understanding the quintain through particular questions. For this, we use a three-point scale in which a high mark means that for a particular question, the case finding is of high importance (H= high importance; M=middling importance; L= low importance), as indicated in [96]. For each finding of each case, we describe its utility and prominence for its contribution to each question.

5.4 Results

5.4.1 Findings of the separate case studies

The multicase study outcomes result from a cross-case comparative aggregation of the findings obtained in the case studies comprising the multicase. Therefore, each case should be studied independently. In this section we present the findings that result from each case study.

Tables 5-2 to 5-7 show the findings of the three case studies for the case study issues under analysis. Table 5-2 and Table 5-3 correspond to the findings of Case #1: Secondary Education Pilot Study. Table 5-4 and Table 5-5 4 correspond to the findings of Case #2: Postsecondary Education Pilot Study. Finally, Table 5-6 and Table 5-7 correspond to the findings of Case #3: Higher Education Quasi Experiment. The information in these tables is organized as follows: the first column shows the findings of the case for the issue indicated in the caption of the Table; the second column shows the partial results that support each of the findings which were extracted from the analysis of the data of each experiment: the third column refers to the origin of the data selected for exemplifying the type of information that supports the partial results.

Table 5-2: Findings Case Study #1: Secondary Education – Issue #1 – What is the impact of a MOOC-based blended experience in terms of students' learning outcomes?

Finding	Supporting Partial Result(s)	Data Source(s)
I. Student's knowledge on banking and mercantile documents increased significantly after the fourth week and teachers and students valued this experienced better than a traditional class	Students obtained significantly better final scores in the post-test than the pre-test. The pre-test average score is 43.4 points whereas the post-test average score is 67.0 points, and this difference is statistically significant (P-Value: 0.00006).	Pre & post accounting test scores
	Students stated that they learned more through this methodology than in a traditional class thanks to the availability of the videos-lectures and the immediate feedback from the exercises	Focus Groups
	The class teacher valued the learning experience.	Teacher interview
II. Students with lower levels of prior knowledge had equal footing in terms of their learning outcomes in mercantile documents	The TILS scores go from 16 points, which corresponds to percentile 12, to 42 points, which corresponds to percentile 96.	Pre & post accounting test scores; TILS scores
	The regression results between student's post-test scores and their TILS scores are not significant (R = 0.1545).	
	The regression results between student's difference between the pre and post-test scores and their TILS scores are not significant (R = 0.3607).	
III. Students with lower motivation, less learning strategies and more anxiety during assessment had equal footing in terms of their learning outcomes in mercantile documents.	On a scale from 1.0 to 7.0, students' motivation results go from a score of 5.34 the lowest, to a 6.75 the highest; the learning strategies go from 4.13 to 6.30; and the test anxiety scores go from 3.6 to 6.0.	Pre & post accounting test scores; MSLQ scores
	No strong correlation was found between student's scores in any of the MSLQ's dimensions, and their performance on the pre-test.	
	No strong correlation was found between student's scores in any of the MSLQ's dimensions, and their performance on the post-test.	
	No strong correlation was found between student's scores in any of the MSLQ's dimensions, and student's difference between the pre and post-test scores.	

Table 5-3: Findings Case Study #1: Secondary Education – Issue #2 – How do students adopt the MOOC-based blended learning experience, and how does this adoption affect their learning outcomes?

Finding	Supporting Partial Result(s)	Data Source(s)
IV. Students' performance in the exercises of the MOOC's final review section is statistically significantly related to their final learning outcomes.	The correlation between the post-test scores and the final review scores is strong (R = 0.66) and statistically significant (ß = 0.2, t = 3.43, P>|t| = 0.004, Prob>F = 0.0037).	MOOC log-files; Post-test scores
V. Students that answered the MOOC's exercises randomly did not learn as much as those that answered consciously, and the teacher valued positively the immediate feedback provided to the students.	There is a negative correlation between the post-test scores and the attempts the students made on the assessments (R = -0.55), and this negative correlation is statistically significant (ß = -0.243, t = -2.55, P>|t| = 0.022, Prob>F = 0.022).	MOOC log-files; Post-test scores
	The teacher had a very positive perception of student's appreciation of the immediate feedback, when they were answering the exercises seriously.	Teacher Interview
VI. Students with less prior knowledge, lower motivation, less learning strategies and/or more anxiety during assessment, had an equal footing it terms of their completion of the MOOC.	No strong correlation was found between student's scores in the TILS and their completion of the different sections of the MOOC.	MSLQ scores; TILs scores ; MOOC log-files
	No strong correlation was found between student's scores in any of the MSLQ's dimensions (motivation for learning, anxiety during assessments and learning strategies) and their completion of the different sections of the MOOC.	
VII. Students greatly valued the learning methodology and advancing on their own pace, and the teacher felt she can focus better on students' individual needs.	Students appreciated being able to watch the videos as many times as needed, in favor of those students that had difficulties keeping up with the more advantaged students.	Focus Groups
	The teacher realized that students had better behavior with this methodology than in a traditional lecture-based class, where she had to draw their attention constantly.	Teacher interview
VIII. MOOC-based BL was perceived by the teacher and the students as an effective methodology to deal with students' diversities and/or disadvantages.	All students agreed that with this methodology, the teacher could attend each student's personal doubts individually, which made their learning process more effective.	Focus Groups
	The teacher remarked those students that always had a harder time understanding were the ones that had the most questions during this experience, and that she appreciated being able to help them more than normal, to help them catch up with the rest of the class.	Teacher Interview

Table 5-4: Findings Case Study #2: Postsecondary Education – Issue #1 – What is the impact of a MOOC-based blended experience in terms of students' learning outcomes?

**Note: DE stands for Diagnostic Exam. There were three instances of this assessment: DE-Instance 1 was on January 13th; DE-Instance 2 was on January 20-29th (different topics were evaluated on different days); DE-Instance 3 was on February 29th.*

Finding	Supporting Partial Results	Data Sources
IX. When no other institutional support was available, studying with the MOOCs helped students obtain better scores in the DEs, and this result is not related to their prior knowledge.	In DE-Instance 1, active users in the MOOCs obtained significantly higher scores in average than the non-active users for all four exam subjects.	MOOCs' Movement Logs; Students' scores in DE; Student's prior knowledge (scores in the Chilean university admission system)
	In DE-Instance 3, active users in M2 and M4 obtained significantly higher scores in average than those who were non-active in the respective MOOCs. In DE-Instance 3, M2 and M4 reported four and two times more movements than M1 and M3.	
	When comparing groups with similar prior knowledge through PSM, the effects of studying with the MOOCs is still statistically significant in all four exam subjects of DE-Instance 1 and in M2 of DE-Instance 3	
	In the interviews the students reinforced that they used and learned from the MOOCs to study for their DE's.	Interview 4; Interview 5; Interview 6; Interview 8
X. When no other institutional support was available, studying with the MOOCs gave students better chances of passing the Diagnostic Exam, and this result is not related to their prior knowledge.	In DE-Instance 1, students that were active users in the MOOCs reported significantly higher approval rates than the non-active users for all four exam subjects.	MOOCs' Movement Logs; Students' scores in DE
	M2 reports the highest activity of the four modules for DE-Instance 3, and the group of students who were active in the M2 module BDE-I3 reported significantly higher approval rates than the non-active users.	
	In the interviews the students reinforced that they used and learned from the MOOCs to study for their DE's.	Interview 4; Interview 5; Interview 6; Interview 8

Table 5-5: Findings Case Study #2: Postsecondary Education – Issue #2 – How do students adopt the MOOC-based blended learning experience, and how does this adoption affect their learning outcomes?

**Note: DE stands for Diagnostic Exam. DE-Instance 1 was on January 13th; DE-Instance 2 was on January 20-29th (different topics were evaluated on different days, with external institutional study support); DE-Instance 3 was on February 29th.*

Finding	Supporting Partial Results	Data Sources
XI. Students are not yet prepared to adopt MOOCs for remedial studies if they are not mandatory.	Between 4% (the minimum) and 18% (the maximum) of the students were active in the MOOCs under study during the case study period, reaching its peak for DE -Instance 1.	MOOCs' Movement Logs
XII. Students study from the MOOCs preferably right before each DE, instead of gradually throughout the entire available study period.	The average number of interactions per day per MOOC the three days before the DE's v/s the rest of the corresponding study periods are: - DE-Instance 1: 591 / 49 - DE-Instance 2: 154 / 58 - DE-Instance 3: 130 / 38	MOOCs' Movement Logs
XIII. Student's activity in the different MOOCs allows detecting prior knowledge gaps.	M2 has the most activity during the case study period, reaching 8.211 movements in total, followed by M4 with 4.619 movements, then M1 with 4.316 and finally M3 with 2.082.	MOOCs' Movement Logs
	M2 topics were not necessarily studied in high school. Moreover, the national admission test does not evaluate trigonometry.	Interview 4; Interview 5; Interview 8
XIV. Of the students that used the MOOCs for studying for their DEs, the more the students interacted with the MOOCs, the better scores they obtained (and vice-versa).	In DE-Instance 1, the amount of movements in the MOOCs significantly predict student's scores in the respective DE, for M1, M2 and M4, which are the MOOCs with the highest number of interactions and active students in DE-I1: - **DE-I1 M1**: N = 96, Mov = 2.629 o ß = 0.002, t = 2.63, P>|t| = 0.010 - **DE-I1 M2**: N = 135, Mov = 3.734 o ß = 0.003, t = 3.04, P>|t| = 0.003 - **DE-I1 M4**: N = 104, Mov = 2.338 o ß = 0.003, t = 2.37, P>|t| = 0.020	MOOCs' movement logs; DE scores
	In DE-Instance 2, the amount of movements in the M2 MOOC significantly predicts student's scores in the respective DE. This is the MOOC with the highest number of interactions and active students for DE-I2: - **DE-I2 M2**: N = 26, Mov = 719 o ß = 0.005, t = 2.10, P>|t| = 0.046	
	In DE-Instance 3, the amount of movements in the MOOCs significantly predict student's scores in the respective DE for M2 and M4, which are the MOOCs with the highest number of interactions and active students for this instance: - **DE-I3 M2**: N = 87, Mov = 3.758 o ß = 0.001, t = 2.16, P>|t| = 0.033 - **DE-I3 M4**: N = 50, Mov = 2.133 o ß = 0.003, t = 2.44, P>|t| = 0.018	
XV. Students from the school's inclusion program studied more from the MOOCs than regular admission students	77% of the students from the inclusion program were active users in the MOOCs, while only 34% of regular admission students were active during the pilot study.	MOOCs' movement logs

Table 5-6: Findings Case Study #3: Higher Education – Issue #1 – What is the impact of a MOOC-based flipped course in terms of students' learning outcomes?

**Note: FC stands for Flipped Class. GPA stands for Grade Point Average. IP stands for Individual Projects.*

Finding	Supporting Partial Result(s)	Data Source(s)
XVI. In average, no differences were found in students' learning outcomes between those participating in the flipped class and students in the traditional class, despite their perception of having learned more in the FC than in a traditional learning experience.	When comparing the course's final grade and considering student's GPA to create comparable groups from both sections, the difference in these grades is not significant.	Course grades; GPA
	When performing the same statistical analysis with the average in the four tests, the difference is also non-significant.	Course grades; GPA
	Students said they perceived that students in their section had obtained better scores than the control group, due to the flipped class methodology that allowed them to better comprehend the course's contents.	Focus Groups
XVII. Group projects in the FC class promote learning, while the individual after-class projects from the traditional course do not.	Students from the control group greatly criticized the individual projects, saying they did not contribute to their learning in the course, in contrary to the experimental group's great appreciation towards the group projects, since they agreed that when discussing the contents in class with their group members, they reinforced the important topics, increasing their learning outcomes and performance in the course assessments.	Course Load; Focus Groups
	Experimental student's performance in the FC grades is significantly better than the control group's performance in the IP grades.	Course grades; GPA
XVIII. Organizing the group projects was difficult, tedious, and more time consuming than the individual projects of the traditional class.	The experimental group indicated that they dedicated an average of 11 hours a week to the course, while the control group reports only 9 hours a week, in average, and this difference is statistically significant.	Course load.
	Students in the experimental group agreed that they dedicated too much time to the management and organization of the group projects.	Focus Groups; Course evaluations
	Students in the experimental group agreed that the group projects were too much work for such little time a week.	
XIX. Students that participated in the flipped class methodology developed two skills that the control group students did not: responsibility and collaborative learning	In the pre-test, there are no statistical differences between the control and the experimental group in any of the six dimensions of the BL abilities questionnaire. Also, there are no statistical differences in the control group's results between the pre and post-test.	BL abilities questionnaire
	The experimental group's results in responsibility and collaborative learning are statistically different (better) than the same group's results in the pre-test and statistically different (better) than the control groups' post-test results.	

Table 5-7: Findings Case Study #3: Higher Education – Issue #2 – How do students adopt MOOC-based flipped methodologies, and how does this adoption affect their learning outcomes?

Finding	Supporting Partial Result(s)	Data Source(s)
XX. Students interacted with the video-lectures much more than the rest of the resources in the MOOC, and these interactions are positively related to their learning outcomes.	Movements in the video-lectures significantly predicted student's final grade in the course (ß = 0.17, t = 2.32, P>|t| = 0.022) and student's final grade in the flipped classes (ß = 0.215, t = 2.82, P>|t| = 0.005).	MOOC log-files; Course grades
	Movements in the exercise quizzes also predicted student's final grade in the course (ß = 0.19, t = 2.22, P>|t| = 0.028), and student's average grade in the course tests (ß = 0.198, t = 2.32, P>|t| = 0.022).	
XXI. Students adopted the MOOC-based flipped class methodology gradually throughout the semester in a successful manner, incorporating the MOOC in their study routine and slowly learning how to use it efficiently.	During the first 2 months of the semester, students interacted very much with topics 2, 3 and 4 but these interactions were not related with student's scores in Test#1, nor their grades in Topics 1, 2, 3 or 4, in any way.	MOOC log-files; Course grades
	The sum of the movements in topics 5, 6, 7 and 8 significantly predicts student's scores in Test#2 (ß = 0.17, t = 2.28, P>|t| = 0.024), and the movements in the exam's topics significantly predict student's scores in the corresponding assessment (Test#4) (ß = 0.32, t = 4.46 P>|t| = 0.000).	
	Movements in topics 6 and 7 significantly predict students' grades in the corresponding flipped classes, and these movements also predict students' grades in the in-class graded quizzes and coevaluations (part of the flipped class grades of each week's work).	
	Movements in topics 7, 8 and 9 significantly predict student's final course grade (R2 = 0.13, F(11,152) = 2.12, Prob>F = 0.02).	
	Students declared that at first, they had a hard time understanding the rhythm of the course, sometimes forgetting to do the before-class activities, or leaving them for the last minute. However, throughout the semester they incorporated these tasks in their routine, and eventually completed them without a problem.	Focus Groups; Course Evaluation results
	Students agreed that watching the video-lectures in the MOOC helped their memory retention, making it easier to understand definitions and key concepts of the course than in a lecture-based class.	Focus Groups
XXII. A MOOC-based flipped class, with before, during; and after class activities, makes learning easier for students.	Students agreed that the weekly work made learning easier.	Focus Groups
	Students agreed that when discussing the contents in class with their group members, they reinforced the important topics, increasing their learning outcomes and performance in the course.	
	In the course evaluations, many comments emphasized how much they appreciated the before, during and after class activities. They agreed that studying the contents before class and discussing it in class makes learning much more fun and easier.	Course Evaluation Results
	Student's interactions in the MOOC successfully predict their flipped class grades (ß = 0.16, t = 2.05, P>|t| = 0.04).	MOOC log-files; Course grades

5.4.2 Cross-case analysis

Previous sections emphasize the distinctive strength of each case, noting each context and their functioning. This section undertakes the cross-analysis of the cases to answer the research questions of the quintain. As was mentioned before, the research questions are:

- **RQ#1:** How do students engage with the MOOC(s) and adopt the MOOC-based blended learning methodology?
- **RQ#2:** What is the impact of MOOC-based blended learning in students' learning outcomes?
- **RQ#3:** Is there a relationship between students' adoption of the MOOC-based blended learning methodology and their learning outcomes?

Table 5-8 shows the cross-case analysis process for each case study.

Table 5-8: Matrix for generating question-based assertions from case findings for the research questions. H = high importance; M = middle importance; L = low importance.

	Finding Description	Utility for RQ#1	Utility for RQ#2	Utility for RQ#3
Secondary Education	I. Student's knowledge on banking and mercantile documents increased significantly after the fourth week and teachers and students valued this experienced better than a traditional class.	L	H	H
	II. Students with lower levels of prior knowledge had equal footing in terms of their learning outcomes in mercantile documents.	L	M	L
	III. Students with lower motivation, less learning strategies and more anxiety during assessment had equal footing in terms of their learning outcomes in mercantile documents.	L	M	L
	IV. Students' performance in the exercises of the MOOC's final review section is significantly related to their final learning outcomes.	L	L	H
	V. Students that answered the MOOC's exercises randomly did not learn as much as those that answered consciously, and the teacher valued positively the immediate feedback provided to the students.	L	L	H
	VI. Students with less prior knowledge, lower motivation, less learning strategies and/or more anxiety during assessment, had an equal footing it terms of their completion of the MOOC.	M	L	L

	VII. Students greatly valued the learning methodology and advancing on their own pace, and the teacher felt she can focus better on students' individual needs.	H	L	M
	VIII. MOOC-based BL was perceived by the teacher and the students as an effective methodology to deal with students' diversities and/or disadvantages.	L	M	H
Postsecondary education	IX. When no other institutional support was available, studying with the MOOCs helped students obtain better scores in the Diagnostic Exams, and this result is not related to their prior knowledge.	L	H	M
	X. When no other institutional support was available, studying with the MOOCs gave students better chances of passing the Diagnostic Exam, and this result is not related to their prior knowledge.	L	H	M
	XI. Students are not yet prepared to adopt MOOCs for remedial studies if they are not mandatory.	H	L	L
	XII. Students study from the MOOCs preferably right before each diagnostic exam, instead of gradually throughout the entire available study period.	M	L	L
	XIII. Student's activity in the different MOOCs allows detecting prior knowledge gaps.	L	L	L
	XIV. Of the students that used the MOOCs for studying for their Diagnostic Exams, the more the students interacted with the MOOCs, the better scores they obtained (and vice-versa).	L	L	H
	XV. Students from the school's inclusion program studied more from the MOOCs than regular admission students	L	L	L
Higher education	XVI. In average, no differences were found in students' learning outcomes between those participating in the flipped class and students in the traditional class, despite their perception of having learned more in the FC than in a traditional learning experience.	L	H	L
	XVII. Group projects in the FC class promote learning, while the individual after-class projects from the traditional course do not.	M	H	H
	XVIII. Organizing the group projects was difficult, tedious, and more time consuming than the individual projects of the traditional class.	M	L	L
	XIX. Students that participated in the flipped class methodology developed two skills that the control group students did not: responsibility and collaborative learning	M	H	M
	XX. Students interacted with the video-lectures much more than the rest of the resources in the MOOC, and these interactions are positively related to their learning outcomes.	L	L	H
	XXI. Students adopted the MOOC-based flipped class methodology gradually throughout the semester in a successful manner, incorporating the MOOC in their study routine and slowly learning how to use it efficiently.	H	L	H
	XXII. A MOOC-based flipped class, with before, during; and after class activities, makes learning easier for students.	M	M	H

5.4.3 Assertions

Finally, we gathered the high-importance findings for each question, as suggested by the entries in Table 5-8, and formulate assertions that can help to satisfactorily understand the benefits and predictions for MOOC-based blended learning's impact on student's adoption and learning outcomes. Additionally, we present assertions over the two emerging research questions that came up from the cross-case analysis.

5.4.3.1 Assertions for Research Question #1

Findings VI and VII from Case #1, XI, XII, XIII and XV from Case #2, and XVIII, XIX and XXI from Case #3 give the information necessary to extract assertions related to the research question *how do students engage with the MOOC(s) and adopt the MOOC-based blended learning methodology?*

In this multicase study, we have three different BL models: secondary education students had mandatory in-class computer assisted instruction, postsecondary education students had MOOCs as an optional remedial compliment, and higher education students had the flipped classroom model. Each model was chosen and designed in response to the context. Four findings lead to our first assertion regarding adoption on the MOOC-based blended learning methodology. Finding VII says that secondary education students greatly valued the learning methodology, advancing on their own pace and watching the videos as many times as needed. In class, students had no trouble understanding the methodological instructions, and from day 1 of the study they obediently followed instructions, worked on the MOOC, and took notes while watching the videos for better retention of the contents, even though no one told them to do so. In summary, these students had no difficulties changing their learning paradigm and immediately became active seekers of their own knowledge, instead of spoon-fed learners. On the other hand, finding XXI says that higher education students adopted the MOOC-based flipped class methodology gradually throughout the semester in a successful manner, struggling at first, but managing to fully change their learning paradigm, and even more, developing responsibility skills according to finding XIX,. In the beginning they left the online activities for the last minute, and interacted with the MOOC inefficiently, but slowly they got the hand of how to use the MOOC and organized their study time better, becoming more responsible with their schoolwork. Finally, findings XI and XII say that postsecondary students studied from the MOOCs preferably right before each diagnostic exam, instead of gradually throughout the entire available study period, and that they are not yet prepared to adopt MOOCs for remedial studies if they are not mandatory, since only between 4% and 18% of students studied from the MOOCs for their diagnostic exams. But since higher education students took time to adjust and stop leaving the online activities for the last minute, we can hypothesis that maybe, if this experience would have lasted longer, students could have learned to be more responsible if they would have been given the time to adjust. Therefore, our first assertion is that *the difficulty or simplicity of adopting the MOOC-based BL methodology depends on how mandatory it is in the course or experience, and how long the experience is. If it is completely mandatory and supervised, the length of the experience is not relevant, but the more optional or less teacher-supervised it is, the longer the experience must be to obtain better adoption results*.

Our second assertion regarding adoption comprises findings VII from Case #1 and XXI from Case #3. These two findings state that students greatly valued and successfully adopted the MOOC-based blended learning methodologies, incorporating the use of the MOOC in their study routine. Both experiences prove that blended learning can produce a paradigm shift in students, from a teacher-centered to a student-centered learning process, where the teachers are not responsible of delivering contents. Therefore, our second assertion is that *the MOOC-based BL methodology can be adopted successfully by students and is specially appreciated by teachers and students for providing the contents through videos that students can watch at their own pace, the immediate feedback provided by the MOOCs' exercises, and higher student participation in class.*

5.4.3.2 Assertions for Research Question #2

Findings I, II, III and VIII from Case #1, IX and X from Case #2, and XVI, XVII, XIX and XXII from Case #3 give information to extract assertions related to the research question *what is the impact of MOOC-based blended learning in students' learning outcomes?*

Our first assertion states that *the MOOC-based blended learning methodology is an effective method for teaching and learning course contents since students perform the same or better in course assessments with this methodology than in a traditional learning experience.* This assertion is sustained by the findings related to student's performance in their assessments in all three case studies: I, IX, X, XVI, and XVII. In the first case study (with secondary education students) the posttest scores of the experience assessment are significantly better than the pretest scores. In the second case study (postsecondary education) active students' scores are significantly better than non-active students' scores in the diagnostic exams, and active students had significantly better chances of passing the diagnostic exams than non-active students. Finally, higher education students' final course grades and average test grades were the same in the experimental group (flipped class) and in the control group (traditional-lecture class). Also, the FC-grades for the group projects in the flipped class were significantly higher than the IP-grades for the individual projects in the traditional-lecture class.

The second assertion regarding learning outcomes is also sustained by the findings related to student's performance in all three case studies (I, IX, X, XVI, and XVII) through which we can affirm that *students perceived they learned course contents more effectively (faster, with a deeper understanding, applied in examples that are connected to the real world, and/or satisfying the zone of proximal development) through the MOOC-based blended learning methodology than in a traditional learning experience.* This assertion is supported by the fact that students revealed that learning was easier through this methodology than in a traditional lecture-based experience. Some aspects mentioned by the students that facilitated their learning were the availability of the video-lectures "anytime, anywhere", the immediate feedback on their exercises, the availability of the teacher to attend student's individual questions, and group projects where they reinforced the course contents.

Finally, in every class there are students that work harder than others, study more, and perform better, since they put more effort in their studies than the rest. Consequently, if the students that always obtain better grades in school, also obtain better grades in MOOC-based blended learning courses, than our results are invalid because they are most likely due to students' personal characteristics and not to the methodology under study. Therefore, for all three case studies we considered a variable, which we called "prior knowledge", as an indicator of effort or study habits. In the higher education case study, we considered students' Grade Point Average as the "prior knowledge" indicator, in the postsecondary education case study we took their university admission scores, and in secondary education, their TILS scores. With this information, we created statistically comparable groups in our analysis of learning outcomes to undermine this effect. Therefore, by combining findings II, III, IX, X and XVI, the third assertion of this study is *MOOC-based blended learning performance results are not related to students' prior knowledge*.

5.4.3.3 Assertions for Research Question #3

If students successfully change their paradigm regarding their learning experiences and adopt the MOOC-based blended learning methodology by incorporating routine changes, new study habits, and new in-class behavior, but do not learn as much as they do in a traditional course, then probably the whole experience would not have been worthwhile. Hence, the third research question is, *is there a relationship between students' adoption of the MOOC-based blended learning methodology and their learning outcomes?*

One very important element of the adoption process of the MOOC-based blended learning methodology is student's engagement with the technology, i.e., the MOOCs. If students do not learn with the MOOC and/or do not use them correctly (for example, responding the exercises randomly to finish quickly, without thinking or reading), then we cannot say they fully adopted the MOOC-based blended learning methodology. Therefore, our first assertion will relate to the relationship between students' engagement with the MOOCs, as part of their adoption of the MOOC-based blended learning methodology, and their learning outcomes.

One the one hand, with finding XIV from the postsecondary education experience, we can say that, of the students that used the MOOCs for studying for their DEs, the number of movements in the MOOCs significantly predict student's scores in the respective DEs, whereas the non-significant instances of movements in MOOCs v/s DE scores correspond to instances with either too few movements or too few active participants to make a statistically significant difference.

On the other hand, in secondary and higher education, students took longer to learn how to study from the MOOC than postsecondary, but they managed it well in both cases at the end. In secondary education, finding V states that some students answered the MOOC's exercises randomly and had much more answers in the exercises than the rest because they answered until they got the right answers. Regarding this, there is a negative correlation between the post-test scores and the attempts the students made on the assessments. Also, the MOOC's final review comprised 57 multiple choice questions, and students' scores in this section are significantly related to the posttest scores, according to finding IV. Therefore, in this experience, students adjusted and learned how to study and learn from the MOOC effectively, succeeding at the end with the final review. Finally in the higher education case study, the first two months of this experience present the most movements in the MOOC. Even so, these movements are not related to student's performance in the first test. But for the assessments for the rest of the course, the number of interactions each student had on the different sections of the MOOC significantly predict their scores on the corresponding course assessments (finding XXI). In addition, movements in the exercise quizzes also predicted student's final grade in the course and their average grade in the course tests (finding XXII).

Therefore, the analysis from the three case studies can lead us to conclude that *a higher number of "clicks" in a MOOC's resources does not guarantee better performance in a course's assessments but interacting consciously and efficiently with a MOOC in a MOOC-based BL experience, is significantly related to better learning outcomes. That is, the number* *of clicks is not necessarily a good proxy for measuring performance in a MOOC-based BL scenario.*

Finally, thanks to findings I, IV, V, VII and VIII from Case #1, IX, X and XIV from Case #2, and XVII, XIX, XX, XXI and XXII from Case #3, and combining assertions presented for RQ#1 and RQ#2, we can proudly state our last assertion for this research question: *once students adopt the MOOC-based BL methodology, change their learning paradigm, engage with the MOOCs, and consciously become responsible for their own learning process, they significantly improve their learning outcomes.*

5.4.3.4 Emerging Research Questions

Throughout this study, two topics of our interest have emerged from the case studies, although they were not initially planned out. The first has to do with the blended learning models and the second has to do with inclusion and giving equal educational opportunities to disadvantaged students:

- **Emerging RQ-I:** Is there a relationship between the blended learning model, students' educational level and their adoption of the MOOC-based blended learning methodology?
- **Emerging RQ-II:** How does a MOOC-based blended learning methodology promote socioeconomic inclusion and equal educational opportunities for disadvantaged students?

For Emerging RQ-I, findings VII, XI, XII and XXI show us that secondary education students adopted the methodology immediately, followed by higher education that adopted it gradually, and finally the post-secondary students adopted it weakly, given that only 18% of students decided to study from the MOOCs, and 62% did not even access the platform. However, since all case studies comprised Digital Natives and the same technology (MOOCs), and given that we did not report any difficulties in using the MOOCs in any of the three case studies, and finally, that the adoption is not linear with regards to the educational level (secondary-higher-postsecondary), we can conclude that the educational level cannot be held accountable for the adoption differences between the groups. Moreover, the adoption is linear to student's autonomy requirements, responsibility, and teacher-presence in each blended learning model. The secondary education pilot study was completely self-paced, but also completely mandatory, since the entire blended learning experience was in-class. Then, the higher education quasi experiment was also mandatory, but required students to perform many before and after-class activities without teacher supervision, which was with what they struggled with the most, as they stated in the results. Finally, the postsecondary pilot study was completely optional and no teacher-presence was available. Therefore, we can suggest that *student's adoption of a MOOC-based blended learning approach is not related to student's educational level (as long as they are digital natives), but student's autonomy and responsibility requirements in the blended learning model does affect the adoption of the methodology.*

Research Question II emerged because throughout this study we have stumbled upon great gaps between students faced to the same learning process, either in prior knowledge, socioeconomic status, study habits and/or different skills required for a successful performance in the course or experience under study. Therefore, we aspired to have given equal educational opportunities to disadvantaged students through this methodology.

In the secondary education case study, all the students were socioeconomically vulnerable, either because of extreme poverty such as living in camping sites without hard floors, or because of unsafe family situations, such as being sons/daughters/siblings of drug traffickers. In the postsecondary education case study, 95 students were from the school's inclusion program, a program aimed at accepting into the career socioeconomically vulnerable students that did not achieve the minimum admission scores, but belong to the top-achieving students of their schools, meaning they are responsible and hard-working, but lacked tools and opportunities to perform better in the admission exams. Therefore, through these two case studies we managed to vaguely answer Emerging RQ-II, although we would like to further investigate this topic in the future.

First, findings II, III, VI, VIII, IX, X, XIII and XV prove to us that *MOOC-based blended learning gives students with prior knowledge gaps or learning strategy gaps, equal chances of performing well in the course's assessments.* This assertion is supported by the fact that secondary students' performance in the experience was not related to any of their personal gaps, and also that postsecondary education students from the inclusion program studied from the MOOCs significantly more than regular admission students.

Also, findings II, III, VI, VIII and XV allow us to assert that s*tudents adopt the MOOC-based BL methodology successfully regardless of their socioeconomic status.* This assertion is supported by the fact that secondary students' adoption of the methodology was not related to any of their personal gaps, and that postsecondary education students from the inclusion program studied from the MOOCs significantly more than regular admission students.

5.5 Summary

This chapter has presented the evaluation addressed to answer the three initial research questions of this dissertation, and the two emerging research questions, all related to the main quintain under study.

To address the research questions, we have proposed an evaluation of three different case studies under the perspective of one multicase study, through a cross-case analysis of the different findings of the cases, leading to a set of ten assertions. For each research question, the assertions are the following:

Research Question #1: How do students engage with the MOOC(s) and adopt a MOOC-based blended learning methodology?

- **Assertion 1.** The difficulty or simplicity of adopting the MOOC-based BL methodology depends on how mandatory it is in the course or experience, and how long the experience is. If it is completely mandatory and supervised, the length of the experience is not relevant, but the more optional or less teacher-supervised it is, the longer the experience must be to obtain better adoption results.
- **Assertion 2.** The MOOC-based BL methodology can be adopted successfully by students and is specially appreciated by teachers and students for providing the contents through videos that students can watch at their own pace, the immediate feedback provided by the MOOCs' exercises, and higher student participation in class.

Research Question #2: What is the impact of MOOC-based blended learning in students' learning outcomes?

- **Assertion 3.** The MOOC-based blended learning methodology is an effective method for teaching and learning course contents since students perform the same or better in course assessments with this methodology than in a traditional learning experience.
- **Assertion 4.** Students perceived they learned course contents more effectively (faster, with a deeper understanding, applied in examples that are connected to the real world, and/or satisfying the zone of

proximal development) through the MOOC-based blended learning methodology than in a traditional learning experience.

- **Assertion 5.** MOOC-based blended learning performance results are not related to students' prior knowledge.

Research Question #3: Is there a relationship between students' adoption of MOOC-based blended learning and their learning outcomes?

- **Assertion 6.** A higher number of "clicks" in a MOOC's resources does not guarantee better performance in a course's assessments but interacting consciously and efficiently with a MOOC in a MOOC-based BL experience, is significantly related to better learning outcomes. That is, the number of clicks is not necessarily a good proxy for measuring performance in a MOOC-based BL scenario.
- **Assertion 7.** Once students adopt the MOOC-based BL methodology, change their learning paradigm, engage with the MOOCs, and consciously become responsible for their own learning process, they significantly improve their learning outcomes.

Emerging Research Question I: Is there a relationship between the blended learning model, student's educational level, and their adoption of the MOOC-based blended learning methodology?

- **Assertion 8.** Student's adoption of a MOOC-based blended learning approach is not related to student's educational level (as long as they are digital natives), but student's autonomy and responsibility requirements in the blended learning model does affect the adoption of the methodology.

Emerging Research Question II: How does a MOOC-based blended learning methodology promote socioeconomic inclusion?

- **Assertion 9.** MOOC-based blended learning gives students with prior knowledge gaps or learning strategy gaps, equal chances of performing well in the course's assessments.
- **Assertion 10.** Students adopt the MB-BL methodology successfully regardless of their socioeconomic status.

6. CONCLUSIONS

To confront the 21st century, students are taught contents from the 20th century with methods from the 19th century.

- *Nadine Ballam* [1]

Chapters 1 through 5 of this manuscript present our motivations to study MOOC-based blended learning, three case studies in different educational scenarios where MOOC-based blended learning was implemented, and a final multicase study that seeks to answer our research questions from a holistic point of view. This final chapter presents a summary of the previous contributions, limitations of the study, future work that can be drawn from our research, and finally, implications and conclusions drawn from the assertions of this doctoral thesis.

6.1 Contributions: Three case studies

This thesis presents three case studies, explained in detail in chapters 2, 3 and 4. Table 6-1 summarizes each one.

Table 6-1: Summary of the three case studies

Case Study	Blended learning model	Case study design	Mixed method analysis data
Secondary Education	In-class computer assisted instruction with 1 MOOC	4-week pilot study with 20 students	**Quantitative data**: MOOC Log-files, Pretest and Posttest grades, Superior Logic Intelligence Test and Motivated Strategies for Learning Questionnaire. **Qualitative data**: 2 Focus Groups and a Teacher Interview
Postsecondary Education	Technology as a remedial compliment with 4 MOOCs	2-month pilot study with 771 students	**Quantitative data**: MOOC Log-files, Diagnostic exam scores, Chilean university admission scores **Qualitative data**: telephonic semi-structured interviews
Higher Education	Flipped Classroom with 1 MOOC	3-month quasi experiment with 312 students	**Quantitative data**: MOOC Log-files, Course load questionnaire, students' grades in course assessments, GPA, BL abilities questionnaire. **Qualitative data**: Focus Groups and Teacher Evaluation Survey.

6.1.1 Secondary Education

The first case study presented in this thesis is a pilot study of a MOOC-based blended learning experience conducted in a Secondary Education School located in a peripheral district of Santiago, Chile. This school is characterized by the vulnerability of its students, with very low income and socioeconomic living conditions.

As part of the curriculum, the school offers a technical degree in three areas: accounting, telecommunications or logistics. Chilean high school technical degrees consist in 2 years of differentiated studies for junior and senior students, and they are a very effective mechanism to either help vulnerable students continue to higher education studies related to their technical degrees, or give them better job opportunities since they may not be able to go to college because of their economical situations [87].

Given the school's vulnerability index, students came from many different backgrounds and living situations. Some have academic support from their families, but others do not and are therefore, in disadvantage regarding personal study time at home, study tools, technologies, and/or even physical space. In order to address these differences, the school was eager to create an innovative curriculum for the technical degrees that lessened this gap. Specifically, the school proposed incorporating digital resources as part of the face-to-face lectures for changing the traditional lecture-based teaching methodology for a more blended experience in which students could advance and evolve at their own pace. The school chose the technical degree accounting course for running a pilot study, and the pilot took place from October 16 to November 12 of 2018. A MOOC was created especially for the course, addressing two specific topics given by the school's curriculum: banking and mercantile documents.

In this school not all students have personal access to a computer or tablet and stable internet connection in their homes, so working in the MOOC outside the classroom was not an option. For this reason, the proposed teaching methodology was to integrate the MOOC in the classroom, taking advantage of the autonomy it gave students in their learning process, and at the same time, giving all the students "equal footing".

Eight classes were taught through the MOOC, and each class lasted 90 minutes. During class, students reviewed the course's contents online individually through the MOOC's video-lectures and completed the exercises in the platform at their own pace. The teacher's role during class was to attend students with more difficulties individually and help them work through the subjects each one struggled with more.

Seventeen students participated in the study as the data sample, 11 girls and 9 boys. Classes took place in one of the school's computer rooms, with enough room for all students and internet connection capabilities for a massive number of people.

6.1.2 Postsecondary Education

The second case study presented in this thesis is a pilot study of a MOOC-based blended learning experience conducted with students that had just been admitted to study Civil Engineering in Pontificia Universidad Católica de Chile. UC-Engineering accepts over 700 freshmen students every year by conducting a rigorous selection process. Even so, the new students have very different backgrounds on basic calculus concepts to successfully address the calculus courses that are imparted in the first year. Therefore, students are required to take a diagnostic exam to assess their prior knowledge and skills in calculus, and they are given 3 instances to pass, or they would fail a first semester calculus requisite.

To help students study for the diagnostic exams, the school decided to produce 4 MOOCs, one for each module. All the contents of the MOOCs were designed to align with the learning objectives and topics addressed in the diagnostic exam. All the MOOCs are self-paced, so no restrictions or deadlines are proposed. All students were mandatorily enrolled in the MOOCs in person a few days before DE-instance 1, but afterwards, studying from the MOOCs was optional. Therefore, we analyzed students' activity in the MOOCs in each of the three periods and contrasted it with their performance in the corresponding exams.

The pilot study took place at UC-Engineering between December 27th, 2015 and March 1st, 2016, with 752 new freshmen UC-Engineer students that took the diagnostic exams on Instances 1, 2 and/or 3.

6.1.3 Higher Education

The third case study of this thesis is a quasi-experiment with the "Organizational Behavior" undergraduate course of the School of Engineer of Pontificia Universidad Católica de Chile. This course is organized into two sections per semester with an average of 150 students each. Given the sections' size, it has resulted very difficult for the course's teacher to promote class participation. To address this problem, during the second semester of 2017, the teacher of the course decided to flip one of the two sections to evaluate if this teaching methodology encourages class participation and communication, and if it promotes a student-centered learning environment. The other section maintained the traditional lecture-based teaching methodology and served as a control group to compare results. For the flipped model, the teacher used an existing MOOC called "Gestión de Organizaciones Efectivas", which he had created and launched a year earlier in Coursera, completely aligned with the course's content.

The course had three 80-minute sessions per week for both the control and experimental sections. The course's instructional design had the objective of maintaining an equivalence between both sections in terms of workload, contents, exercises, and assessment activities, which resulted in a sequence of activities for before, during and after each face-to-face session. The contents and learning objectives for the experimental and control groups were the same and only differed in the order they were taught throughout the week, given the different methodological approaches (flipped class and lecture-based).

The study lasted an entire semester, from August 21 to November 17 of 2017, with 312 students, where 145 were in the control group and 167 were in the experimental group.

6.1.4 Case study findings

The three case studies responded the following two issues, individually:

- **Issue #1: What is the impact of a MOOC-based blended learning experience in terms of students' learning outcomes?** This question aims at understanding if the MOOC-based blended learning methodology affects student's performance in the course in any way.
- **Issue #2: How do students adopt the MOOC-based blended learning methodology, and how does this adoption affect their learning outcomes?** This question aims at understanding how students assimilate and integrate the MOOC-based blended learning methodology in their learning process.

The individual findings for each issue are summarized in Figure 6-1, where the green posts correspond to the findings from the secondary education case, the blue posts correspond to the findings from the postsecondary education case, and the grey posts correspond to the findings from the higher education case study.

Issue #1: What is the impact of a MOOC-based blended learning experience in students' learning outcomes?

I. Student's knowledge on banking and mercantile documents increased significantly after the fourth week and teachers and students valued this experienced better than a traditional class.

II. Students with lower levels of prior knowledge had equal footing in terms of their learning outcomes in mercantile documents.

III. Students with lower motivation, less learning strategies and more anxiety during assessment had equal footing in terms of their learning outcomes in mercantile documents.

IX. When no other institutional support was available, studying with the MOOCs helped students obtain better scores in the Diagnostic Exams, and this result is not related to their prior knowledge.

X. When no other institutional support was available, studying with the MOOCs gave students better chances of passing the Diagnostic Exam, and this result is not related to their prior knowledge.

XI. Students are not yet prepared to adopt MOOCs for remedial studies if they are not mandatory.

XII. Students study from the MOOCs preferably right before each diagnostic exam, instead of gradually throughout the entire available study period.

XVI. In average, no differences were found in students' learning outcomes between those participating in the flipped class and students in the traditional class, despite their perception of having learned more in the FC than in a traditional learning experience.

XVII. Group projects in the FC class promote learning, while the individual after-class projects from the traditional course do not.

Issue #2: How do students adopt the MOOC-based blended learning methodology, and how does this adoption affect their learning outcomes?

IV. Students' performance in the exercises of the MOOC's final review section is significantly related to their final learning outcomes.

V. Students that answered the MOOC's exercises randomly did not learn as much as those that answered consciously, and the teacher valued positively the immediate feedback provided to the students.

VI. Students with less prior knowledge, lower motivation, less learning strategies and/or more anxiety during assessment, had an equal footing it terms of their completion of the MOOC.

VII. Students greatly valued the learning methodology and advancing on their own pace, and the teacher felt she can focus better on students' individual needs

VIII. MOOC-based BL was perceived by the teacher and the students as an effective methodology to deal with students' diversities and/or disadvantages.

XIII. Student's activity in the different MOOCs allows detecting prior knowledge gaps.

XIV. Of the students that used the MOOCs for studying for their Diagnostic Exams, the more the students interacted with the MOOCs, the better scores they obtained (and vice-versa).

XV. Students from the school's inclusion program studied more from the MOOCs than regular admission students

XVIII. Organizing the group projects was difficult, tedious, and more time consuming than the individual projects of the traditional class.

XIX. Students that participated in the flipped class methodology developed two skills that the control group students did not: responsibility and collaborative learning

XX. Students interacted with the video-lectures much more than the rest of the resources in the MOOC, and these interactions are positively related to their learning outcomes.

XXI. Students adopted the MOOC-based flipped class methodology gradually throughout the semester in a successful manner, incorporating the MOOC in their study routine and slowly learning how to use it efficiently.

XXII. A MOOC-based flipped class, with before, during; and after class activities, makes learning easier for students.

Figure 6-1: Summary of findings for each case study

6.1.5 Multicase study & thesis assertions

To present a deeper comprehension of the impact of MOOC-based blended learning, the next step of this study was to cross-analyze the three blended learning experiences in a multicase study adjusted to our research purposes. We structured the multicase study starting from the main research aim as the umbrella of the study, and then we defined three research questions that guided the evaluation and cross-case analysis. The research aim of this work is *to study the MOOC-based blended learning approach from student's perspective.* The research questions under this umbrella are:

- **RQ#1:** How do students engage with the MOOC(s) and adopt the MOOC-based blended learning methodology?
- **RQ#2:** What is the impact of MOOC-based blended learning in students' learning outcomes?
- **RQ#3:** Is there a relationship between students' adoption of the MOOC-based blended learning methodology and their learning outcomes?

In addition, two emerging research questions appeared during the cross-case analysis:

- **ERQ-I:** Is there a relationship between the blended learning model, student's educational level, and their adoption of the MOOC-based blended learning methodology?
- **ERQ-II:** How does a MOOC-based blended learning methodology promote socioeconomic inclusion and equal educational opportunities for disadvantaged students?

The purpose of a cross-case analysis is to make assertions about the main objective and the derived research questions. Therefore, from the individual findings of each case study, we formulated assertions that can help understand the benefits and predictions for MOOC-based blended learning's impact on student's adoption and learning outcomes. Additionally, we present assertions over the two emerging research questions that came up from the cross-case analysis. Figure 6-2 summarizes the assertions presented in this study.

Figure 6-2: Summary of thesis assertions

6.2 Limitations

This research proposal has three limitations which need to be highlighted in honor of the reliability of this work.

First, the case studies correspond to two pilot studies and one quasi-experiment, meaning that students are not randomized in any of the scenarios. Studies with randomized participants are known to provide more robust and generalizable results than non-randomized experiments. Second, regarding the secondary education pilot study, the N in this experience is very small. Even so, statistically significant findings have been reported which suggests that certain results could be expandable to other similar scenarios.

Finally, also regarding the secondary education pilot study, we do not know for sure if students discussed and/or memorized their answers from the pretest when responding the posttest. Therefore, the results of the post-test should be considered only as a reference for evaluating knowledge improvement.

6.3 Future work

My thesis leaves a few untied knots that I would like to continue working in a nearby future. First, a very important topic that was out of the scope of this investigation is how to effectively assess students in blended learning scenarios. This work maintains the traditional assessments that students and teachers were previously accustomed to. However, we know that there are many novel assessment methodologies that are more consistent with this teaching model. Therefore, future work would be to learn about different assessment approaches in blended learning and analyze which ones work better in each educational context.

Next, this entire thesis worked with the MOOCs' log-files to obtain the information about student's interactions with the MOOCs. However, for future investigations, we propose to design easier ways of obtaining the information about students' interactions with the technology and the relationship between the interactions (in general), student's performance in the technologies' assessments (if applicable), and student's performance in the course. This thesis proposition invested many hours in extracting and analyzing the data, which is not a problem in an investigation project, but non-viable for teachers.

Consequently, this work evidenced the increase of responsibility and collaborative learning skills in the higher education quasi experiment. However, this line of work deserves a deeper analysis, seeking to answer questions such as: which specific activities promote the above-mentioned skills? Can these skills be promoted with any blended learning model, or only flipped classroom? And also, can these skills be promoted in any educational level?

Finally, this work stumbled upon the fact that MOOC-based blended learning helps even disadvantaged student's learning process and give them equal footing. However, we would very much like to further investigate this topic, since it was not in the original scope of this investigation, and therefore, we only had enough data to superficially answer one research question regarding disadvantaged students, instead of performing an in-depth analysis in this line of work.

6.4 Implications and final conclusions

My thesis has implications on many levels. In this section I shall discuss them from the perspective of the different roles in the educational context.

6.4.1 Implications for teachers

Teachers have been looking for new approaches to teaching and learning for the last few decades, in search of innovative methodologies that will help students adapt better to the world's rapid changes and constant technological progress. However, changing from the traditional lecture approach to a new teaching strategy is time consuming and very challenging on many levels. Therefore, this work introduces teachers to the blended learning methodology, with design and implementation recommendations, and positive final outcomes, to facilitate their transition from the lecture-based class to a blended learning model.

This thesis presents three case studies of educational scenarios that changed lecture-based lessons into blended learning experiences. Therefore, the first thing we would like to highlight is that all the teachers involved in these experiments were "normal" teachers that had to learn everything from scratch and managed to transition to blended learning successfully. Even though it was time consuming at first, they valued the new teaching mechanism positively, despite the additional effort they had to put into their classes.

An advantage of blended learning is that there are many models to choose from, giving the teachers flexibility and the possibility of deciding on the model that suits them best. If the course is long, teachers can propose a blended learning model that requires student autonomy, since they will have time to adjust and adopt the methodology successfully. If the course is short, then we recommend a blended learning model with higher teacher presence and mandatory activities to help accelerate student's adoption.

If students have meaningful knowledge gaps between them, we recommend a blended learning model that allows students to advance at their own pace, and at the same time, allows the teacher to concentrate and help the disadvantaged students in the face-to-face sessions. On the other hand, if students are fairly similar, then teachers can propose blended learning models that motivate a higher understanding of the contents, challenging them to deepen their comprehension of the topics under study.

The technology in blended learning is a means to an end, not an end in itself. Therefore, the selection of the technology should be in favor of helping the teachers “teach better” and the students “learn better”, nothing else. When selecting the technology, we recommend starting by identifying *what we need* and then navigating the possible technological solutions. In this study all the blended learning models worked solely with self-paced MOOCs, specifically with the following MOOC resources: video-lessons, online individual exercises and assessments, and uploaded lectures. Even so, we are conscious that blended learning can use infinite technologies and encourage the exploration of the solutions that best fit each educational context. When doing so, we recommend to keep in mind Assertion 6, that says that *a higher number of "clicks" in a digital resource does not guarantee better performance in a course's assessments, but interacting consciously and efficiently with a technology in a blended learning experience, is significantly related to better learning outcomes.*

Finally, we would like to remind teachers that in blended learning, their role changes from deliverers of information to creators of learning experiences in student-centered learning environments. Therefore, even though a blended learning model can be carefully planned out before-hand, teachers and students should be prepared to face errors or make mistakes and have the flexibility to adapt and change for a successful implementation.

6.4.2 Implications for students

The biggest implication for students exposed to a blended learning experience, is that when they successfully adopt this learning methodology, they truly become responsible for their learning process, and shift from the traditional paradigm of being *spoon-fed* learners, to being active seekers of their own knowledge.

At first, students will most like struggle to adopt this new paradigm, and it even may affect their performance in the course. However, once they adopt the blended learning methodology, their learning outcomes will improve, along with their perception of their learning. They will *feel* they learn more than through traditional teaching, and they will also be more motivated in the course, with higher class participation, collaboration between students and more responsibility towards the classwork.

Students will have no problems technology-wise since they are digital natives. Even though they might have never used or seen the chosen technology, they will learn how to work with it (sign in, navigate, find the assignments, etc.) without any trouble at all. Even more, it will probably not even be necessary to explicitly teach them anything: simply give them a few minutes at the beginning of the experience and they will find all the tools on their own.

Blended learning requires students to be more autonomous than traditional lecture-based classes, so one important recommendation for students is to focus on organizing their time and classwork from the beginning and rely on their teachers and peers if they need help. This way, the transition from lecture-based classes to the blended learning approach will be easier and smoother.

6.4.3 Implications for educational institutions

Educational institutions have the task of encouraging teachers to implement blended learning approaches in their classes, giving them the time, the tools, and the flexibility to accomplish this change successfully. However, this motivation must be a part of the institution's *culture*. Teachers are generally expected to give "perfect" classes, without errors or mistakes. This expectation makes them many times reluctant to try new teaching techniques, since preparing a perfect class is more time consuming and stressing than preparing a class they could "learn from, improve, and retry". Therefore, educational institutions need to change this culture and eliminate the fear of making mistakes in the organization. Since I come from the Computer Science department, I would like to quote Jennifer González from her article "Teaching in Beta: What we can learn from software developers":

> "In software development, the term *beta* refers to software or other products that have not yet been perfected, but are released to the public for a kind of trial run. The *beta phase* is an accepted, normal, predictable stage of product development. It's a culture whose motto — "Release early, release often" — lifts up the notion that continuous improvement is way better than eternally holding out for perfection.
> So how about education? Isn't it time we consider making *beta* a standard part of our approach? We already try new things all the time. The difference is our attitude about the process: So many people in education expect perfection the first time around. When we don't get it, we reject the good idea, move on to the next new one, and repeat the cycle….
> But imagine if we embraced *beta*, if every attempt at something new were treated as the first in a series of iterations – repetitions of a process with the goal of making improvements each time around…
> As an educator, you are a designer. A developer. You design and develop spaces, materials, systems and experiences. It's time you start thinking of yourself that way."

Both institutions that collaborated in my thesis, the School of Engineering of Pontificia Universidad Católica de Chile and Colegio Eliodoro Matte Ossa from the SIP Foundation, gave the teachers complete flexibility to try blended learning. For example, the teacher of the higher education course was previously exempted from any possible consequences of that semester's teacher evaluation survey results, since he had a high risk of being poorly evaluated by the experimental and/or the control group if something went "wrong". In addition, he was allowed to have two different methodologies in the different course sections, even though they corresponded to the same course.

In conclusion, teachers will only dare to experiment and innovate in their teaching strategies if they have full support of the educational institution they belong to. Therefore, the educational institution must promote a *culture of innovation and "teaching in beta"*, with genuine openness to change.

6.4.4 Implications for current literature and educational researchers

This thesis has many contributions to both educational researchers and current literature. First, we propose definitions for *adoption* and for *blended learning* that integrate pedagogical, technological, and paradigmatic dimensions. Next, we propose an integral method to analyze student's adoption of the blended learning teaching methodology and its impact in student's learning outcomes. This method integrates qualitative and quantitative data. The minimum data needed for this analysis is: (1) student's performance in course assessments, (2) student's use of the technology (log-files or similar), (3) student's perception of their adoption and of their learning, (4) teacher's perception of the experience, and (5) student's prior knowledge.

Also, we contribute to current literature with three case studies and one final multicase study that design, implement and analyze blended learning with MOOCs in real educational contexts. In addition, these case studies gather both qualitative and quantitative data, which is very rare.

Finally, our assertions will help teachers and educational researchers design better blended learning experiences, which should be easier for educational researchers to analyze, easier for students to adopt, for teachers to implement, and finally, experiences that should cause greater impact in student's learning experience with less previous work from the design and implementation team.

6.4.5 Implications in education

Finally, we hope to contribute to *education* by motivating teachers, educational institutions and educational researchers to shift from the traditional teacher-centered paradigm to a student-centered learning paradigm, through either blended learning or other teaching models that focus on acquiring new skills, information, and talents through actions and students' experiences in the world, instead of communicating knowledge in a unilateral lecture format.

We strongly believe that this change is necessary and urgent, and are happy to provide evidence, through this work, that **MOOC-based blended learning is beneficial to students in terms of their adoption process, their learning outcomes, their development of responsibility and collaborative learning skills, their prior knowledge gaps or personal disadvantages, and in their learning experience as a whole.**

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