Visual data-enriched design technology for blended learning

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To my parents & Arnau,

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Abstract

This doctoral thesis focuses on a gap identified in the literature by investigating how visual representations, authoring support, and data analytics can aid teachers in designing for learning in complex scenarios that blend the use of different spaces for learning and different types of technological tools and resources, e.g. Massive Open Online Courses. The contributions lie in the research domain of Learning Technologies, and more specifically in the domains of Learning Design, Authoring Tools, Data Analytics, and Blended Learning. In particular, the thesis presents and discusses design principles, challenges, and implications for designing complex blended pedagogies, a visual analogy, and theoretical representation of these complex scenarios. Moreover, it advances the design and development of edCrumble, a data-enriched visual learning design authoring tool for educators. The thesis follows a design-based research approach involving co-creation processes. In doing so, the thesis also contributes with a co-creation case study that brings to light lessons learnt and challenges encountered during its implementation.

Resum

La present tesi doctoral es centra en investigar com les representacions visuals, el suport tecnològic i l’analítica de dades poden ajudar al professorat a dissenyar processos d’ensenyament-aprenentatge complexos que combinen l’ús de diferents espais, eines i recursos tecnològics, com per exemple els Cursos Massius i Oberts en Línia (MOOCs). Les contribucions s’emmarquen en el camp de la investigació en Tecnologies per a l’educació i, més concretament, en els camps de Tecnologies per al Disseny d’aprenentatge, Analítiques de dades i Aprenentatge combinat. En particular, la tesi contribueix amb principis de disseny, reptes i implicacions per a dissenyar pedagogies combinades que inclouen l’ús de tecnologia, així com amb una metàfora visual i una representació teòrica d’aquests escenaris complexos. A més a més, contribueix al disseny i al desenvolupament de l’edCrumble, una eina de disseny d’aprenentatge visual enriquit en dades per al professorat. La tesi segueix un enfocament de recerca basat en el disseny, que inclou processos de co-creació. En fer-ho, la tesi també contribueix amb un estudi de cas de co-creació aportant les lliçons apreses i els reptes que s'han trobat durant la seva implementació.

Resumen

La presente tesis doctoral se centra en investigar como las representaciones visuales, el soporte tecnológico y la analítica de datos pueden ayudar al profesorado a diseñar procesos de enseñanza-aprendizaje complejos que combinan el uso de diferentes espacios, herramientas y recursos tecnológicos, como por ejemplo los cursos en línea masivos i abiertos (MOOCs). Las contribuciones se enmarcan en el campo de investigación de las Tecnologías para la Educación y, más concretamente, en los campos de Tecnologías para el Diseño de aprendizaje, Analíticas de datos y Aprendizaje combinado. En particular, la tesis contribuye con principios de diseño, retos e implicaciones para el diseño de pedagogías combinadas que incluyen el uso de tecnología, así como una metáfora visual y una representación teórica de estos escenarios complejos. Además, contribuye al diseño y desarrollo de edCrumble, una herramienta de diseño de aprendizaje visual enriquecido con datos para el profesorado. La tesis sigue una metodología de investigación basado en el diseño, que incluye procesos de co-creación. En consecuencia, la tesis también contribuye con un estudio de caso de co-creación aportando las lecciones aprendidas y los retos que se han encontrado durante su implementación.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The Learning Design (LD) field aims to support teachers in becoming learning designers by improving their teaching practices through evidence-based design decisions and supporting the sharing and co-creation of learning designs among communities of teachers (Dalziel et al., 2016; Laurillard, 2012; Mor, Craft, & Hernández-Leo, 2013). Nowadays, the need to follow LD goals has received considerable attention as, with the spread of the use of technology in education, the complexity of educational designs has increased significantly, which presents both challenges and opportunities. On the one hand, the use of internet-connected technology has allowed teachers to go beyond the use of traditional face-to-face (f2f) instruction through the adoption of more complex blended scenarios that combine multiple modalities of teaching and learning in which learning contexts and spaces; physical and digital tools; synchronous and asynchronous teaching and learning processes; as well as formal and informal structures are mixed (Ellis & Goodyear, 2016; Norberg, Stöckel, & Antti, 2017), with all the complications that this entails. On the other hand, these new complex educational contexts offer opportunities for educators and researchers, as they usually integrate technology that facilitates the automated collection of educational data during teaching and learning processes (Hernández-Leo, Martinez-Maldonado, Pardo, Muñoz-Cristóbal, & Rodríguez-Triana, 2019). This integration of technology leads to the provision of data-based evidence that can improve the overall quality of the learning experiences. The present doctoral thesis is situated at the intersection of the research fields alluded to above: Technology-Support for Learning Design, Blended Learning, and Data Analytics.

Innovation in education is time-consuming as well as challenging to develop in an effective way (Laurillard, 2008). Innovative approaches and best practices are usually presented in a way that is difficult for the vast majority of educators to understand and, furthermore, there is no direct connection between these scenarios and learning environments (Conole, 2010). In this context, the LD field has emerged as a paradigm that focuses on providing a general descriptive framework for representing educational practices in a way that may be shared effectively (Agostinho, 2011; Conole, 2012; Laurillard et al., 2013). This approach has been found to be useful for several stakeholders involved with educational institutions (faculty and instructional designers) to document their practices and interpret the practices of others (Agostinho, 2011).

Research and practice in LD aim to provide suitable textual, visual, and computational means to represent teaching practices as well as tools to manipulate and share them (Grainne Conole & Wills, 2013; Mor et al., 2013). The LD process often involves making decisions about the selection of the most appropriate pedagogical model, the definition of the flow of tasks, the specification of roles, as well as the choice of the most suitable resources and educational tools that can support the tasks defined. All with the objective of arriving at potentially effective learning given the needs of the particular educational context. For some time now, LD tools have been conceived of to support teachers in the process of documenting their teaching practices so that their learning design ideas are explicit and sharable (Agostinho, 2011; Grainne Conole & Wills, 2013; Hernández-Leo et al., 2018; Laurillard et al., 2013). Persico et al. (2013) and Prieto et al. (2013) present and compare a variety of tools that have been developed to guide the decision-making process in LD. In this regard, Conole (2012) distinguishes between two types of LD tools: "pedagogical planners" and "tools for visualizing designs". The author argues that whereas pedagogical planners may guide and support practitioners in making informed design decisions while they are planning their teaching practices, tools for visualizing designs may be used to visualize and represent learning designs.

However, despite the variety of existing proposed representations of pedagogical practice, some are too specific for particular pedagogies and general approaches are not sufficiently accessible for teachers who do not have the required technical skills (Pozzi, Asensio-Pérez, & Persico, 2016). Consequently, more intuitive visual representations of LD are required (Agostinho, 2011; Boloudakis, Retalis, & Psaromiligkos, 2018; Grainne Conole & Wills, 2013; Maina, Craft, & Mor, 2015; Villasclaras-Fernández, Hernández-Leo, Asensio-Pérez, & Dimitriadis, 2013). Additionally, despite the available options and potentialities for teaching and learning innovations that the LD field can bring to the education landscape, there is a gap in the adoption of existing LD tools by actual practitioners (Cameron, 2009; Celik & Magoulas, 2016; Dagnino, Dimitriadis, Asensio-Pérez, & Pozzi, 2018). Sharing is one of the main pillars of LD (Dalziel, 2015), but sometimes it is insufficient reason for teachers to adopt the habit of documenting their practices so they may be shared. Thus, one of the near-future LD challenges is reducing this gap and providing LD tools that will facilitate their adoption (Cameron, 2009; Dagnino et al., 2018; Hernández-Leo et al., 2018, 2011).

Planning and visualizing are especially critical when implementing innovative pedagogy models such as problem-based learning (PBL), flipped classroom (FC), and hybrid Massive Open Online Courses (hybrid MOOCs). Yet, those cases are considered by several authors as complex blended scenarios (Littlejohn & Pegler, 2007). These new blended scenarios present several design challenges as their design complexity often impedes the reporting of well-documented case studies. Whereas several studies support the idea that blended learning has a positive impact on teaching and learning effectiveness (Garrison & Kanuka, 2004; López-Pérez, Pérez-López, & Rodríguez-Ariza, 2011; Means, Murphy, & Baki, 2013; Moskal, Dziuban, & Hartman, 2013; Pérez-Sanagustín, Hernández-Correa, Gelmi, Hilliger, & Rodriguez, 2016; Sharpe, Benfield, Roberts, & Francis, 2006), other authors highlight that "the studies of effectiveness lack consistency in what constitutes BL environments, and what outcomes are being compared" (Siemens, Gašević, & Dawson, 2015). Thus, there is limited evidence on how pedagogy and/or technology influence learning outcomes in BL scenarios (Arbaugh, 2014; Littlejohn & Pegler, 2007; Torrisi-steele & Drew, 2013).

Furthermore, and by extension, very little is currently known about the best ways to design effective BL (Bralić & Divjak, 2018). Most of the time, research in this line appears in the form of case studies composed of long text descriptions that often provide design recommendations drawn from the lessons learned. Despite this, they sometimes omit details about how the blended schema was articulated (e.g. the structure of the course, description of the activities, technology used, and pedagogy applied). This fact prevents final practitioners who want to understand the reported case from learning from it or even reusing or replicating it, which thereby thwarts the effective sharing of BL practices as well as the evaluation and comparison of final outcomes. Accordingly, some studies report the need to provide support to practitioners who are willing to implement BL and help them to face the challenges that usually arise during the process (Moskal et al., 2013; Porter, Graham, Spring, & Welch, 2014; Torrisi-steele & Drew, 2013).

In this way, the field of LD might provide some insights on how to approach the aforementioned problem, as one of its main purposes is to provide support on “how to represent teaching practice in an appropriate form to enable teachers to share ideas about innovative online pedagogy and think about the process of design” (Agostinho, Bennett, Lockyer, & Harper, 2011). The use of a systematic way of representing BL designs would facilitate their comprehension and allow sharing and comparison of the outcomes of different blended LDs so that their effectiveness could be more accurately studied, with the ultimate end of improving these types of practices.

Apart from the challenges, the use of technology in blended learning design practices has also afforded new opportunities for improving teaching and learning processes. Nowadays, educators and researchers can extract data from blended educational practices, which combine f2f instruction with online activities supported by technology, to analyze and understand what is happening in the educational settings they have designed (Michos, Hernández-Leo, & Albó, 2018). With the increased use of technology in education, educational data science has become more accessible, providing tools and techniques to make sense of educational data (Amarasinghe, Hernández-Leo, & Jonsson, 2019; Hernández-Leo et al., 2019; Michos et al., 2018). The data collected may serve different purposes depending on the type. Although learning analytics (LA) is the most well-known type of data collected from specific technological environments – data on students’ interactions, which can be used to understand their learning processes and experiences (Lockyer & Dawson, 2011) – there are others available that may contribute to better educational design practices that are much less explored. Hernández-Leo et al. (2019) present a layered framework which distinguishes between three types of data analytics. In addition to LA, the authors identify *community analytics* – metrics and patterns of design activity within a community of teachers and related stakeholders (Hernández-Leo et al., 2019; Michos & Hernández-Leo, 2018) – as well as *design analytics* – metrics of design decisions and related aspects that characterize learning designs (Hernández-Leo et al., 2019).

Whereas data on students’ interactions may be used to understand their learning processes and experiences (LA), metrics of design decisions and related aspects characterizing learning designs (design analytics) can increase awareness of and reflection on decisions made during the learning design process as well as inform future design decisions (Hernández-Leo et al., 2019). Moreover, the metrics and patterns of design activity within a community of teachers and related stakeholders (community analytics) can increase awareness of and reflection on individual and collective design activities as well as stimulate an orientation toward and inspiration on how to improve design practices (Hernández-Leo et al., 2019; Michos & Hernández-Leo, 2018).

Despite the range of existing proposed LD tools and representations of pedagogical practice (Agostinho, 2011; Hernández-Leo et al., 2018; D. Laurillard et al., 2013; Pata, Beliaev, Robtsenkov, & Laanpere, 2017; Persico et al., 2013; Prieto et al., 2013), there is a need for new approaches that address the complexity as well as the new challenges and opportunities of blended learning educational practices. This is especially true when considering the least-explored data analytics mentioned above: design analytics and community analytics. Thus, the main objective of this dissertation is to explore *how to assist teachers in the design of complex blended learning practices with visual authoring support and design analytics.*

The remaining sections of this introductory chapter are structured as follows: the next section states the broad purpose of the dissertation as well as the specific objectives defined in order to fulfill it; Section 1.3 outlines the research methodology that was used throughout the research process; Section 1.4 presents the findings of the thesis; Section 1.5 covers the main conclusions; Section 1.6 discusses future research directions that may emerge from the thesis; and finally, Section 1.7 summarizes the structure and contents of the rest of the dissertation.

1.2 Dissertation objectives

As mentioned in Section 1.1, the main aim of the thesis is to answer the research question: *How can teachers be assisted in the design of complex blended learning practices with visual authoring support and design analytics?* In order to achieve this aim, we have defined two dissertation objectives:

1. **To study the challenges that teachers face when designing complex blended learning educational practices**.

The definition of blended learning is still under discussion in the research field. In this thesis we have decided to use the definition provided by Heinze and Procter (2014):

> Blended Learning is learning that is facilitated by the effective combination of different modes of delivery, models of teaching and styles of learning, and founded on transparent communication amongst all parties involved with a course. (Heinze & Procter, 2004)

Within this definition, we focus on blended learning designs that comprise *complex* combinations of modes of delivery, modes of teaching and ways of learning, such as blended learning using MOOCs (combining a university course with a MOOC, which is itself a course, can be challenging) or using pedagogical models with complex structures in terms of time, content design, and different learning spaces (like PBL and FC). Nowadays, the complexity of blended learning cases has increased due to the opportunities that advances in technology have provided. However, the challenges associated with the design of these new complex scenarios are still underexplored.

2. **To conceptually and technologically assist the design process of complex blended learning using visual authoring and design analytics.**

This second objective tackles the need to support the design process of complex blended learning from three perspectives: conceptually, technologically, and analytically.

First, and aligned with LD's objectives, there is a need to provide systematic ways of describing educational practices to be able to share them effectively. There must be a switch from the current isolated teaching practices to a more collaborative strategy when designing and implementing teaching and learning processes. Sharing educational practices of what works and what does not within a community of educators can be a promising and enriching way of advancing toward a better educational landscape within the present continually and rapidly changing world. Previous researchers have provided several solutions for describing teaching practices, often in the form of frameworks, text-based design templates, and authoring tools. However, more visual representations are needed, especially in the case of complex blended learning designs. Very little is currently known about the conceptual support that visual representations can provide to teachers when planning complex blended learning designs.

Second, the spread of ICTs is having an impact on educational settings. Teachers have access to a large number of tools for use in their educational practices, among which are some designed to support teachers during the learning design process (planning, implementing, and sharing their educational experiences). Despite the many existing learning design tools, their adoption by teachers is still a challenge. Less-technical tools that do not require a high level of technology skills and that are similar to teachers' established practices (i.e., similar to the educational tools currently used by teachers) are required. In particular, design authoring tools addressing the challenges and opportunities (new visual design representations and data analytics) that technology can provide when designing complex blended learning are still lacking.

Third, the use of technology in education provides the opportunity to collect information, in the form of data analytics, on teaching and learning processes automatically. Learning analytics are the most explored type of data, with design and community analytics the least explored. Specifically, more research on the support that design analytics can bring to teachers during the learning design processes is essential. Moreover, it is also critical to explore what kinds of design analytics are available as well as which are the most effective in helping to improve educational designs.

Figure 1.1 presents a general overview of the context, research question, and objectives of the thesis.

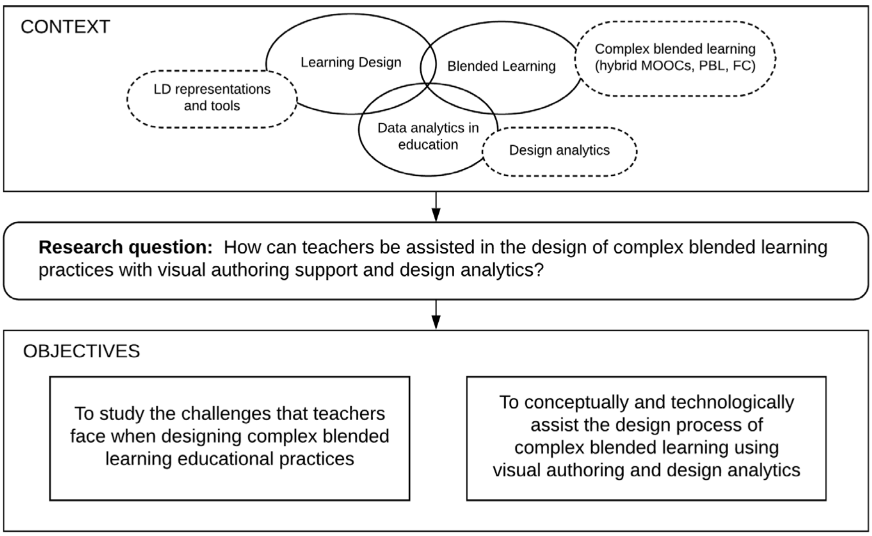

Figure 1.1. General overview of the context, research question, and objectives of the thesis.

1.3 Research methodology

In order to construct the research methodology of the dissertation I have followed the frameworks for planning research defined by Creswell (2003) and Little and Carter (2007). The frameworks are founded on three main concepts that are intimately connected: epistemology (knowledge claims), methodology (strategies of inquiry), and method (as well as data collection and analysis). The epistemology is the justification of knowledge and influences the methodology selection, which in turn provides justification for the methods used. Additionally, objectives, research questions, and design shape the choice of the methodology, and methodology shapes the objectives, research questions, and design (Little & Carter, 2007); it is a two-way relationship. As Little and Carter (2007) argue, good quality research should attend to all three elements (epistemology, methodology and method) and demonstrate internal consistency between them.

1.3.1 Choosing an epistemological position

Epistemology influences the methodology and the methods as well as provides a potential connection between research practice and formal theories of knowledge (Creswell, 2003; Hitchcock & Hughes, 1995; Little & Carter, 2007). "Epistemology includes assumptions about the form knowledge takes, the ways in which knowledge can be attained and communicated to others, and ultimately who can be a knower, and what tests and criteria must be involved in order to establish knowledge" (Hitchcock & Hughes, 1995).

My educational background in engineering has influenced and shaped the way in which I see and understand the world, and consequently, the choice of my epistemological position. As an engineer, my work inherently involves designing and building artificial things (e.g. software programs based on specific requirements). In contradistinction to science disciplines that are used to exploring how natural things are and work, we (engineers) are used to making artifacts based on specific desired requirements (Simon, 1969). Hence, we are used to design. But what does *design* mean? As Simon (1969) stated, design is "devising courses of action aimed at changing existing situations into preferred ones." Within the engineering context, as problem solving-oriented professionals, we are basically used to *designing solutions* to problems.

In line with this view, pragmatic philosophies are also oriented toward applications and solutions to problems – the problem being more important than the methods – using all approaches to understand it (Creswell, 2003). Pragmatism provides systems of inquiry rooted not in claims of truth, but rather in the viability of theories to explain phenomena and produce change in the world (Barab & Squire, 2004). This approach derives from the work of Peirce, James, Mead, and Dewey (Cherryholmes, 1992) and may take different forms but, for many of them, knowledge claims arise out of actions, situations, and consequences rather than antecedent conditions, as in postpositivism (Creswell, 2003).

Beyond my own view of knowledge understanding, though, I believe pragmatism also matches well with the phenomenon investigated in this thesis and its context (supporting teachers in improving learning design processes).

Interestingly, like engineering, teaching is not a theoretical science that describes and explains some aspect of the natural or social world, but is rather a design science whose objective is to make the world a better place (Collins, 1992; D. Laurillard, 2012; Simon, 1969). Teachers are designers because they use what is known about teaching but also the implementation of their designs to keep improving them (D. Laurillard, 2012).

However, as Juuti & Lavonen (2006) argue, following Dewey's pragmatic approach (Rodgers, 2002), teaching experience without active reflection is not knowledge: it is only by means of reflective action that an experience becomes knowledge. The authors describe the pragmatic triangle of actors from Davidson (1990), within the context of education, as follows: a triangle that relates speaker (researcher), interpreter (teacher), and the world (designed learning environment as a means to more intelligible teaching). They argue that in the scientific realist and social constructivist view of science, teachers and researchers live in different worlds, whereas "through reflective discussion, obtaining similar experiences in the classroom and anticipating each other's intentions, the researcher and the teacher could share the same world" (Juuti & Lavonen, 2006).

Pragmatism does not assume that there is one real world that will be uncovered through scientific inquiry, but instead defends the notion of intersubjectivity where the truth is highly dependent on the context and humans have similar experiences in the shared world. It is within this same context (the world) that, after uncovering the problem (defining together – researchers and teachers – what needs to change in the teaching and learning environment, as well as the opportunities and constraints), researchers explicate it with the artifact to be designed. Then, researchers and teachers interact with each other and decide the main objectives pursued by the artifact and create a strategy to achieve those objectives and then test the strategy (Juuti & Lavonen, 2006).

In this context, and especially given the fact that the world in which we live is ever-changing and ever-evolving, the relationship between educational research and educational practice is not one of the simple application of knowledge: it demands a re-conceptualization of the role of teachers from mere providers of knowledge to designers of learning (Biesta & Burbules, 2003; D. Laurillard, 2012; Mor & Craft, 2012).

Hence, based on the discussion presented in this section, the epistemological position of this thesis is one of intersubjectivity embedded in the philosophical stance of pragmatism (Biesta & Burbules, 2003; Creswell, 2003; Rodgers, 2002). Lastly, as the next sections (methodology and methods) will be influenced by and build upon this epistemological selection, Table 1.1 presents, as a summary, the four most important consequences of pragmatism for design research that Biesta & Burbules (2003) highlighted, based on the key ideas of John Dewey (Rodgers, 2002).

Table 1.1. Consequences of pragmatism for design research. Summarized from Biesta & Burbules (2003).

Pragmatism provides us with a different way to…	**Pragmatic point of view**	**Possible influence in designing research**
Conceive of the relationship between knowledge and action.	Knowledge provides us with possibilities for refining and supporting our day-to-day problem solving, but without a certain foundation for human action.	The kinds of educational questions that are selected for study.
Think of the relationship between theory and practice (educational research and educational practice).	The relationship between educational research and practice is not one of application but of cooperation and coordination.	The ways in which research teams are formed, and who is included in them.
Think about the objects of our knowledge.	It is not that the world of science is closer to reality than the world of everyday life. Objects of knowledge are instruments for action, and different objects, different worlds, provide us with different opportunities and possibilities for action.	The choice of research methods, emphasizing the use of multiple tools of inquiry to gain different perspectives on the problems at hand.

Think about objectivity and relativity.	Intersubjectivity: the scope of intelligence is not restricted to the domain of means, techniques, and instruments, but includes also the domain of ends, purposes.	The way in which we regard questions of content in our research in relation to questions about the organization of the context being researched (researcher's own context).

1.3.2 Selecting an appropriate methodology

The selection of the methodology for this dissertation takes as a starting point the applied nature of the epistemology of pragmatism. Traditionally, researchers have adopted the view of research as ranging from basic to applied. Whereas basic research aims to extend the fundamental understanding within a scientific field, applied research strives to solve problems that confront an individual, a group, or society at large (Reeves, 2000). However, as Stokes (1997) asserts, it is possible to look beyond this dualistic view and forge a research paradigm where both theoretical and practical contributions coexist – named by Stokes as a "use-inspired basic research" paradigm. In his book, *Pasteur's Quadrant: Basic Science and Technological Innovation*, Stokes (1997) defines a matrix view of research with four quadrants. Within this matrix, Stokes compares the pragmatic research of the microbiologist Louis Pasteur with the basic science of the physicist Niels Bohr and the applied science of Thomas Edison (figure 1.2).

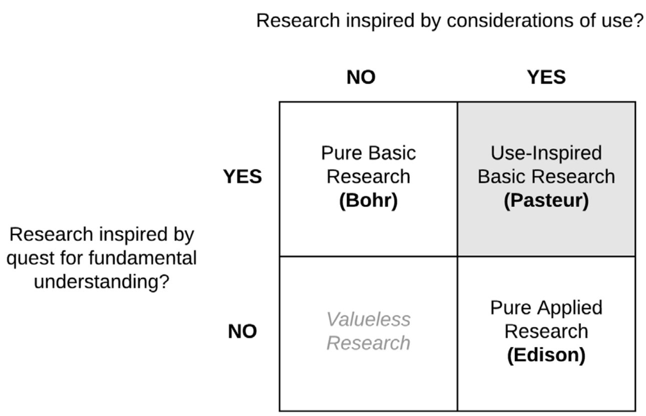

Figure 1.2. Pasteur's quadrant. Adapted from Stokes (1997), p.73.

In the educational research field, there is a common optimistic belief that use-inspired basic research approaches can produce greater gains than what traditional research has achieved in the past several decades

(Mckenney & Reeves, 2014; Nieveen et al., 2006; Wademan, 2005). In education, we face complex process as learning, cognition, knowing, and context. It is, above all, because context matters in terms of learning and cognition that "research paradigms that simply examine these processes as isolated variables within a laboratory will necessarily lead to an incomplete understanding of their relevance in more naturalistic settings" (Barab & Squire, 2004; Brown, 1992). At the same time, the arguments above can be applied to the specific field of educational technology research. As Reeves (2008) stated, "technology is much more than hardware. It is a process that involves the complex interactions of human, social, and cultural factors as well as the technical aspects." Thus, he argues that "it requires new directions in research goals, moving away from traditional predictive methods to long-term collaborations based on development goals".

In this context of applied research, the approach that best instantiates Stokes' Pasteur quadrant in terms of pragmatism is Design-Based Research (DBR) (Anderson & Shattuck, 2012; Biesta & Burbules, 2003; Juuti & Lavonen, 2006; Wademan, 2005). The first expression used to refer to DBR was "design experiments", which was originally defined by Ann Brown (1992) and Alan Collins (1992). Over the next 27 years, it has been called by many different names, among the most common of which are: educational design research, development research, information system (software) design and formative research, and design-based research (Juuti & Lavonen, 2006; Reeves, Mckenney & Herrington, 2011).

DBR is defined by Barab & Squire (2004) as "a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings." Reeves (2000) summarizes the main characteristics of the approach as follows:

- Addressing complex problems in real contexts in collaboration with practitioners;
- Integrating known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems;
- And conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles.

It is important to highlight the fact that DBR is not in itself a methodology (Herrington, McKenney, Reeves, & Oliver, 2007), but a research approach whose interventions lie within a wide range of methodologies using mixed methods (Anderson & Shattuck, 2012). At the same time, the use of a mixed methods approach ties in well with the epistemic selection of the thesis. Whereas quantitative and qualitative approaches are related respectively to postpositivist and constructivist knowledge claims, the mixed methods approach is one in which the researcher tends to base knowledge claims on pragmatic grounds (Cresswell, Plano-Clark, Gutmann, & Hanson, 2003; Creswell, 2003). For, as Creswell notes, "pragmatic researchers draw liberally from both quantitative and qualitative assumptions, they are 'free' to choose the methods, techniques, and procedures of research that best meet their needs and purposes" (2003).

1.3.3 Implementation of the methodology

The main idea of DBR is that future designs benefit from theoretical principles derived from prior research (Collins, Joseph & Bielaczyc, 2004; Peterson & Herrington, 2005). This logically implies that DBR is based on iterative cycles – what Collins et al. (2004) call *progressive refinement* – cycles that will last "until all of the bugs are worked out" (Collins et al., 2004, p. 18).

The iterative nature of the DBR approach is represented visually in Reeves' (2000) model in Figure 1.3. As may be seen, Reeves envisions the implementation of DBR through four iterative stages: it starts with the analysis of a practical problem together with practitioners; it continues with the proposal and development of initial solutions within a pre-defined theoretical framework; then, the developments are evaluated and tested in practice; and finally, the results of the evaluations are documented for further reflection and the production of *design principles*.

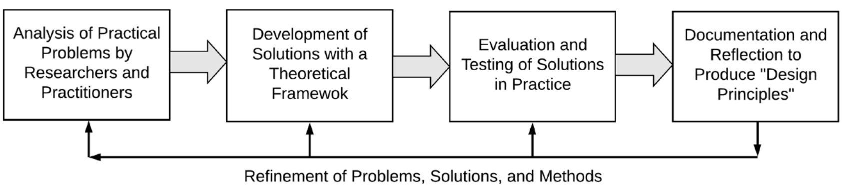

Figure 1.3. Design-Based Research approach by Reeves (2000), p.9.

For this thesis, I decided to use the extended model of Reeves' approach to DBR as defined by Wademan (2005), called "Generic Design Research Model" (Figure 1.4).

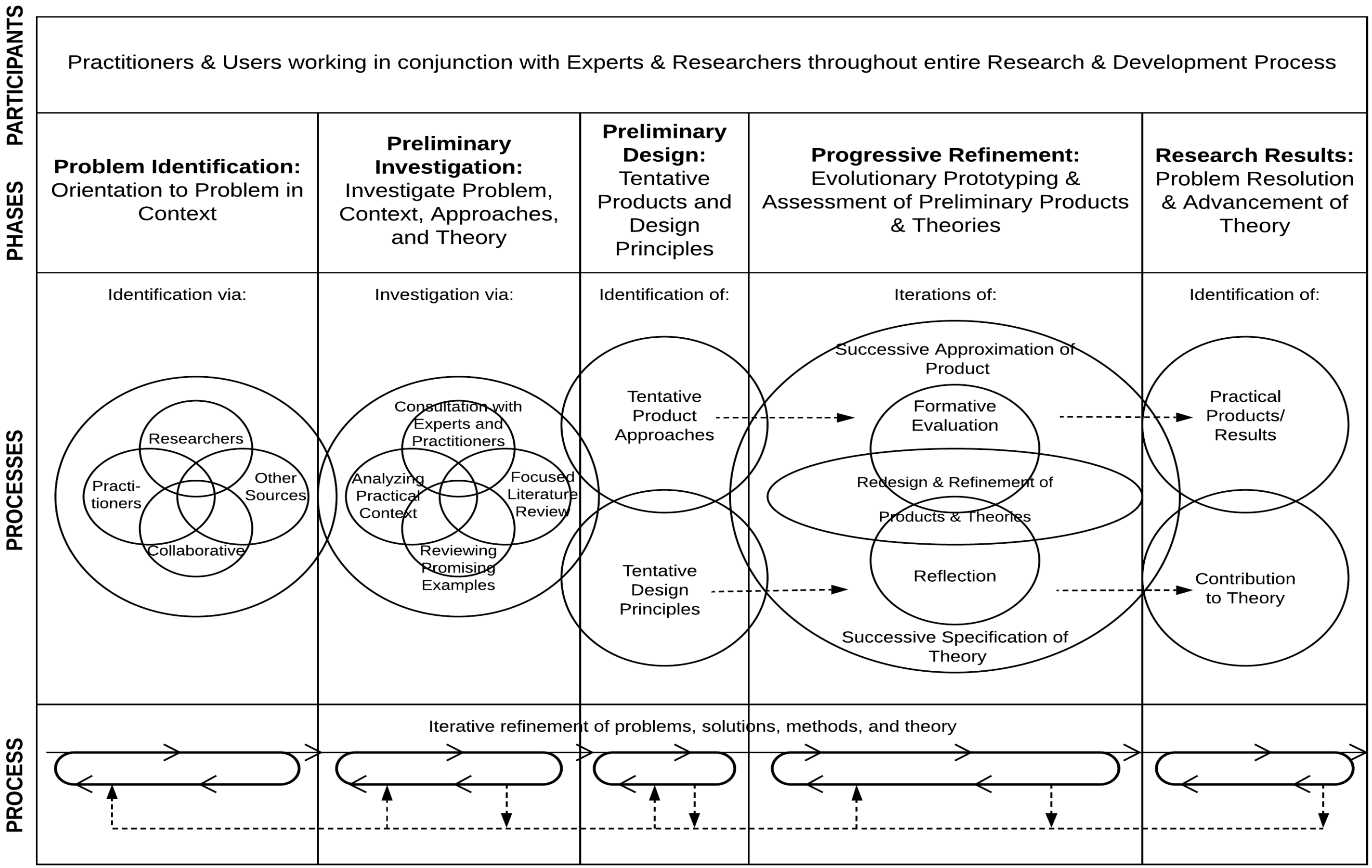

Figure 1.4. Wademan's Generic Development Research Model, adopted from Wademan (2005), p. 228.

As this figure shows, Wademan's model illustrates more clearly the join work between the successive approximation of practical products (*interventions*) and the successive approximation of theory (which he also calls *design principles*) (Van den Akker, Bannan, Kelly, Nieveen, & Plomp, 2013).

In the following paragraphs, I outline the different phases of the DBR model proposed by Wademan (2005) and how they are applied in the context of this dissertation (Figure 1.5). As Figure 1.5 indicates, I have adapted Wademan's model and divided the progressive refinement phase into two phases (phases four and five), distinguishing between prototyping and assessment cycles. Moreover, the figure also shows the research articles produced in each step of the DBR approach. These publications comprise the different chapters of the dissertation.

Phase 1: Problem identification. This phase involves the initial identification of the research problem. A literature review, which addressed the blended learning design issues identified by previous researchers, led us to identify the opportunity for this thesis work, which resulted in the research problem context and the main research question stated in the introduction. Furthermore, we did a survey study (W1) among 43 university teachers to explore the challenges that teachers face when adopting and implementing complex blended learning designs, which is relevant to the first objective of the thesis). Specifically, we examined the case of MOOC-based blended learning educational practices (bMOOCs). The findings of this study indicated a high level of acceptance of bMOOCs by the university teachers surveyed. Flipped learning was the hybrid research approach preferred and barriers and difficulties identified were mostly institutional and technological but also pedagogical. Moreover, we detected the need to provide guidance and models to teachers to uncover the best practices that shape hybrid pedagogies in order to reduce the main entry barrier, which is the novelty of the approach. Furthermore, we identified that more research would be required – with a larger sample and analyzing bMOOC case studies – in order to offer deeper insights and understanding. The results also revealed the need for further research on how to reduce the technological, pedagogical, and institutional problems that arise when designing and implementing bMOOCs in universities.

An additional study exploring how undergraduate students were taking MOOCs was also carried out during this first phase (C2). This study focused on understanding the profile of undergraduate students participating in MOOCs (on the MOOC platform MiríadaX), their registration, preferred topics, and completion patterns and how they compared to other types of participants. The results of this study were complementary to the main research focus of the thesis, so although we have included it in the DBR scheme in Figure 1.5, we report the research article in Appendix A.

Phase 2: Preliminary investigation. During this phase, we investigated the problem (identified in phase 1) in greater depth. Specifically, we examined the context of and approaches to the design of complex blended learning scenarios by means of several case studies, a workshop with practitioners, and a quasi-experiment in real classroom settings.

The implementation of two studies using online videos in f2f classrooms led us to explore at first hand the challenges that arise during the design of blended learning cases. The first was a case study (C1/J4) that explored the use of MOOC videos in f2f classrooms. Specifically, it used a combination of Video-Based Learning (VBL) and Project-Based Learning methodologies to study students' behavior and satisfaction with using the videos, the videos' utility, as well as the position of the professors. The second research project, by contrast, was a quasi-experiment (J1) that explored the design considerations involved when using mobile devices in collaborative classrooms. The study investigated how the use of different mobile devices influenced students' engagement, behavior, and experience when watching academic videos. Above all, it aimed to compare the use of smartphones versus laptops in the visualization of videos to support hands-on in-class activities. Additionally, two case studies (W2 and W3) of blended learning scenarios using MOOCs also contributed to our understanding of the design challenges in more complex blended learning cases.

Finally, based on the lessons learned during the problem identification phase and some of the research studies above, we carried out a design workshop with teachers (C3). The objective of the workshop was to explore preliminarily how to guide teachers in designing blended learning. We focused on the bMOOC design case and the results helped us to understand the challenges of providing guidance to teachers in the learning design process. We prepared a first paper-based visual representation of blended learning designs that would be used by the teachers during the workshop to visually represent their bMOOC cases.

The results of all of the studies above allowed us to generate a list of design principles that would constitute the foundation for the subsequent DBR phases and cover part of the first research objective of the thesis: to study the challenges that teachers face when designing complex blended learning educational practices.

Phase 3: Preliminary design. This phase consolidated the preliminary design product (a visual representation of blended learning designs) and the design principles extracted from the previous DBR phases. The findings of the previous phases led to our enhancing the visual representation to be more complete in order to overcome the limitations identified in the first version during the workshop with teachers (phase 2). The proposal of a visual representation responds to the need identified in part of the second objective of the thesis: to conceptually support complex blended design processes.

Phase 4: Prototyping of preliminary products and design principles. The first research work carried out in this phase was the evaluation of the paper-based representation (from phase 3) by experts in a design workshop (J2). The results of the workshop were analyzed and contributed to a final representational model which would serve as the basis for developing the first online prototype of the authoring tool for designing blended learning. The online authoring tool aims to cover the technological part of the second objective of the thesis: technologically support complex blended design processes.

To further the development process of the authoring tool, we carried out several participatory design workshops with two school communities. The co-creation process with high school teachers over several months generated iterations in the development process in which each new version of the prototype incorporated the design principles extracted from the previous iteration (refining the design theory, problem, solution, and method through successive approximation to the theory and the final product). The use of prototyping cycles in design-based research is a strategy to ensure reliability of the design before final field work study (Kennedy-Clark, 2015). The entire development process is reported in a research article (J5), as well as the final product (C4) and the collection of the design principles (C5). The authoring tool (based on the visual representation produced in previous phases) aims to support teachers in the design of blended learning. The characterization of the design elements that the tool provides allowed us to incorporate design analytics visualizations as part of the features of the tool.

Phase 5: Assessment of preliminary products and design principles. This phase involves the assessment of the final product (the authoring tool and its design analytics) as well as the corresponding design principles. Thus, it tackles the last part of the second objective of the thesis: explore how to technologically assist the design process of complex blended learning using visual authoring and design analytics. However, because the authoring tool is based on the visual representation conceptualized during the initial phases, this phase evaluates the tool but also the visual representation.

During this phase, we conducted several workshops with different kinds of participants: teachers, students, and EdTech related stakeholders. These iterative workshops (J3) strove to evaluate the final version of the authoring tool, which included considering most of its features, but specifically the features related to the visual representation and design analytics. Furthermore, a more specific study was carried out as the last step in this phase to explore the value of a more advanced proposal of design analytics (concept-level design analytics) integrated into the authoring tool and to evaluate its potentialities for supporting the learning design process (C7).

Phase 6: Research results. This phase concluded the iterative DBR approach with the evaluated final product and design principles. At this stage we reflected on the overall research process and identified the main outcomes of the research performed throughout the thesis, which are presented in Section 1.4. As previous methodology sections have indicated, the results of the DBR approach are not only practical products (authoring tool) but also theoretical contributions (design principles).

It is worth noting that, in line with the nature of the research approach, the research studies that compose the DBR process followed in this thesis include several methodologies: a survey study, a quasi-experiment, case studies, co-creation workshops (participatory design workshops), and a user study. It is important to highlight that most of the DBR cycles involved a co-creation process: specifically, during the conceptualization, the development, and evaluation phases. We decided not to explain this concrete methodology in detail in this chapter as it is reported in-depth in a research publication presented in Section 3.1.

As Kennedy-Clark (2015) stated, one of the issues that may arise in a thesis that follows DBR is that a solo researcher (in this case, myself as a PhD student) plays different roles within the research process (designer, developer, facilitator, and evaluator). While this fact may be positive for the researcher since it allows the student to learn different approaches and understand the whole research design, it is necessary to implement checkpoints during the process to ensure that objectivity is maintained (Kennedy-Clark, 2015). To address this issue, the DBR approach followed in this dissertation involved multidisciplinary research teams, as reported in detail in Section 3.1.

To conclude this section, Table 1.2 is a summary of the research objectives of each phase of the DBR process. The following section will present the research methods employed during the entire DBR process.

Table 1.2. Research objectives of each phase of the DBR process.

Phase	**Research objectives**
Ph1: Problem identification	To identify the main research problem and to formulate the main research question of the thesis: *How can teachers be assisted in the design of complex blended learning practices with visual authoring support and design analytics?* Within this phase we also started exploring the thesis' first objective (which belongs to the above research question): *To study the challenges that teachers face when designing complex blended learning educational practices.*
Ph2: Preliminary investigation	To investigate the problem identified in phase 1 more in-depth. Specifically, we investigated the context and approaches regarding the design of complex blended learning scenarios by means of several case studies, a workshop with practitioners, and a quasi-experiment in real classroom settings. Results contributed to the first objective of the thesis as well as to developing the preliminary design of the following research phase.
Ph3: Preliminary design	To elaborate a preliminary product and design principles from the results obtained during the two previous research phases. We came up with the first version of the visual representation for blended learning designs (for the case of hybrid MOOCs), which contributed partially to the second objective, *to conceptually support the design process of complex blended learning*.
Ph4: Prototyping of preliminary products and design principles.	To iteratively prototype an online version of the product developed in the preliminary design phase, contributing to the technological and analytics part of the second research objective, *to technologically assist the design process of complex blended learning using visual authoring and design analytics*. At the same time, to make progress on the theoretical side by extracting new design principles from the co-creation process with practitioners during creation of the different versions of the product: a learning design authoring tool for blended learning based on the visual representation conceptualized during the previous research phase.
Ph5: Assessment of preliminary products and design principles.	To evaluate the final product resulting from the previous phase as well as to update and create new design principles. Particularly, tackling the design analytics features of the authoring tool.
Ph6: Research results.	To reflect upon the entire DBR process and conclude with the main research results (practical and theoretical) which are presented in this dissertation.

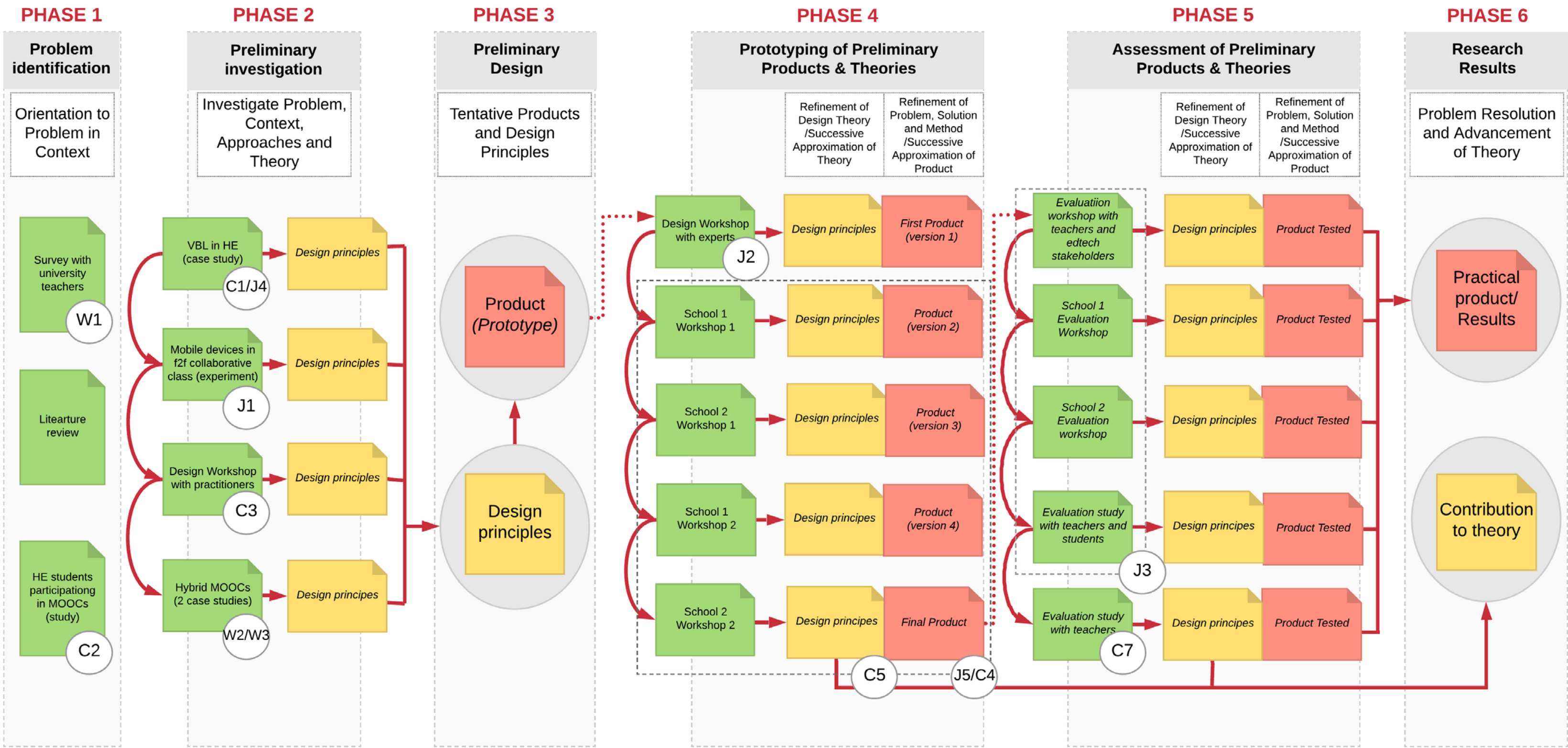

Figure 1.5. Design-Based Research process of the dissertation. Adaptation of Wademan's (2005) Generic Development Research Model. The white circles indicate the associated research articles produced in each step of the DBR process (J: journal article; C: conference article; W: workshop article).

1.3.4 Describing methods

In this section, I present the selected methods of the dissertation. The selection was guided by the chosen epistemology and methodology, with the aim of choosing the methods which would produce the most relevant data to answer the research questions.

As discussed above, DBR interventions usually involve mixed methods that apply a variety of research techniques (Anderson & Shattuck, 2012). Moreover, the pragmatic researcher bases inquiry on the assumption that collecting diverse types of data, both quantitative and qualitative, best provides an understanding of the research problem (Creswell, 2003). Therefore, a considerable assortment of data-gathering techniques of different natures have been used throughout the thesis. Table 1.3 shows them, indicating where they were used (in which publications) as well as indicating their purpose in this thesis.

Table 1.3. Data-gathering techniques used throughout the thesis. Purposes described according to Cohen, Manion, & Morrison (2007).

Technique	Description	Used in…*	Purpose
Collection of artifacts	Collection of a diverse set of online and paper-based artifacts generated by the participants (e.g. online designs from the authoring tool and generated materials from paper-prototyping activities)	J2, J3, C3, C7, W4, W5	Registering the learning design process, as well as the use of the systems and tools by the participants.
Questionnaires	Online and paper-based questionnaire(s), using different types of items: open and closed questions, multiple choice questions, rank ordering, and rating scales.	J1, J2, J3, C1/J4, J5, C3, C7, W1, W3, W5	Getting the opinions of participants over a wide range of topics.
Observations	Naturalistic and semi-structured observations conducted by one or more researchers. The data collected were audio	J1, C1/J4, J5, C3	Discovering participants' responses to, perceptions of, messages contained in, and attitudes to the

	and/or video recordings, pictures, and observation notes.		physical environment.
Focus groups	Transcripts of voice recordings during focus groups with teachers.	J5	Developing themes for subsequent interviews and/or questionnaires. Empowering participants to speak out and in their own words.
Interviews	Semi-structured, face-to-face, one-to-one interviews with teachers (recorded and transcribed).	J3, C1/J4, C5, J5	Capturing the opinions of the participants in depth, after an initial analysis of other data sources (e.g., observation data or questionnaires answers).
System Logs and datasets	Automatic registers of user actions within the systems used (e.g. online educational platforms, online video repositories or authoring tool)	J1, C1/J4, C2, C7	Registering the actions that users perform during their interaction with the systems and tools to understand how the users behave when using them.
Role-playing	Group activity with workshop participants simulating school communities where each participant had a different teacher role.	J3, W5	Simulating social situations that are intended to shed light on the role/rule contexts governing "real life" social episodes.
**J: journal publication; C: conference article; W: workshop paper. See Figure 1.5.*			

Most of the interventions within the DBR approach utilized more than one method of data collection. Thus, we have applied, depending on each case, researcher and/or methodological triangulations (Cohen et al., 2007) as well as concurrent or sequential triangulations (Cresswell et al., 2003).

1.4 Main results

This section presents the main contributions and the evaluation results obtained during the research process. It also provides a list of publications up to the time of thesis submission and the projects to which this work has contributed.

1.4.1 Contributions

Herrington et al. (2007) state that DBR involves outputs in the form of both knowledge and products. Specifically, the authors distinguish between three types of outputs in DBR. First, scientific outputs in the form of design principles, which they define as evidence-based heuristics, that can inform future development and implementation decisions (Herrington et al., 2007). In this respect, the authors wrote that:

> Design principles contain substantive and procedural knowledge with comprehensive and accurate portrayal of the procedures, results and context, such that readers may determine which insights may be relevant to their own specific settings (Herrington et al., 2007, p. 4095).

Second, practical outputs (design artifacts) and third, societal outputs (professional development of the participants). The main contributions of this thesis are introduced below, as well as the corresponding type of output according to Herrington et al. (2007):

1. **Design principles, challenges and implications for designing complex blended pedagogies** (design principles)

To meet the first objective (Section 1.2), this thesis contributes models, challenges, and implications for designing complex blended learning educational practices. Specifically, it provides:

a. *A survey exploring barriers to teachers' adoption of hybrid MOOCs* (Section 2.1).
   Despite being a new blended learning strategy, the survey results showed a high level of acceptance of hybrid MOOCs by university teachers. In order to reduce the main entry barrier, the novelty of the approach, results point to the importance of providing teachers with design guidance and models to uncover the best practices that shape hybrid pedagogies. The findings also indicated the need for research on how to reduce the technological, pedagogical, and institutional problems that arise when implementing blended MOOCs in higher education.

b. *A quasi-experiment exploring how the use of different mobile devices influences students' engagement, behavior, and experience when watching academic online videos in a collaborative classroom* (Section 2.2).
   The study showed that the use of laptops provides more positive results than using smartphones in terms of student engagement, collaborative behaviors, and the overall Video-Based Learning (VBL) experience. The findings suggested that the type of mobile device used in collaborative learning activities that use videos need to be carefully chosen in order to maximize students' and groups' comfort. However, the results also showed positive trends across academic years on the potential of smartphones to reach significant levels of engagement and user satisfaction.
c. *A case study of experimenting with new approaches to hybrid courses using video-based learning on a traditional campus* (Section 2.3).
   Contrary to popular belief, the use of VBL is not the sole province of a flipped classroom (FC) methodology. It is also possible to use videos in a hands-on class as a support tool that encourages more autonomous, flexible, and significant learning. The adoption of a flipped or a hands-on classroom approach depends on diverse aspects, including the nature of the course (with practical or theoretical orientations), the behavior of the students (depending on their needs and preferences, time constraints, etc.), and the design of the activities proposed by the teachers (requiring students to watch videos within a rigid timeframe, e.g. prior to class, or offering flexibility).
d. *A case study of using a MOOC transformed into an SPOC in a f2f university course* (Section 2.4).
   Results indicated that blended learning with MOOCs (and SPOCs) can be a sustainable model for universities as well as a catalyst for a shift from teacher-centered to student-centered learning. Among the challenges found during the hybridization process, we highlight the following key points:
   - The importance of institutional support during the design and implementation of complex blended courses.
   - The opportunity of having a private MOOC instance facilitated by the MOOC platform in the form of an SPOC, which avoids the technological challenge of finding alternative technological solutions to host and articulate the course content.
   - The important role of professors: without their willingness to adapt to new teaching situations, it would have been impossible to have this experience.

- The hybridization made possible to implement the course: the course would not have been possible in a f2f format without high costs.
- The technological and pedagogical challenges that students and teachers faced when they had to manage two platforms (the Virtual Learning Environment from the university and the SPOC platform), for example in terms of facing different registration and login processes in the two platforms, or in the challenging process of grading course participants through both platforms (i.e., managing insufficient grade information on the SPOC platform in order to comply with university assessing standards).

e. *A case study of using two MOOCs in an on-campus course for high school students* (Section 2.5).
The types of challenges faced during the learning design process were essentially pedagogical, technological, and legal in nature; the two MOOCs used were not owned by us, and their content came from teachers of two other universities hosted on two different MOOC platforms. The blended learning design had positive results in terms of student learning outcomes and satisfaction with the MOOC videos used. The intentionality expressed, of continuing to learn through MOOCs, was more optimistic than the results of what finally occurred.

2. Visual metaphor and representation of complex blended learning designs (design artifact and design principles)

The visual representation proposed in this thesis (described mainly in Section 3.3) provides conceptualization support for designing complex blended learning. It allows teachers to represent blended courses in a visual way and to easily visualize the overall structure of the learning designs as well as the relationships between different design elements. The representation provides teachers with a context for fostering reflection and decision making during the planning of complex blended learning designs. Despite how it has been conceptualized (and evaluated) previously in the case of hybrid MOOCs, visualization was also assessed during the prototyping cycles (phase 4 of the DBR process) with other complex blended learning scenarios such as PBL and FC. Moreover, the thesis contributes a new visual comparison for representing blended learning designs: the video editor analogy (presented in the evaluation study of Section 5.1). The analogue proposed facilitated the transition from the theoretical (paper-based) visual representation to the online interface, which served as the basis for the main editor of the authoring tool.

3. **Design and development of a learning design authoring tool and analytics to guide teachers in designing complex blended learning approaches** (design artifact and design principles)

This dissertation contributes with the design and the actual development of edCrumble (Chapters 4 and 5), a data-enriched visual learning design authoring tool for educators. The aim of edCrumble is to support teachers in the design of blended learning scenarios. The tool facilitates the representation of hybrid educational practices through a visual representation involving a layered-timeline or video editor analogy and characterized and supported by design analytics – metrics of design decisions and related aspects characterizing learning designs which can foster awareness and reflection on decisions made during the learning design process as well as inform future design decisions. Moreover, the tool (freely available online at https://ilde2.upf.edu/edcrumble/) is integrated into a social platform that allows teachers to share their designs with a community of educators both within and beyond their institution. In addition to the authoring tool, this thesis also advances a series of design principles with the purpose of informing the development of learning design tools toward better learning design adoption, which addresses the adoption gap identified in Section 1.1. Of those design principles, two main rules were formulated in order to facilitate the adoption of LD tools by educators in their daily practices (Section 4.3 provides a complete description):

a. LD tools should connect with teachers' existing practices. Associated design principles are:
   - *Content and activity-centered planning.*
   - *Planning tools based on time.*
   - *Usability matters: the Google Apps effect.*
b. LD tools should solve teachers' day-to-day problems. Associated design principles are:
   - *Facilitate learning design within a community of educators.*
   - *Increase the utility perception for solving teachers' day-to-day problems.*

In addition to the three main contributions of the thesis presented above, there have also been the following indirect contributions as a result of the DBR process:

1. **Co-creation process and challenges in the development of TEL tools** (design principles)

As explained in the research methodology section, this thesis has entailed co-creation, through participatory design workshops, in order to involve participants in the conceptualization, development, and evaluation of the artifacts and design principles of the DBR process. The report of the co-creation process as well as the challenges we encountered during its implementation may also be considered as an indirect contribution. Specifically, they take the form of design principles that, we hope, may help other researchers who are thinking of incorporating co-creation in the design of teacher tools within a DBR approach. The complete co-creation process and challenges are reported in Section 3.1. The design principles derived are presented as follows:

a. Participant recruitment process and motivation.
   - *Using several sources to recruit participants* (research projects, conference, etc.) opens the project to different collaboration strategies and different stakeholders, and facilitates and ensures the availability of participants throughout the DBR process.
   - *Combining short-term and long-term collaboration strategies*: While the isolated collaborations in time (participants who attended single workshops or user studies) provided highly motivated participants, there were several time limitations (e.g. for collecting data) and participants were more decontextualized. By contrast, long-term collaborations (participants collaborating in a research project for several months) allow for more in-depth collaboration, but is costly in terms of maintaining participant motivation high throughout the process.

b. Managing workshop time and participant expectations.
   - *Maintaining balance between outputs for the researcher and those for participants:* When the collaboration between the researcher and participants goes beyond the research work (i.e., the participants have been promised new knowledge), the workload dedicated to the collection of data and that dedicated to imparting new knowledge to the participants must be well-balanced in terms of time in order to manage participant expectations.

c. Prioritizing feedback diversity.
   - *Maintaining balance between feasible developments and direct proposals from participants:* In the development process of edCrumble, the feedback prioritization process was always a balance between considering the points that could feasibly be developed in the time we had until the next workshop, and always including a direct proposal from the participants to ensure they would continue to be motivated and engaged in the research process.

d. Potential and challenges of the co-creation methods used.
   - Section 3.1 evaluates the methods used during the edCrumble co-creation process.

2. Professional development of the participants (societal outputs)

The “collaborative nature” inherent to the process of defining and accomplishing a DBR research project has an additional benefit to the extent that it enhances the professional development of all actors involved (Herrington et al., 2007). To achieve the objectives of the thesis, the DBR process involved several groups of participants who participated in different kinds of workshops. In almost all the workshops conducted, co-creation for its own sake was not the ultimate object, for they also conferred something to the participants beyond participating in our research project. The workshops supported them in their professional development; mainly teacher training. Specifically, our work has contributed to expanding participant knowledge of:

a. *Hybrid MOOCs design and models*
   Teacher training occurred during a workshop with university teachers and educational stakeholders who were participants in a local conference on MOOCs. Specifically, it was the design workshop with practitioners shown in Figure 1.5 in phase 2 of the DBR process. Participants were taught models and design strategies for using MOOCs in their traditional f2f courses at university. The activities in the workshop were built upon the research conducted by Pérez-Sanagustín et al. (2017) on hybrid MOOC frameworks and by Delgado-Kloos, Muñoz-Merino, Alario-Hoyos, Ayres, & Fernández-Panadero (2015) on hybrid MOOC models.
b. *Problem-Based Learning (PBL)*
   Teacher training took place over two workshops with high school teachers, who were participants in the CoT research project (see Section 1.4.4). Specifically, these were workshops 1 and 2 with school 1, as indicated in Figure 1.5 in phase 4 of the DBR process. Participants were taught about designing a lesson involving PBL with edCrumble since our authoring tool provides a simple guideline on the steps to follow to implement PBL. In addition to the practical design work during the workshop, participants were asked to perform several tasks – including viewing short video lectures and participating in a forum discussion, etc. – prior to the first workshop in order to learn the theoretical side of PBL. Adopting an FC approach, we set up a Moodle course to allow participants to do these pre-workshop tasks online.
c. *Flipped Classroom (FC)*
   Teacher training was conducted over two workshops with high school teachers, who were participants in the CoT research project. Specifically, these were workshops 1 and 2 with school 2, as shown in Figure 1.5 in the phase 4 of the DBR process. Participants were taught about designing a lesson using an FC with edCrumble since, as in the PBL case, our authoring tool also provides a simple guideline giving the steps to follow for implementing an FC. Besides

the practical design work during the workshops, participants were asked to perform several tasks – including viewing short video lectures and participating in a forum discussion, etc. – prior to the first workshop in order to learn the theoretical side of FC. Adopting an FC approach, we set up another Moodle course to allow participants do these pre-workshop tasks online.

d. *Evidence-based learning design (design and community analytics)*
Teacher training was carried out over three workshops with teachers, researchers, and EdTech related stakeholders, who were participants in a local conference on innovation in education, in addition to the participants of the CoT project. Specifically, these were the first three evaluation workshops during phase 5 of the DBR process (see Figure 1.5). Each workshop taught participants to design and document activities that incorporate ICT and new teaching-learning methodologies, and how to share them on an online community platform (edCrumble) and reflect on how participants could improve them with the help of data analytics. Participants learned about the 3 types of data analytics defined by Hernández-Leo, Martinez-Maldonado, Pardo, Muñoz-Cristóbal, & Rodríguez-Triana (2019) that can support teaching-learning processes, as well as the importance of being aware of the support that data analytics can provide in making decisions for the improvement of teaching practices. Lastly, participants had the opportunity to learn how to use our authoring tool, which facilitates the process above, in an online teaching community.

To conclude this section, Figure 1.6 is a diagram with an outline of the thesis context, the objectives, and the main contributions as discussed above, as well as the evaluation studies, which will be described in detail in the next section.

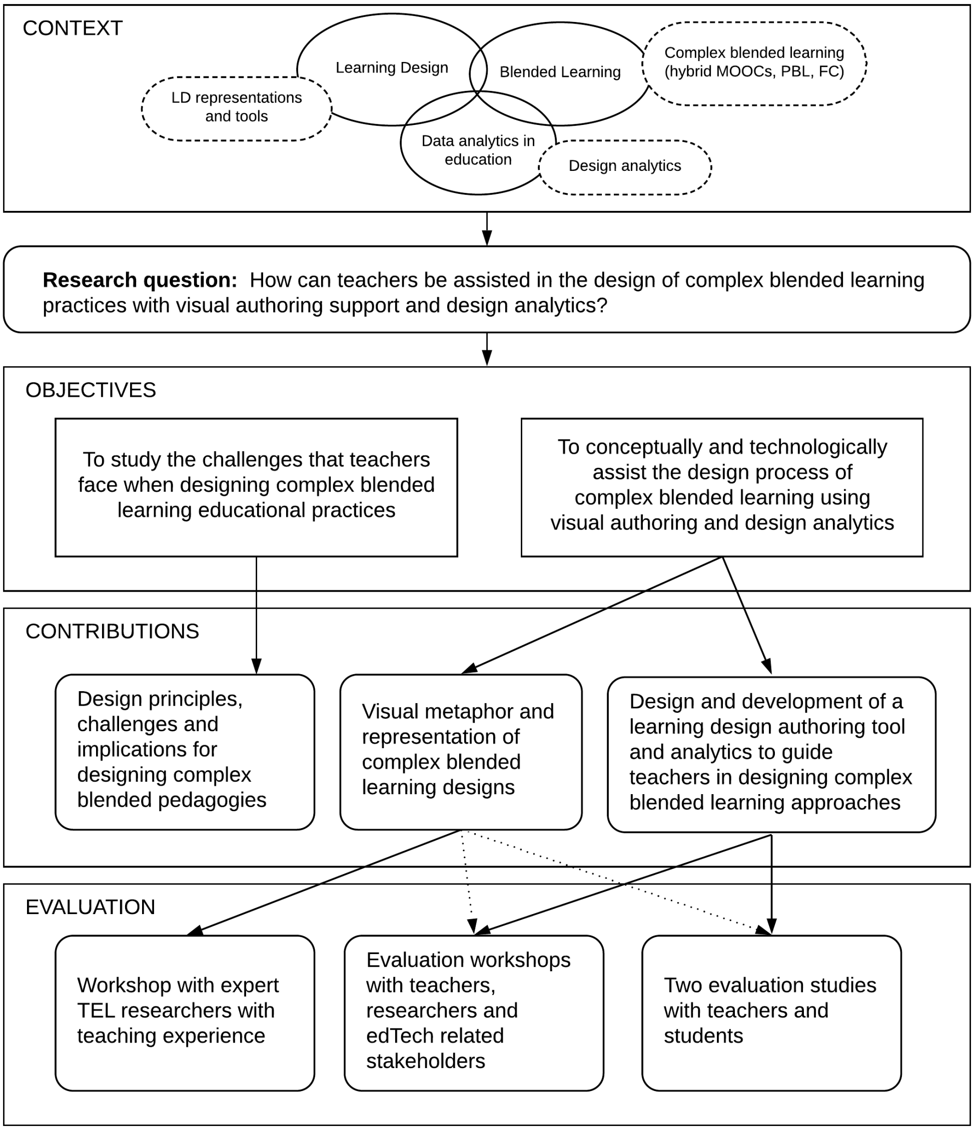

Figure 1.6. General overview of the context, research question, objectives, main contributions and evaluation studies of the thesis.

1.4.2 Main evaluation studies

This thesis comprises several evaluation studies carried out during the DBR process (Figure 1.6) as follows:

1. Workshop with expert TEL researchers with teaching experience

The first evaluation study that we performed was during the first cycle of phase 4 of the DBR process, during the workshop with Technology Enabled Learning (TEL) experts (Figure 1.5). The workshop served the purpose of evaluating the preliminary design of the product of the thesis, the visual representation for blended learning designs. The results of the study were useful for analyzing whether the elements provided by the model – the timeline with activity layers, resource layers, and activity descriptions – were valid for visually representing and designing for the specific case of MOOC-based blended learning designs. The outputs of both workshops – the design workshop with practitioners carried out during phase 2 and the workshop with experts in phase 4 – helped to improve the different versions of the model, which led to a final model proposal that represented the blended courses visually. The evaluation study results showed that this representation allows educators to easily visualize the overall structure of the learning designs and the relationships between the different design elements, which provides a context for fostering reflection and decision making during the planning of MOOC-based blended learning designs.

2. Evaluation workshops with teachers, researchers, and EdTech-related stakeholders and an evaluation study with students

During phase 4 of the DBR process, after the evaluation of the visual representation, we developed the first version of the online prototype of edCrumble. We tested and improved the tool through several development iterations together with high school teachers from two school communities (explained in Section 4.1). Despite these iterations involving the assessment of different versions of the authoring tool, the final version was evaluated during phase 5 of the DBR process (see Figure 1.5). We conducted three workshops with different participant profiles: with the teachers who participated in the tool's development iterations, but also with teachers and EdTech-related stakeholders and students who had not seen the tool until the day of the evaluation workshops, which corresponded with the first four iterations of phase 5 of the DBR process. The evaluation reported in Section 5.1 demonstrates that the tool has specific features that facilitate support for designing blended learning, reveals the factors that may facilitate or impede its adoption, and connects it to solving real educational challenges. The evaluation also occasioned a detailed analysis of its usability and informed to what extent the tool is able to represent blended learning designs.

3. An evaluation study with teachers

With the second research objective of this thesis in mind, one of the main features of edCrumble is the design analytics. Despite the previous evaluation study also including the evaluation of the design analytics provided by the tool, the last cycle of the fifth phase of the DBR process evaluated a more advanced type of analytics. Specifically, during my research stay at the University of Pittsburgh (USA), we integrated concept-level design analytics – fine-grained level design analytics focused on visualizing critical metadata associated with smart learning content – into edCrumble and carried out a user study to assess their value in supporting the design process of teachers (reported in detail in Section 5.2 of this thesis). The results indicated that the use of concept-level design analytics may reduce the cognitive load of design tasks, especially in terms of mental demand. We also demonstrated that the use of design analytics facilitated the selection of the most suitable activities without significantly affecting the overall design time. Interestingly, the presence of the visualizations changed the behavior of teachers in the process of selecting the activities, by just previewing their contribution to the visualization without looking deeper into their content. When examining the learning outcomes, the most impressive result was the almost complete disappearance of future concepts from sessions designed with the help of visualization. Selecting content that requires future concepts is usually a design error, and the presence of concept-level design analytics helped teachers to avoid these errors. In addition, our results suggested that analytics may have a greater impact on concept-level balance when it is necessary to select just a few activities, as the instructor needs to be more precise in selecting the best ones. On the contrary, when the instructor can select a higher number of activities, the probability of covering the concepts by chance is higher and the visualizations have a smaller impact on improving the overall balance among concept levels.

The following sections present the publications up to the date of thesis submission and the projects to which this work has contributed.

1.4.3 Publications

This dissertation is organized and presented as a compendium of the following research articles published or submitted for review at the time of presenting the dissertation. The list only includes those publications in which the dissertation's author is the first author and are directly related to the doctoral work.

Publications in JCR-indexed international peer-reviewed journals:

(J1) Albó, L., Hernández-Leo, D. & Moreno-Oliver, V. (2018). Smartphones or laptops in the collaborative classroom? A study of video-based learning in higher education, *Behaviour & Information Technology*, 38(6), 637-649 https://doi.org/10.1080/0144929X.2018.1549596

(J2) Albó, L., Hernández-Leo, D. (2019). Conceptualizing a visual representation model for MOOC-based blended learning designs, *Australasian Journal of Educational Technology* (in press).

(J3) Albó, L., Hernández-Leo, D. (2019). edCrumble, a data-enriched visual authoring design tool for blended learning (Submitted to journal, currently under review).

Publications in non-JCR-indexed international peer-reviewed journals:

(J4) Albó, L., Hernández-Leo, D., Barceló, L., & Sanabria, L. (2016). Video-based Learning in Higher Education: The Flipped or the Hands-On Classroom? *Special Issue of the European Journal of Open, Distance and E-Learning (Best of EDEN 2015)*, 50–61.

(J5) Albó, L., Hernández-Leo, D. (2019). Co-creating a web-based visual representation model for authoring blended learning designs (Submitted to journal, currently under review).

Publications in international conference proceedings:

(C1) Albó, L., Hernández-Leo, D., Barcelo, J., & Sanabria, L. (2015). Video-Based Learning in Higher Education: the Flipped or the Hands-on Classroom? In *EDEN Annual Conference* (pp. 400–408). Barcelona, Spain.
[BEST PAPER AWARD FINALIST]

(C2) Albó, L., Hernández-Leo, D. & Oliver, M. (2016). Are higher education students registering and participating in MOOCs? The case of MiríadaX Methodology. *Proceedings of the European MOOC Stakeholder Summit 2016*, 197–210.

(C3) Albó, L., & Hernández-Leo, D. (2016). Blended learning with MOOCs: towards supporting the learning design process. In G.

Ubachs & L. Konings (Eds.), *The Online, Open and Flexible Higher Education Conference 2016* (pp. 578–588). Rome (Italy): EADTU, October 2016.

(C4) Albó, L., & Hernández-Leo, D. (2018). edCrumble: designing for learning with data analytics. In V. Pammer-Schindler, M. Pérez-Sanagustín, H. Drachsler, R. Elferink, & M. Scheffel (Eds.), *Lifelong Technology-Enhanced Learning. EC-TEL 2018. Lecture Notes in Computer Science, vol 11082.* (pp. 605–608). Leeds, UK: Springer, Cham.
[BEST DEMO AWARD]

(C5) Albó, L., & Hernández-Leo, D. (2018). Identifying design principles for learning design tools: the case of edCrumble. In V. Pammer-Schindler, M. Pérez-Sanagustín, H. Drachsler, R. Elferink, & M. Scheffel (Eds.), *Lifelong Technology-Enhanced Learning. EC-TEL 2018. Lecture Notes in Computer Science* (Vol. 11082, pp. 406–411). Leeds, UK: Springer, Cham.

(C6) Albó, L., Butera-Castelo, R., & Hernández-Leo, D. (2019). Supporting the planning of hybrid-MOOCs learning designs. In M. Calise, C. D. Kloos, C. Mongenet, J. Reich, J. A. Ruipérez-Valiente, G. Shimshon, T. Staubitz, M. Wirsing (Eds.), *Proceedings of Work in Progress Papers of the Research, Experience and Business Tracks at EMOOCs 2019 (European MOOCs Stakeholders Submmit Conference)* (pp. 8–13). Naples, Italy: CEUR-WS.

(C7) Albó, L., Barria-Pineda, J., Brusilovsky, P., Hernández-Leo, D. (2019). Concept-level design analytics for blended courses. In M. Scheffel, J. Broisin, V. Pammer-Schindler, A. Ioannou, & J. Schneider (Eds.), *Transforming Learning with Meaningful Technologies. EC-TEL 2019. Lecture Notes in Computer Science* (Vol. 11722, pp. 541–554). Delft, The Netherlands: Springer, Cham.

Publications in international workshops:

(W1) Albó, L., Hernández-Leo, D., & Oliver, M. (2016). Blended MOOCs: University teachers' perspective. In C. Delgado Kloos, P. J. Muñoz-Merino, R. M. Crespo-García, & C. Alario-Hoyos (Eds.), *Trends in Digital Education: Selected papers from EC-*

TEL 2015 Workshops CHANGEE, WAPLA, and HybridEd (Vol. 1599, pp. 11–15). Aachen: CEUR-WS.

(W2) Albó, L., & Gelpí, C. (2017). From a FutureLearn MOOC to a blended SPOC: the experience of a Catalan Sign Language course. In *HybridEd Workshop, EMOOCs 2017*, Leganés, Spain. http://hdl.handle.net/10230/32158

(W3) Albó, L., & Hernández-Leo, D. (2017). Breaking the walls of a campus summer course for high school students with two MOOCs. In *HybridEd Workshop, EMOOCs 2017*, Leganés, Spain. http://hdl.handle.net/10230/32157

(W4) Albó, L., & Hernández-Leo, D. (2018). Co-creation process and challenges in the conceptualization and development of the edCrumble learning design tool. In A. Piotrkowicz, R. Dent-Spargo, S. Dennerlein, I. Koren, P. Antoniou, P. Bailey, T. Treasure-Jones, I. Fronza, C. Pahl (Eds.), *Joint Proceedings of the CC-TEL 2018 and TACKLE 2018 Workshops*. Leeds, United Kingdom: CEUR-WS.

(W5) Albó, L. & Hernández-Leo, D. How educators value design analytics for blended learning. In *Hybrid Learning Spaces - Design, Data, Didactics*, *ECTEL 2019*. Deft, The Netherlands (accepted).

1.4.4 Projects

Part of the work carried out during this thesis contributed to certain objectives of the following research projects:

- **Project:** RESET (REformulating Scalable Educational ecosysTems).
  - **Dates**: 2015 – 2017.
  - **Funding entity:** Spanish Ministry of Science and Innovation (TIN2014-53199-C3-3-R).
  - **Participant entities:** Universidad Carlos III de Madrid (UC3M), Universidad de Valladolid (UVA), Universitat Pompeu Fabra (UPF).
  - **Principal Investigators (UPF):** Josep Blat and Davinia Hernández-Leo.
  - **Website**: http://reset.gast.it.uc3m.es/

- **Project:** CoT (Communities of Teaching as a data-informed design science and contextualized practice).
  - **Dates**: 2016 – 2019.
  - **Funding entity:** RecerCaixa, Catalonia.
  - **Participant entity:** UPF.
  - **Principal Investigator:** Davinia Hernández-Leo.
  - **Website:** https://ilde2.upf.edu/CoTprojectRC/

- **Project:** MDM (Maria De Maeztu DTIC Strategic Research Program) – Educational Data Science (EDS).
  - **Dates:** 2016 – 2019.
  - **Funding entity:** Spanish Ministry of Science and Innovation (MDM-2015-0502).
  - **Participant entity:** UPF.
  - **Principal Investigator of EDS sub project:** Davinia Hernández-Leo.

- **Project:** SMARTLET (Learning analytics to enhance the design and orchestration in scalable, IoT-enriched, and ubiquitous Smart Learning Environments).
  - **Dates:** 2018 – 2020
  - **Funding entity:** European Regional Development Fund as well as by the National Research Agency of the Spanish Ministry of Science, Innovations and Universities (TIN2017-85179-C3-3-R).
  - **Participant entities:** UC3M, UVA, UPF.
  - **Principal Investigator (UPF):** Davinia Hernández-Leo.
  - **Website:** https://smartlet.gsic.uva.es/

1.5 Conclusions

As mentioned in Section 1.2, the main goal of this dissertation was *to study how to assist teachers in the design of complex blended learning practices with visual authoring support and design analytics*. In order to fulfill this research aim, two objectives were defined, upon which the following thesis conclusions are based:

1. **To study the challenges that teachers face when designing complex blended learning educational practices.**

In order to achieve this objective, we performed case studies of complex blended learning and carried out a survey that explored barriers to teachers adopting hybrid MOOCs. We identified 5 main challenges, listed as follows, together with their related findings:

- *The novelty of the complex blended learning approaches*

In the case of hybrid MOOCs, we have identified the novelty of the approach as a main entry barrier for its adoption by teachers. In order to address this challenge, guidance for design and support for sharing novel hybrid educational practices are required.

- *Technology-related challenges*

The use of different modes of delivery involves, in most of cases, a combination of several educational web-based platforms. In the case of hybrid MOOCs, the typical combination is a MOOC platform with a Virtual Learning Environment system (VLE), e.g. Moodle. The technological challenges are diverse: for instance, in terms of handling different registration and login processes on various platforms; or in the challenging process of grading and supporting participants of the course through different systems; or in the attempt to embed content from one delivery platform into another in order to achieve a more integrated system. The ability to have a private MOOC instance facilitated by the MOOC platform in the form of an SPOC may avoid the technological challenge of finding alternative technological solutions to host and articulate the course content from the MOOC in the VLE as, for instance, when it is not possible or is desirable to use the MOOC from its own platform within the design.

- *Pedagogical challenges*

The use of different teaching models and learning styles in complex blended learning designs entails pedagogical challenges. These challenges usually involve decision making on the choice of the best hybrid model to be implemented, such as: selecting the most suitable delivery platform(s) relative to its pedagogical potential, time, and place; deciding where each part of the content is to be delivered; choosing whether to follow some known pedagogical model, etc. In some cases, the hybridization of MOOCs with university courses converge in video-based learning (VBL) activities inside or outside of class when videos from the MOOC are used. Our findings suggest that the type of mobile device used in collaborative learning activities involving the use of videos need to be carefully chosen in order to maximize student and group comfort. In one of our studies, we demonstrated that the use of laptops in collaborative in-class activities that require the visualization of videos is more appropriate than the use of smartphones. We have shown that the use of laptops provides more positive results in terms of student engagement with the videos, collaborative behaviors, and the overall VBL experience. Moreover, in another case study, we also found that VBL may not only converge with an FC methodology, but it may also be possible to use videos in a hands-on class as a support tool that encourages more autonomous, flexible, and significant learning.

- *Institutional challenges*

Institutional support is very important when carrying out complex blended learning designs, to the point where, in some cases (e.g. in our case study using an SPOC), institutional support becomes essential. Without the support of the university – in our case study, the support provided by the university's MOOC management and production team – the blended experience would not have been possible.

- *Legal challenges*

In complex blended learning, the content is usually hosted on different delivery platforms. In cases where content from other institutions is used (e.g. the use of content from MOOCs at other universities and different MOOC platforms) in a blended course, challenges of a legal nature often arise. The use of several delivery platforms may involve the research process having to take into consideration the terms of use of the content of each platform, since each delivery system has its own rules, which may affect the design of the course (e.g. some delivery platforms do not allow the reproduction of their videos to a wide audience, as may be the case with large classes). The attempt to embed content from one delivery platform into another in order to achieve a more integrated system may also lead to legal challenges relating to content-owner rights.

2. **To conceptually and technologically assist the design process of complex blended learning using visual authoring and design analytics.**

In order to fulfill this objective, we proposed a visual representation model for blended learning designs and its web-based version, instantiated in the authoring design tool edCrumble.

The visual representation conceptually supports teachers in designing complex blended learning practices, providing a systematic way for representing them so that they may be shared and easily understood. Results have shown that using the visual representation, teachers can easily visualize the overall structure of the complex blended learning designs as well as the relationships between their different design elements. The representation, mainly composed of a timeline with two activity layers (in-class, out-of-class) and their activity descriptions, provides teachers with a context for fostering reflection, awareness, and decision making during the planning process. The visualization was assessed during the prototyping cycles with hybrid MOOCs, PBL, and FC complex blended learning scenarios.

edCrumble supports teachers conceptually, technologically, and analytically in the design process of blended learning. Our results demonstrate that use of the tool may raise awareness and support reflection, as well as facilitate planning by providing the opportunity to share plans within a teaching community. Moreover, specific characteristics of the tool – such as the timeline, the distinction between in-class/out-of-class layers, and the design analytics – have been identified as features that offer advantages over current teaching methods. Our results from the evaluation workshops indicate that design analytics provided by the tool support teachers greatly in the design of blended learning, by fostering awareness during the design process, teacher coordination and collaboration, and workload balance between in- and out-of-class sessions, among others. The results from the last user study presented showed that the use of concept-level design analytics improves the overall learning design quality by reducing the designer's mental demand effort and without requiring extra design time. The video analogy used for building edCrumble's main interface was useful in providing acceptable usability results during the tool's evaluation workshops. However, despite positive perceptions of the effectiveness, satisfaction, and overall ease of use, it appears that the system's efficiency needs to be improved, especially for longer-term designs, e.g. several months' length.

Accomplishing the objectives of the dissertation above means that it is possible to assert that this thesis has achieved its goal of answering the research question proposed, "*How can teachers be assisted in the design of complex blended learning practices with visual authoring support and design analytics?*" Adhering to LD principles, we have proposed a visual and systematic representational model for complex blended designs together with design analytics and have demonstrated that they can effectively support teachers in the design of complex blended learning approaches, which results in better learning design planning and quality. Lastly, we hope that the design principles generated throughout the DBR process of this dissertation may inspire and support other researchers devoted to advancing the LD field and the development of TEL tools for supporting teachers to become better designers.

Despite DBR being a long-term and concentrated approach to educational inquiry, in line with Goff & Getenet (2017) this thesis has demonstrated that it is also possible to adopt DBR in shorter-term and less intensive studies, such as a doctoral dissertation. Moreover, the publications related to the contents of this dissertation, including three papers – two accepted and one under review – in international JCR-indexed peer-reviewed journals, two in international peer-reviewed journals – one accepted and one under review – and several in international conference and workshop proceedings (see Section 1.4.3), may be considered as indicators of the relevance and originality of our proposals. In the next section we describe the research opportunities that the limitations of our work entail, which is presented as future work.

1.6 Future work

As the previous section has described, this thesis brings relevant and original contributions to the fields of educational technologies and learning design, addressing the support of teachers in the design of complex blended learning approaches with design analytics. However, we encountered several challenges and limitations throughout the DBR process, which are listed below with the aim of guiding for potential future work.

Several limitations of this thesis came from the research approach chosen. DBR requires frequent and prolonged periods of fieldwork, off-set by periods of review, reflection and re-design (Herrington et al., 2007). Using the DBR approach has limited the generalization of the findings in the traditional sense, instead, the use of design principles has allowed a more analytical generalization (Herrington et al., 2007). Moreover, DBR interventions are rarely if ever designed and implemented perfectly; thus, there is always room for improvements in the design and subsequent evaluation. This evolution through multiple iterations is but one of the challenges of the methodology in that it is difficult to know when (or if ever) the research program is completed (Anderson & Shattuck, 2012). Further iterations of the tool are needed in order to keep studying the potential of design analytics in the design process as well their connection with learning and community analytics.

Specifically, further research may explore the following lines of work.

- **Improve the user interface of edCrumble**

By following suggestions gathered through practitioner workshops, future work may consider the improvement of the usability and accessibility of edCrumble. For instance, providing a better and responsive user interface design allowing the access of the tool from multiple devices (smartphones, tablets, etc.). Moreover, the improvements regarding the interface may consider the use of an inclusive design (features, colors, graphs, etc.). However, one of the main objectives that future improvements of the user interface design should address is the reduction of the time needed for designing a course which is one of the main limitations of the current version (especially for long courses, e.g. semester courses).

- **Allow the interoperability of edCrumble outputs with existing educational tools and platforms**

The main limitation of edCrumble is the lack of connection with existing planning tools and delivery platforms that would allow the enactment of the design outputs generated by the tool. Further work may explore the possibilities of facilitating the enactment and orchestration of the edCrumble designs in existing delivery platforms (Virtual Learning Environments, MOOC platforms, etc.). Results from the workshops with high school teachers also indicated that future work may consider connecting the tool with existing planning tools (e.g. Google Calendar) allowing teachers to import and export their lesson plans into and from edCrumble. Future research in this line may study how the provision of interoperability and enactment of the design outputs may have an effect on reducing the design time and facilitating the adoption of the tool by actual teachers.

- **Improve the integration of MOOCs**

Despite some initial work has been done in order to allow the integration of MOOCs into the edCrumble during the design process (Appendix C), further work is necessary to provide a more in-depth integration. Specifically, it would be interesting that future versions of the system allow users to import MOOC courses, but also open educational resources used on MOOCs (e.g. videos, quizzes, interactive activities, etc.).

- **Include artificial intelligent components into the design tool**

Further research may explore the integration of intelligent components into the design tool in order to facilitate the learning design process. Some ideas are listed as follows:

- *Intelligent systems for providing pedagogical design guidance (following known pedagogical models)*. The pedagogical guidance in the current version of edCrumble is based on templates that provide a list of the pedagogical steps to follow in the design in order to implement a certain model. The integration of intelligent guidance components (e.g. using automatic scripts) may facilitate the planning of pedagogical models using the tool and help in their future implementation.
- *Recommender systems that facilitate the selection of the most appropriate learning resources depending on the design*. edCrumble provide an educational resources panel. The selection of the resources during the design process depend on the teachers. Future improvements may consider the implementation of a recommender system that support users in the selection process of the most appropriate learning resources depending on the characteristics of the design. Design analytics provided by the tool could nourish the recommender system by providing information about the current design: educational level, topic, number of students, type of class, etc.
- *Intelligent system that recommend similar designs existing in the platform (successful and not successful) during the design process in order to help users in their design decisions*. Results presented in some of the publications of the current thesis show that teachers appreciate and value having other teachers' ideas and designs. The implementation of a recommender system that facilitate the discovering of relevant designs to the users during the design process could reduce the time of search for designs in the actual edCrumble community, saving teachers' time.
- *Automatic pattern extraction (automatic classifier) of existing designs in the platform*. Further research could explore the use of algorithms for extracting educational patterns of the existing designs in edCrumble. A pattern extraction system or a learning design classifier could nourish above recommender systems but also may help in detecting new pedagogical models arising from a bottom-up approach.

- **Improve and study new possibilities regarding the design analytics (and types of visualizations) provided by the tool**

Further research studies may explore different types of visualizations regarding the design analytics provided by the current version of the tool. It would be interesting to study the effectiveness and usefulness of different types of visualizations as well as to explore the connection of the design analytics with learning and community analytics. Moreover, future work may explore open educational resources containing concept-level metadata, beyond the computer science context where the C7 publication was based on, to extend our study of using concept-level design analytics.

- **Extend the design layers of the visual representation**

Despite the solution proposed by the thesis regarding the visual representation of the blended learning design, which uses two main design layers (in and out-of-class). It would be interesting to study the extension of these two layers by exploring more hybrid layers considering different spaces where the learning design may occur.

1.7 Structure of the dissertation

This section describes the structure of the following chapters of the dissertation. Since the thesis is presented as a compilation of articles, each chapter is composed by several published or submitted for review papers (already listed in the above section 1.4.3). In order to achieve a sense of unity of the whole research work, each chapter contains a short introduction that explains the role of the articles presented in the research process described in the introduction. This thesis format has been followed previously by other researchers with the aim of making the dissertation more enjoyable than the traditional format and fostering the dissemination of the work (Manathunga, 2017; Michos, 2019; Muñoz, 2015). Table 1.4 presents the chapters' titles and an overview of how publications are distributed among the chapters (each of them contains at least one journal article).

Table 1.4. Distribution of the publications among the chapters of the thesis.

Chapter	Title	Publications*
Chapter 2	Teachers' challenges in the design of blended learning.	J1, J4/C1, W1-3
Chapter 3	Conceptual support for designing blended learning.	J2, C3, W4
Chapter 4	Technological support for designing blended learning.	J5, C4, C5
Chapter 5	Design analytics support for designing blended learning.	J3, C7
Appendix A	Are higher education students registering and participating in MOOCs? The case of MiríadaX.	C2
Appendix B	How educators value design analytics for blended learning.	W5
Appendix C	Supporting the planning of hybrid-MOOCs learning designs.	C6
**J: journal article; C: conference proceedings publication; W: workshop paper. (See section 1.4.3)*		

Whereas the second chapter is devoted to the first objective of the thesis (*To study the challenges that teachers face when designing complex blended learning educational practices*), the other chapters address the second objective (*To conceptually and technologically assist the complex blended design processes using authoring support and data analytics*). The appendixes are composed by other articles that complement the research done in some of the chapters. Figure 1.7 shows the general overview of the chapters' structure regarding the research objectives, contributions and evaluation studies of the thesis.

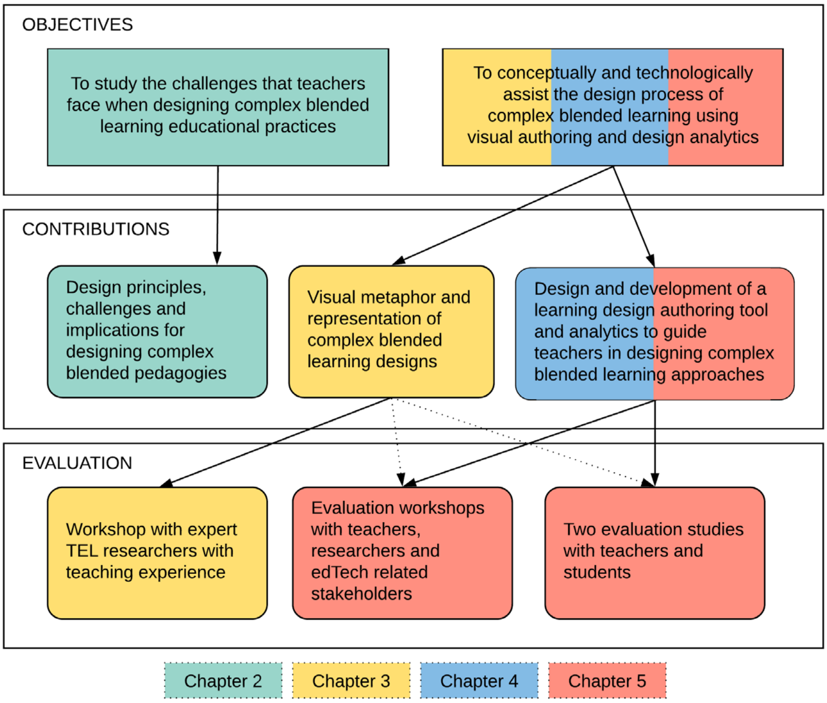

Figure 1.7. General overview of the chapters' structure regarding the research objectives, contributions and evaluation studies of the thesis.

Moreover, figure 1.8 presents the structure of the rest of the document regarding the DBR approach adopted during the thesis, indicating where the chapters and sections are placed in the whole research process. The following is a list providing a brief summary of each chapter's content and its associated sections (each section is an article):

- **Chapter 2:** addresses the thesis' objective of studying the challenges that teachers face when designing complex blended learning educational practices. It presents five research articles which tackle the identification of problem and the preliminary investigation phases of the DBR process:
  - a survey with teachers (W1) to identify the main entry barriers of adopting and designing blended learning approaches using MOOCs (Section 2.1).
  - a quasi-experiment (J1) exploring the design considerations of using mobile devices in collaborative classrooms (S2.2).
  - a case study (J4/C1) of using MOOC videos in f2f classrooms (S2.3).

    - two case studies (W2 and W3) of blended learning scenarios using MOOCs (S2.4 and S2.5).
- **Chapter 3:** addresses the conceptual part of the second objective of the thesis. It presents the conceptualization process of the preliminary design product and design principles: a visual representation model for blended learning designs. It is composed of three papers:
    - the first (W4) is an article that gives an overview of the whole co-creation process followed in the articles presented in chapters 3, 4 and 5 (S3.1);
    - the second (C3) is a preliminary exploration of how to guide teachers in designing blended learning that helped us to conceptualize a first version of the representation (through a workshop with practitioners) (S3.2);
    - whereas the third article (J2) exposes the conceptualization of the visual representation model from the initial proposal until the final model (through a workshop with experts)—which will serve as basis for the first online version of the authoring tool for designing blended learning (S3.3).
- **Chapter 4:** addresses the technological part of the second objective of the thesis. It is composed by three articles:
    - the first (J5) shows the development process of the authoring tool (carried out through participatory design workshops with two school communities) (S4.1);
    - the second (C4) is a demonstration article which briefly describes the final version of the tool (S4.2);
    - and the third (C5) presents the design principles extracted during the development phase (S4.3).
- **Chapter 5:** addresses the evaluation of the product as well as the design analytics as part of the second objective of the thesis. It contains two articles:
    - the first paper (J3) offers a more in-depth description of the authoring tool (and design analytics) as well as it provides a general evaluation of the final product—which is made upon several workshops using different participants: teachers, students and EdTech related stakeholders (S5.1).
    - the second paper (C7) is specifically focused on exploring the value of concept-level design analytics integrated into the authoring tool and evaluating its potentialities (S5.2).

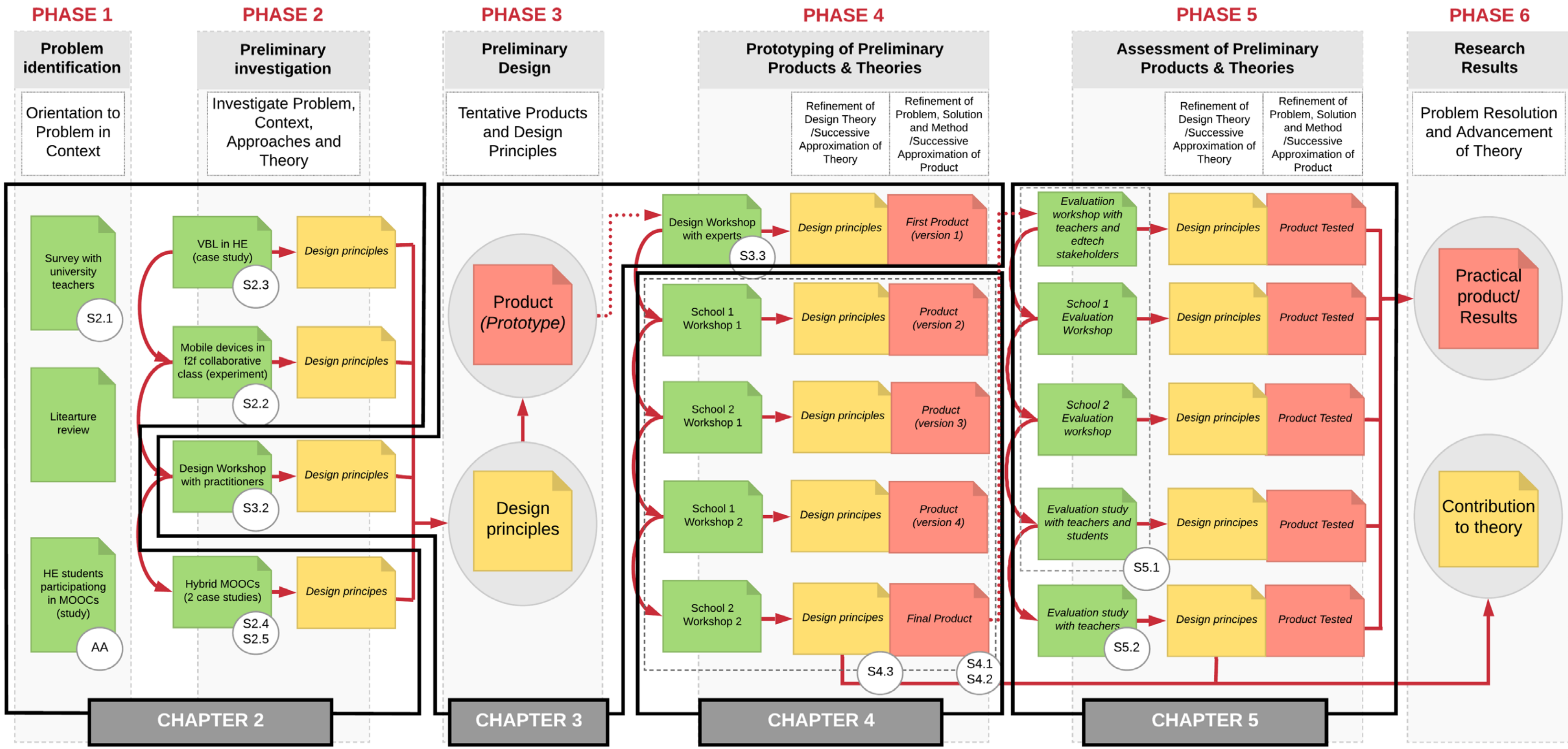

Figure 1.8. Structure of the rest of the document (S: section; A: appendix).

CHAPTER 2

TEACHERS' CHALLENGES IN THE DESIGN OF BLENDED LEARNING

This chapter addresses the thesis' objective of studying the challenges that teachers face when designing complex blended learning educational practices (Figure 2.1). It presents five research articles which tackle the identification of the problem and the preliminary investigation phases of the DBR process (Figure 2.2). In particular, this chapter includes:

- A survey with teachers (W1, see Section 1.4.3) to identify the main entry barriers of adopting and designing blended learning approaches using MOOCs (Section 2.1).
- A quasi-experiment (J1) exploring the design considerations of using mobile devices in collaborative classrooms (Section 2.2).
- A case study (J4/C1) of using MOOC videos in f2f classrooms (Section 2.3).
- Two case studies (W2 and W3) of blended learning scenarios using MOOCs (Section 2.4 and Section 2.5).

An additional study exploring how undergraduate students were taking MOOCs was also carried out during this first phase (C2). This study focused on understanding the profile of undergraduate students participating in MOOCs (on the MOOC platform MiríadaX), their registration, preferred topics, and completion patterns and how they compared to other types of participants. The results of this study were complementary to the main research focus of the thesis, so although we have included it in the DBR scheme in Figure 1.5, we report the research article in Appendix A.

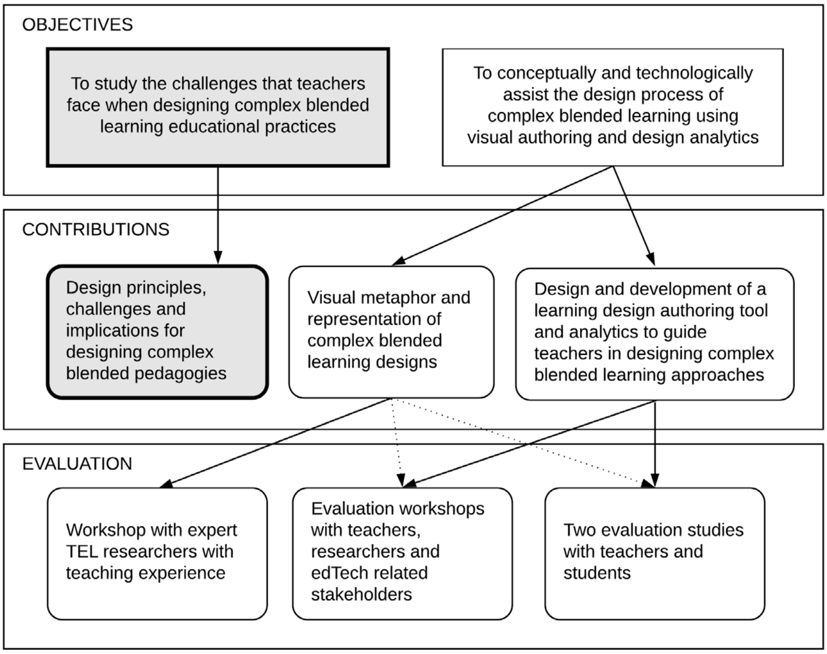

Figure 2.1. Objectives and contributions covered by Chapter 2.

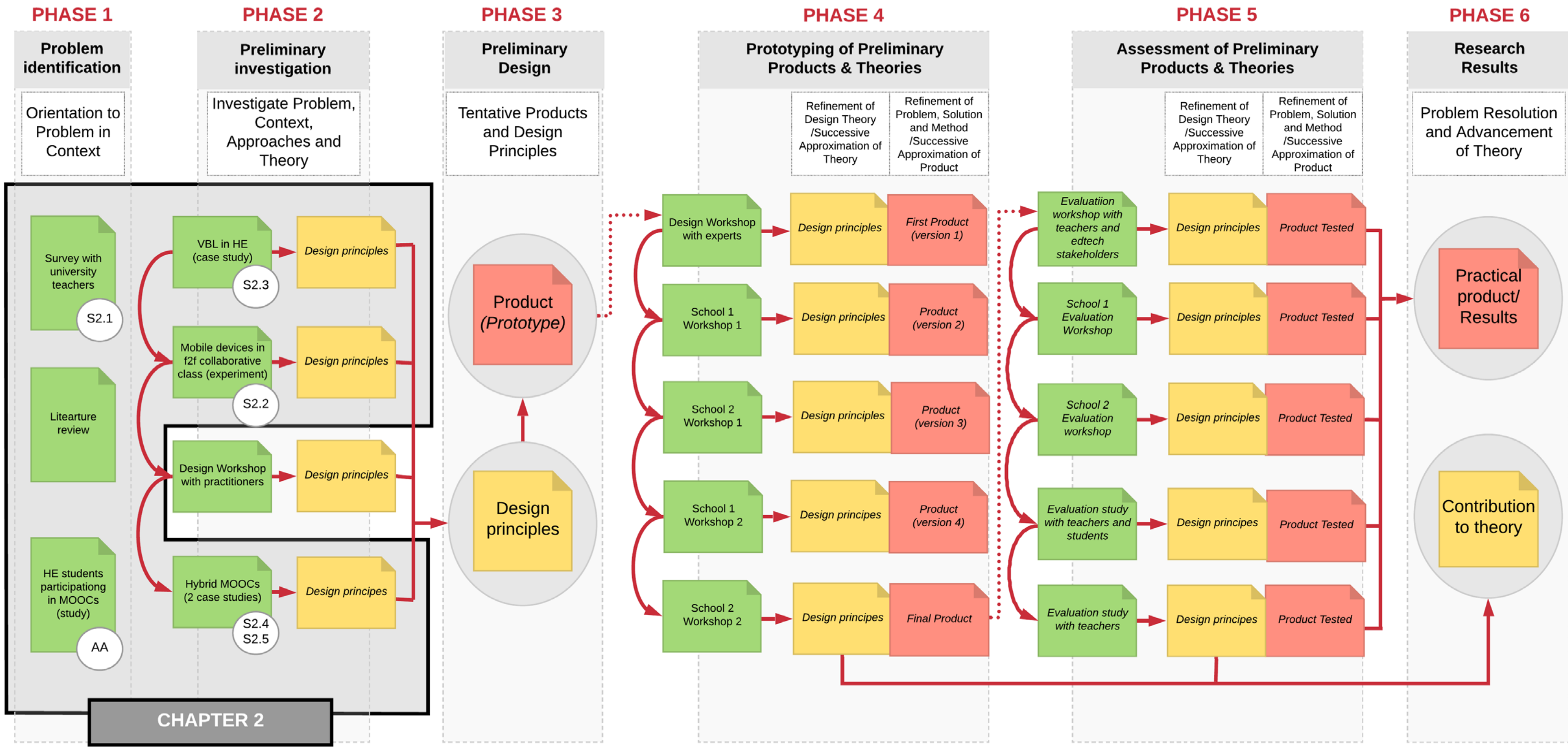

Figure 2.2. Part of the research process covered by Chapter 2.

2.1 Blended MOOCs: university teachers' perspective

The content of this section was presented at the international workshop *HybridEd Workshop: MOOC-based Models for Hybrid Pedagogies* (HybridEd 2015) collocated with the *Tenth European Conference on Technology Enhanced Learning* (EC-TEL 2015) and was published in the following workshops proceedings:

Albó, L., Hernández-Leo, D., & Oliver, M. (2016). Blended MOOCs: University teachers' perspective. In C. Delgado Kloos, P. J. Muñoz-Merino, R. M. Crespo-García, & C. Alario-Hoyos (Eds.), Trends in Digital Education: Selected papers from EC-TEL 2015 Workshops CHANGEE, WAPLA, and HybridEd (Vol. 1599, pp. 11–15). Aachen: CEUR-WS.

Blended MOOCs: university teachers' perspective

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Abstract. Blended Massive Open Online Courses (bMOOCs) have arisen as a blended learning strategy that combines the use of MOOC platform-supported activities and video-based content with in-class face-to-face activities in Higher Education contexts. While first bMOOCs experiences are being reported in the literature, it is unclear which is the general perception of this approach by university teachers. This paper presents a survey study among 43 professors planning or already involved in the creation and use of MOOCs in their institutions. Results indicate a high level of acceptance. Flipped learning is the hybrid methodological approach preferred, but other approaches are also highlighted. Barriers and difficulties are mostly institutional and technological but also pedagogical.

Keywords: MOOCs, Blended Learning, bMOOCs, Blended MOOCs, Higher Education, Methodology, Professors

1 Introduction

Massive Open Online Courses (MOOCs) are playing an important educational role in higher education [1], but further research is needed to assess the quality of these courses and adopt suitable teaching strategies to promote a more personalized and scaffold learning and provide some type of reliably and valid certification [2] [3]. Blended MOOCs (bMOOCs) have recently emerged as an alternative model to merge traditional and online strategies for better teaching and learning in higher education contexts [2]. This new approach uses MOOC content and activities as part of courses also supported by face-to-face (f2f) sessions, leading to diverse types of hybrid methodological combinations. One of them is flipped learning or the flipped classrooms that suggest learners first to view MOOC videos at home and afterwards enacting f2f discussions in class [4]. However, there are several ways of combining f2f and digital learning [5] [6]. Then, each context and learning objectives requires first to identify the best hybrid model that can take advantage MOOCs in effective, efficient, and engaging ways [6]. Moreover it is crucial to explore the acceptance level of this novel methodology by the professors in charge of the course and identify the main entry barriers.

This paper aims to answer four research questions around professors' perception regarding bMOOCs: (RQ1) What is the level of acceptance of this methodology by university teachers? (RQ2) Which are the main barriers to entry? For those who are thinking in using this strategy, (RQ3) which model of bMOOC methodology they plan to use? And (RQ4) which difficulties do they foresee? To answer these questions, the paper reports a survey study that collects the opinion of professors planning or already involved in the creation of MOOCs.

2 Methodology

This study uses a survey research methodology in order to acquire a detailed view of the meaning of the phenomenon for individuals [7]. Participants were university professors and support staff who participated in a specific workshop about MOOCs. The workshop was focused on how to create a MOOC in Open edX environment [8]. Blended learning approaches with MOOCs were not explicitly discussed as part of the workshop. It took place in the Universitat Autònoma de Barcelona, the 19th of May of 2015, in the context of the Catalan universities MOOC platform (UCATx) [9] conference. In total there were 53 participants, 43 of them were thinking of making a MOOC, or they already had developed one. Therefore, the final sample of this study was 43. To collect both quantitative and qualitative data sequentially, it was used an online questionnaire – which was sent to the participants several days in advance of the workshop by email – with open- ended and close-ended questions. Hence, a quantitative and descriptive qualitative data analysis was also applied.

3 Results and Discussion

3.1 Wide acceptance

An important number of the professors – 14 out of the 43 responses (32%) – do plan to use their MOOCs to also support their formal university f2f courses (Table 1). However, in most cases – 17 (40%) –, professors did not consider that, as it will be shown below, due to the novelty of the methodology. Despite that, 100% of the professors who did not consider the blended strategy believe they could use bMOOC in the future – 65% without conditions, 17'5% if the institutional barriers are overcome and 17'5% if the technological barriers disappear –.

The rest of the respondents –12 out of 43 (28%) – did not have f2f classrooms therefore they can not follow the proposed approach. In no case, the use of a blended methodology was rejected after being considered as a possible option. With these results and answering the RQ1, it can be affirmed that bMOOCs are widely accepted by the professors participating in this survey

Table 1. Participants' considerations of using their MOOC as part of their traditional courses.

Have you considered using your MOOC in your f2f classrooms?	#	%
I did not consider this possibility.	17	40
Yes, I will use the MOOC in my f2f classes.	14	32
I do not have access to f2f classrooms.	12	28
I considered this option but finally I will not use it.	0	0

3.2 Main entry barrier: still a very novel approach

Most participants – 10 out of the 17 (60%) – did not consider using bMOOC because they did not think of / know about the possibility of using their MOOC in their f2f classes. The other reason of not considering a blended approach with MOOCs – that 2 of the 17 participants manifested (11'8%) –, was the potential institutional barriers in accepting the introduction of new methodologies in class. Only one participant (6%) of those who did not consider bMOOC, was because of the potential difficulties that can arise when combining different learning platforms, for example, the university platform with MOOC platform. Moreover, one respondent exposed his own answer, which is that she or he conceives MOOCs as external teaching endeavors. In no case, the reason for not taking in consideration the bMOOC approach was due to the perception that students will refuse this methodology or because of the belief that materials prepared for a MOOC are not useful for f2f classrooms. Concerning the RQ2, the main entry barrier identified is the novelty of the methodology. Most of professors do not know the possibility of using their MOOCs in classroom, however, they manifested that they could use it in the future.

3.3 Blended MOOCs implementation and foreseen difficulties

Concerning the percentage of MOOC content which will be used by the professors in the traditional classrooms: in most cases – 6 out of 14 (43%) – all MOOC content will be used as part of the f2f classrooms, whereas 5 out 14 (36%) of professors will use the online content partially. In only 3 cases (21%) they will simply recommend the MOOC as complementary material. In relation to RQ3, flipped classroom approach was the most voted by the respondents (29%) when it was asked to them how will use the MOOC in their traditional classes. A 5% will use the contents in class hours as a support material. Also a 5% will offer the MOOC to the students who fail the course and have to face exam preparation that they will make it a few weeks or months later. Some of the professors (4%) did not still know how they will use the MOOC whereas the same number (4%) will base their f2f classes in their massive open online course.

However, participants who are planning to use their MOOC in a blended approach identified some possible foreseen difficulties (regarding the RQ4). Technological problems: related to MOOC and university platforms, lack of simulation or design activities as well as automatic evaluation related to special subjects as electronics and possible problem to assure reliably evaluation in a continuous assessment. Institutional barriers: budget and low future vision related with innovation processes. Issues related to professors: low institutional support, low motivation and involvement in new learning methodologies and high effort to introduce novel methodologies and produce new high quality content in new formats. Issues related to the students: lack of self-discipline and perseverance in autonomous work. Legal aspects: rights of authorship (images, videos…etc.).

4 Conclusions

Despite being a new blended learning strategy, bMOOCs show a high level of acceptance by the professors. In order to reduce the main entry barrier, related to the novelty of the approach, it could be appropriate to provide guidance and models to the professors to unveil good practices shaping hybrid pedagogies. Further research, with a larger sample and analyzing bMOOCs case studies, is necessary in order to offer deeper insights and understanding. Results also indicate the need for research on how to reduce the technological, pedagogical and institutional problems that appear when implementing bMOOCs in Higher Education.

Acknowledgements

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2.2 Smartphones or laptops in the collaborative classroom? A study of video-based learning in higher education

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Smartphones or laptops in the collaborative classroom? A study of video-based learning in higher education

Laia Albó, Davinia Hernández-Leo & Verónica Moreno Oliver

BEHAVIOUR & INFORMATION TECHNOLOGY
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Smartphones or laptops in the collaborative classroom? A study of video-based learning in higher education

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ABSTRACT
This paper explores how the use of smartphones vs. laptops influences students' engagement, behaviour and experience watching academic videos in a collaborative classroom. Experiments were run in authentic teaching sessions with a total of 483 first-year higher education students. The methodology applied is a quasi-experimental design with post-test-only, being the independent variable, the device used to visualise the academic videos. Results indicate that the use of laptops has provided better results in terms of student's engagement with the videos, their collaborative behaviour and satisfaction with the device. Hence, the findings of this research suggest that the type of mobile device used in activities that consider the use of videos in a collaborative class need to be carefully chosen to maximise the student's comfortability – and in consequence, their engagement with the video-based learning activity and their positive behaviour and experience within the collaborative context.

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KEYWORDS
Video-based learning; computer-supported collaborative learning; higher education; human–computer interaction; smartphones; laptops

1. Introduction

Despite the use of videos has a long history in education, the popularity of Video-Based Learning (VBL) has increased as a result of new forms of online education, most noticeably in the case of Massive Open Online Courses (Giannakos 2013; Yousef, Chatti, and Schroeder 2014). VBL has unique features that make it an effective Technology-Enhanced Learning approach which can improve learning outcomes as well as learner satisfaction given its flexibility and motivational potential (Yousef, Chatti, and Schroeder 2014). Yet, the mere use of videos in class is not an improvement (neither a pedagogy) by itself. Videos are resources that should be considered as supporting material in the application of active teaching and learning methodologies (Blomberg et al. 2014) that are aligned with the requirements of a specific learning situation, considering desired learning goals and the target learner group (Blomberg et al. 2014; Seidel, Blomberg, and Renkl 2013).

In this line, Masats and Dooly (2011) provide a series of coherently integrated video activities to guide future teachers in the design of VBL scenarios. According to the way in which videos are used, authors describe four categories in which VBL experiences can be grouped: video-viewing, video-modelling, video-coaching and video-making. As these experiences (especially those including video-viewing) do not necessarily need to happen in the presence of the educator, their application has led to blended learning designs where the visualisation of videos is proposed to be done outside the classroom and active face-to-face (f2f) activities are suggested for the classroom. This approach has been recently termed as the 'Flipped Classrooms' (FC) – or inverted classrooms – as an instance of the VBL approach that enables saving in-classroom time devoted to the explanation of concepts (Tucker 2012). In the FC model, learners watch video lectures as homework. The class is then turned into an active learning session where the teacher proposes the use of case studies, labs, games, simulations, or experiments to discuss the concepts presented in the video lecture (Herreid and Schiller 2013). In many cases, it is showed that the result of introducing videos in a learning design eventually converges in an FC model. But other researchers have noticed that other models are possible. For example, it is also possible to use videos in a hands-on class as a support tool that encourages a more autonomous, flexible and significant learning during the realisation of practical activities (Albó et al. 2016). In addition, with the advances in technology, higher education is experiencing a change in how VBL resources are delivered (Maniar et al. 2008). Students can visualise the videos with their computers at class or at home but also have the opportunity to do so with their mobile devices: tablets,

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smartphones, laptops, etc. at any place and time. So, with the use of mobile devices, potential learning occurs regardless of location: beyond the space of a brick and mortar course or even beyond the space inside an online course management system (Gikas and Grant 2013).

Yet, on the captious side, research shows that the use of mobile devices in the classroom can be an element of distraction for learning, can reduce quality of f2f interactions and hands-on skills, or create dependency (Anshari et al. 2017). For instance, the use of smartphones in class facilitate multitasking (Grinols and Rajesh 2014), what some studies associate with a decrease of the students' academic performance (Jacobsen and Forste 2011; Lepp, Barkley, and Karpinski 2015). Moreover, some scholars state that mobile phone screens are too small to provide a comfortable learning environment (Wang and Shen 2012). In a study investigating whether the screen size constrains video-based mobile learning, Maniar et al. (2008) reported that physical screen size of a mobile device does influence the learning experience. For example, learners' satisfaction regarding their learning experience differed based on the screen size: in the large and medium screen conditions, students' responses tended to be positive whereas the students' responses in the small screen condition were not entirely positive. Their findings were in agreement with other researchers who suggested that screen size is critical to the success of effective learning (Papanikolaou and Movromoustakos 2006).

More recent research problematises the situation (questioning the current validity of previous research), claiming that we, humans, are getting more used to the use of small screens to support daily-life activities and that smartphones are gaining space in the educational ecosystem as educators and students are showing more and more positive attitudes towards them (Abachi and Muhammad 2014; Al-Emran, Elsherif, and Shaalan 2016; Briz-Ponce et al. 2017; Byrne-Davis et al. 2015; Cheon et al. 2012; Chung, Chen, and Kuo 2015). There is evidence that the use of this technology in class can provide benefits affecting potentially effective learning, such students' motivation, enjoyment, flexibility, consistency, engagement, convenience (Conradie, Lombard, and Moller 2013; Papanikolaou and Movromoustakos 2006; So 2016). While the use of small screens is still recognised to be challenging in the delivery of entire courses, researchers reckon that they are a good option to offer short learning activities (e.g. those based on the visualisation of videos) if the content is adapted to these devices (Alamri et al. 2014).

Therefore, there is a need for further research investigating how the use of different types of devices can impact learning scenarios that employ videos (Conradie, Lombard, and Moller 2013; Lepp, Barkley, and Karpinski 2015) using different pedagogies and learning designs (Conradie, Lombard, and Moller 2013; Gedik et al. 2012; Wang and Shen 2012). This paper is focused on this research line, in particular, it investigates the impact of using smartphones in comparison to the use of laptops to support VBL activities in collaborative classroom scenarios within the engineering teaching context. Whereas there are some studies in the Computer-Supported Collaborative Learning literature that explore the relevance of the group size in a group-based mobile learning (Melero, Hernández-Leo, and Manatunga 2015) and whether interactive groupware interfaces can support small group work in classrooms (Clayphan et al. 2016), no previous study has investigate how the use of different mobile devices influences the students' engagement, behaviour and experience watching academic videos in a collaborative classroom. These types of scenarios have been also underexplored in the VBL literature. Yet, they are especially challenging and interesting, given the collaborative nature of the task and the potential for using one or several devices within a group, and the research questions they trigger around the effects that these types of the devices (smartphones vs. laptops) can cause in student behaviour in this context (Kukulska-Hulme et al. 2009).

The structure of the paper is as follows. Section 2 details the hypothesis of the study and Section 3 describes the methodology. Results are presented in Section 4, followed by a discussion in Section 5. Section 6 closes the paper with the main conclusions of the research.

2. Purpose of the current study

The purpose of this study is to investigate how the use of different mobile devices influences students' engagement, behaviour and experience watching academic videos. Specifically, it aims to compare the use of smartphones versus the use of laptops in the context of the visualisation of videos to support hands-on in-class activities. In order to address this objective, six hypotheses have been stated based on the previous research mentioned above.

Regarding the engagement of students for visualising the videos:

- H1.1. Students using laptops (given their bigger screen sizes) will visualise more videos than those using smartphones.
- H1.2. The number of video visualisations of the students using smartphones will increase through the three years. As students are becoming more used to using mobile devices and the performance of this type of device improves over time.

Regarding the behaviour of the students' visualising the videos:

- H2.1. Students using laptops will tend to visualise the videos completely (full duration) whereas students using smartphones will tend to stop watching videos before they finish.
- H2.2. Students using laptops will tend to visualise the videos in group whereas students using smartphones will tend to visualise the videos individually.

Regarding the students' experience watching the videos:

- H3.1. Students using smartphones would prefer using another device for watching videos more than the students using laptops.
- H3.2. Students using laptops will find videos more useful than students using smartphones.

3. Methodology

This research was conducted using a quasi-experimental design with post-test-only (Creswell 2002). This methodology was considered appropriate because the objective of this investigation was to study a cause-and-effect relationship: whether the use of different mobile devices influences the student's engagement, behaviour and experience watching academic videos. We were able to manipulate the independent variable, the device allowed for visualising the academic videos, which had two categories: smartphone and laptop, to analyse the different outcomes or dependent variables: the effects predicted in the six hypotheses described above in the cause-and-effect equations.

3.1. Participants, sample and treatment conditions

Participants were the students of the course 'Introduction to ICT' of the academic years 2014–2015, 2015–2016 and 2016–2017 (Moreno and Hernández-Leo 2014). This course is a mandatory subject for first-year students of the bachelor's degrees in Computer Engineering, Telecommunications Network Engineering and Audiovisual Systems Engineering at Engineering School of a Spanish university. The course is quarterly and offers a global overview of the university, its resources, the chosen degrees, an introduction to transversal skills and the professional field of ICT engineering. Introduction to ICT has 6 ECTS (European Credit Transfer and Accumulation System) credits corresponding to 150 h of student work, of which 50 are in class sessions. These 50 h are divided into lectures (28 h), medium-group sessions (8 h) and seminar sessions with a small group of students (14 h).

Specifically, the setting for this research was a 2-hour f2f seminar session, of the mentioned course, focused on explicitly addressing the transversal skills of teamwork and oral communication. This seminar implies an individual reading of an article related to problems that typically appear in teamwork; a critical reflection in teams about several questions proposed by the teacher; and finally, an oral presentation in which each team must share with the other classmates the key take-away points of the session. Each seminar session had an average of 14 students and participants worked in teams of 3–5 people.

In the first edition, which corresponds to the academic year 2014–2015, 147 students participated in the experiment. They were divided into 12 seminars resulting in 35 working teams. In the second edition (2015–2016), we had 167 students divided as well as in 12 seminars resulting in 43 teams. Finally, in the third edition (2016–2017), 169 students participated in the study within 11 seminars and 50 teams. This study considers the aggregated data of the three editions therefore the final sample is 483 students – 35 seminars and 128 teams (see Total column in Table 1). The allocation of students to seminar sessions is randomly done by the university secretariat. Team formation within each seminar was freely done by the students. Thus, a quasi-experimental design was considered.

In order to manipulate the treatment conditions, the seminars were divided into two groups randomly: laptops group (during the seminar students were allowed to access the videos only using laptops) and smartphones group (during the seminar students were allowed to access the videos only using smartphones). Table 1 shows the frequencies of participants in each experimental group by academic year. In total, of the 483 students, 233 were in the laptops group condition whereas 250 were in the smartphones group.

3.2. Procedure

Each seminar consisted of a two hours activity about how to improve team work and oral communications skills. This was divided into three main students' tasks (see Figure 1):

(1) Reading (individual – 10 min): each student had to read a short article about the main challenges of teamwork. The teacher delivered copies of the article to the students on paper together with the description of the seminar activity.
(2) Collaborative discussion and presentation preparation (in teams – 40 min): the first 20 min

Table 1. Participants' sample of the experiment.

Ed.	Academic year	Laptops group (Freq.)			Smartphones group (Freq.)			Total (Freq.)		
		Seminars	Teams	Students	Seminars	Teams	Students	Seminars	Teams	Students
1	2014–2015	6	16	65	6	19	82	12	35	147
2	2015–2016	6	23	95	6	20	72	12	43	167
3	2016–2017	5	21	73	6	29	96	11	50	169
Total		17	60	233	18	68	250	35	128	483

students had to work in teams and discuss possible answers to five questions regarding the article – which was posted by the teacher in the seminar description document. During the last 20 min of this task, each team had to summarise the key points of the discussion preparing a four-seven minutes presentation. To support the discussion and prepare the presentation, the teacher recommended watching four academic videos: two of them were related to how to support teamwork (useful to find answers to the proposed questions related to the article read); whereas the other two were related to the oral communication skills (with hints about how to prepare a good oral presentation). Watching the recommended videos was optional: students could decide by themselves whether watching the videos (and which ones and when) or not. The videos lasted between 1.5 and 4.5 min. Watching the whole four videos would take about 12 min (out of 40 min which would require the activity – the 30% of the total time allocated for doing the activity).

(3) Presentation (in teams – 60 min): each team had to do the final presentation (4 min) – in which the participation of all the team members was mandatory – in front of all the other students of the seminar. Finally, the teacher gave feedback to each team after their presentations.

At the beginning of the session, before starting the three activities described above, the teacher showed in a classroom projection where they could find the videos. Moreover, she wrote on the board the name of the recommended videos for the session. She also highlighted that all the videos had subtitles and transcriptions in the three official languages of the university (Catalan, Spanish and English). Finally, she asked the students to form the teams (between three and five people). The videos used in the experiment were recorded and edited by a team of technicians from the university together with the academic team of the subject. The translations of the videos were done by a professional translator and reviewed by two experts in the content ensuring that the quality of the videos was the same regardless of the language.

Some days before the seminars, the teacher sent an email to the students asking them to bring their own devices to that particular seminar session. Moreover, the teacher always had three auxiliary laptops in case there were teams without their own devices. At the beginning of the session, after introducing the videos, the teacher asked participants to only use one device to visualise them (laptop or smartphone, depending on the condition associated to the particular seminar). Students did not know what the activity would be until they got to class to ensure that no participant was more prepared than other. In addition, the two groups received the same introduction at the beginning of the activity. Finally, all teams from all seminars and experiment groups (laptops and smartphones) had as minimum one device available for participating on the activity. Table 2 shows the number of available devices per teams depending on the device used and experiment edition (data obtained by the observations in class, described in the next section of this article).

3.3. Instrumentation, data collection, analysis and threads to validity

This study used three instruments to gather the data from the field: an observation protocol, automatic registers from the videos in YouTube and a questionnaire (see Figure 1).

During each seminar, at least one researcher was observing the participants whereas they were doing the second task, with the main objective of observing how

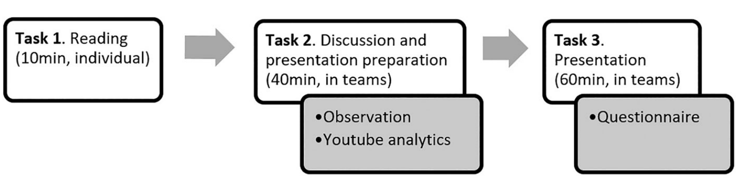


Figure 1. Main tasks of the 2 h seminar and their associated research instruments.

Table 2. Number of available devices per teams depending on the experimental group.

		Laptops group				Smartphones group			
Ed.	Academic year	Teams (Freq.)	Students per Team (in average)	Available devices (Freq.)	Available devices per team (in average)	Teams (Freq.)	Students per team (in average)	Available devices (Freq.)	Available devices per team (in average)
1	2014–2015	16	4.0	18	1.2	19	4.3	51	2.7
2	2015–2016	23	4.1	41	1.8	20	3.6	46	2.3
3	2016–2017	21	3.5	36	1.7	29	3.3	63	2.2
Total		60	3.8	95	1.6	68	3.7	160	2.4

students were interacting with the videos through the devices (laptops or smartphones). The observers participating in this study were trained by the main researchers using an observation protocol. This served as a guide during the observations since it divided the occurrences to observe depending on its priority: high, medium or low (see Table 3).

All the visualisations were registered by the video hosting service (YouTube) including the date, time, location and the device used to visualise the videos. Furthermore, at the end of the activity, the teacher delivered a questionnaire to gather data from the participants regarding their use of the videos during the activity. In particular, the most relevant questions were the following:

(1) How many videos did you visualise?
(2) Have you watched all the videos completely? If you have not watched or watched only some of the videos, specify the reason.
(3) Would you like to watch the videos in another device? (Yes. Which? / No / I don't know)
(4) How did you organise yourselves within the team to watch the videos? (Using a single device to watch the videos all together/Using more than one device – equally distributed/Each team member watched the videos on their own)
(5) Indicate your level of agreement with the following statement (1 being lowest and 4 being highest): I found the videos useful to develop the session's task.

Table 3. List of occurrences to observe depending on its priority.

Level of priority	Occurrence to observe
High	How students were watching the videos: - Individually - With one or more members of the working team - With pairs - They do not watch the videos - With a high volume or with headphones - *Others* Level of concentration during the visualisation: - They watch the entire video in silence - They discuss the video whereas they are watching it - *Others*
Medium	The interaction between the different working teams: - They discuss or share information about the videos with the members of other working teams - They share doubts with the members of other teams - *Others*

Low	Interaction between the students and the teacher:
	- What type of questions they ask to the teacher
	  - Related with the content
	  - Related with doubts about the activity's performance
	  - *Others*

Participants were assured that data collection, storage, and reporting would guarantee confidentiality and anonymity; they gave their informed consent for participation. The analysis of the data was done by using mixed methods design with convergent parallel design (Creswell 2002). The statistical test chosen was a group comparison statistic. Specifically, the Mann–Whitney *U* test was used to examine differences in engagement, behaviour and experience between students using laptops and those using smartphones (as the sample was not normally distributed). Moreover, an ANOVA test was performed to examine the differences between the three editions of the experiment regarding the number of visualisations in the case of the smartphones group. All the statistics were implemented using SPSS software for Windows (IBM SPSS Statistics, version 23).

Triangulation was used to compensate the threats that the quasi-experimental approach introduces to internal validity (Creswell 2002). Furthermore, since observers may become more experienced during the time, it was used as a strong observation protocol and training. However, despite the external validity is major in quasi-experiment research than in true experiments (as it occurs in real contexts rather than artificial approaches) (Creswell 2002) and the sample used was high (483 students), it has to be taken into account that this study has been implemented within a specific context that add limitations to the generalisation of the results: participants were engineering students of a first-year graduate programme in a public Spanish university.

At the same time, this sample's homogeneity allowed a better control for the characteristics of participants that might influence the relationship between the independent and dependent variables minimising the external factors in the experiment. Other extraneous variables identified (as can be the time of the seminar's sessions and the type of classrooms used) were affecting equally to whole sample. All the seminars were happening in random time slots during the morning (between the 8:30am and the 2:30pm) as well as both experimental groups had the seminars randomly in three different type of classrooms: with fix tables and chairs, with mobile tables and chairs and with mobile chair-desks. Finally, the teacher in charge was the same person for all seminars during all the three editions. She participated as an additional researcher in the experiment and helped in monitoring the process closely so that the threats to internal validity were minimised.

4. Results

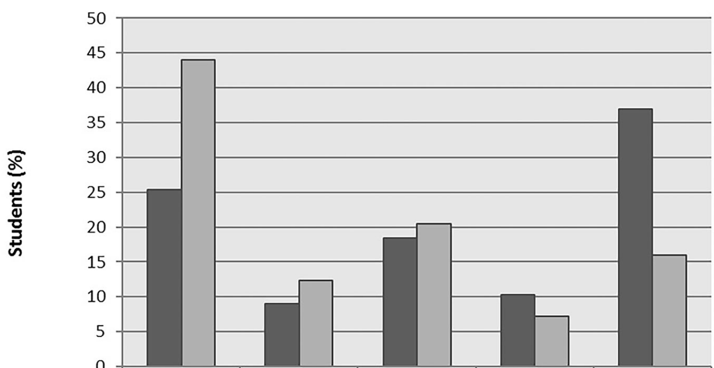
The results obtained in this study are analysed considering three different perspectives: (a) students' engagement watching the videos (i.e. number the videos watched per student/working team depending on the device used); (b) their behaviour watching the videos (i.e. duration of the visualisations or working teams' organisation); and their experience's valuation (i.e. satisfaction with the device used or the perception of the videos' usefulness).

4.1. Students' engagement watching the videos

An indicator of students' engagement with the use of videos is the number of videos they (decided to and) actually watched during the activity. Figure 2 shows the results from the questionnaires regarding the number of videos watched by the students depending on the device used. Results indicate that students using laptops ($n = 233$, mean = 2.24, sd = 1.623) watched more videos than students using smartphones ($n = 250$, mean = 1.39, sd = 1.493) – students using laptops watched 2.24 videos (in average) whereas students using smartphones watched 1.39 videos (the significance of this result was checked using the Mann–Whitney U test with a resulting $p < .05$, Cohen's d = 0.54). The major differences can be seen at the extremes of the graph where 44.0% of the students using smartphones did not watch any video whereas in the case of the laptops group it is only 25.3%. However, 36.9% of the students using laptops watched the four recommended videos while in the case of the smartphones group it was only 16.0%.

The above finding is supported by the results obtained from the observations in class. In Figure 3 it can be seen the number of videos watched by the teams depending on the device used. Similar than in the previous results, teams using laptops were observed watching more videos than those using smartphones (means of 1.70 and 1.09 respectively, being a significant result, checked using the Mann–Whitney U test with a resulting $p < .05$, Cohen's $d = 0.48$). According to these direct observations by researchers, 45.6% of the teams that were using smartphones did not watch any video whereas this was only observed in 25.9% of the teams using laptops. However, 33.3% of the teams using laptops watched more than two videos in contrast to the 13.3% observed in the case of teams using smartphones.

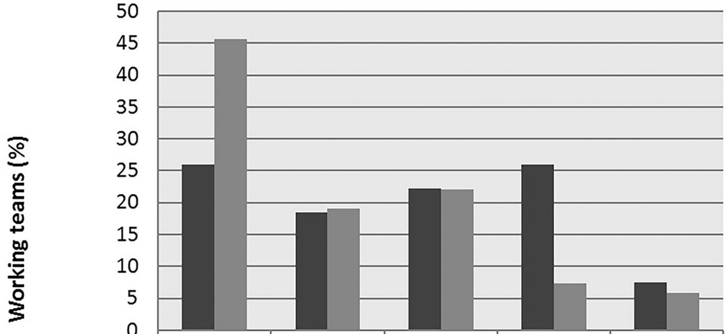
Data obtained from YouTube analytics was not considered for comparing the number of videos watched depending on the device used with the above results from the other sources (observations and questionnaire' responses) because it was not possible to distinguish if



	0	1	2	3	4
Laptops	25,3	9,0	18,5	10,3	36,9
Smartphones	44,0	12,4	20,4	7,2	16,0

Videos watched

Figure 2. Number of videos watched by the students depending on the device used. Results from the questionnaire: Laptops, $n = 233$, mean = 2.24, sd = 1.623 – Smartphones, $n = 250$, mean = 1.39, sd = 1.493 (Mann–Whitney U, $p < .05$, Cohen's $d = 0.54$).



	0	1	2	3	4
Laptops	25,9	18,5	22,2	25,9	7,4
Smartphones	45,6	19,1	22,1	7,4	5,9

Figure 3. Number of videos watched from the working teams depending on the device used. Results from the observations: Laptops, $n = 54$, mean = 1.70, sd = 1.312 – Smartphones, $n = 68$, mean = 1.09, sd = 1.231 (Mann–Whitney U, $p < .05$, Cohen's $d = 0.48$).

visualisations were individual or in teams. Despite this limitation, if we look at the number of total views (referring to all videos) during the laptops' sessions, there were 190 views; whereas during the smartphones' sessions there were 140 views. Moreover, if we look at the visualisation time, the overall minutes students watched in total was 384 min during the laptops' seminars whereas in the smartphones group the overall minutes watched from the all videos were 296 min.

When participants were asked in the questionnaire about the reasons why they did not watch the videos, most of the participants who did not watch any video stated that it was because they were prioritising preparing the task itself (an oral presentation) instead of watching the videos (80% in the case of laptops group and 53% in the smartphones group). The second reason expressed in both groups was that they did not find necessary the visualisation of the videos to perform the task (10% in the case of laptops group and 15% in the smartphones group). Of those using smartphones, the third reason expressed (13%) was related to having technical problems for watching the videos (especially with the Internet connection). Moreover, 9% of them stated that they forgot watching the videos because they were focused on doing the activity. Other reasons that were given in the case of the smartphones group include: they did not find the device comfortable enough to watch the videos, they found the subtitles were too small to read (even more when they were sharing the device), they did not have headphones and that the screen was too small.

Within the smartphones group, it is interesting to visualise the number of videos watched in average depending on the academic year (Figure 4) in order to check whether this number has been increased as the hypothesis H1.2 suggested. Despite results show a trend of increasing numbers of videos watched per student through the years (sample sizes of 82, 72 and 96; means of 1.24, 1.32 and 1.56; standard deviation of 1.384, 1.471 and 1.595), the result is not statistically significant (checked using an ANOVA test with a resulting $p > .05$, $n^2 = 0.009$). This result was supported by the data obtained from the observations in class and the YouTube analytics.

4.2 Students' behaviour watching the videos

The questionnaire included two questions regarding student's behaviour watching the videos. The first one was about the completeness of the visualisations, whether they had watched the videos from the beginning to the end or just part of the videos. In particular, the question was 'Have you watched all the videos completely?' and the possible answers to choose were 'No', 'Only some of them' and 'Yes, all of them'. Results are presented in Figure 5 and the difference between the means for the two experimental groups was statistically significant (tested using Mann–Whitney U test, $p < .05$, Cohen's $d = 0.44$): students using laptops ($n = 172$, mean = 2.56, sd = 0.623) visualised more videos in their whole duration than those using smartphones ($n = 138$, mean = 2.28, sd = 0.637).

Most of the students using laptops (63.4%) stated that they watched all the videos completely while most of the students in the smartphones group (52.2%) only watched completely some of them. In any case, somehow surprisingly, there was an important percentage of students

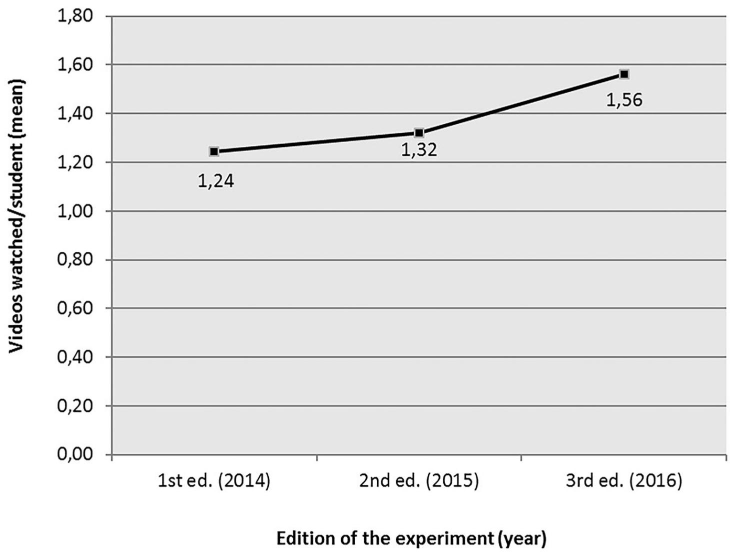


Figure 4. Mean of number of videos watched per student within the smartphones group depending on the experiment's edition (academic year). Results from the questionnaire: $n1 = 82$, $n2 = 72$, $n3 = 96$ (ANOVA $p > .05$, $n^2 = 0.009$).

using smartphones (37.7%) that watched all the videos completely.

The second question related to the organisation of the teams when it came to visualise the videos. Results indicate that there is a significant difference between the laptops and the smartphones groups (checked with the Mann–Whitney U test, $p < .05$, Cohen's $d = 0.34$). The first tend to watch the videos in teams (sharing the device/s) whereas in the second this happens in much less frequently (see Figure 6). The different answers were coded in order to compare the means of the two groups as follows: one device per working team was coded with a 1; more than one device per working team with a 2; and one device per each member of the team with a 3. The resulting means were 1.29 in the laptops group (sd = 0.537) and 1.51 in the smartphones group (sd = 0.744). Despite the difference, a somehow surprising percentage of students using smartphones (64.3%) shared one device between 3 and 5 people.

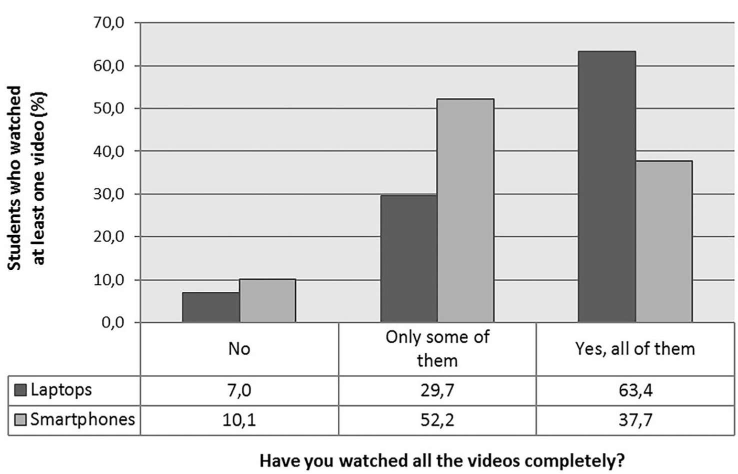


Figure 5. Frequency of videos watched completely depending on the device used. Results from the questionnaire: Laptops, $n = 172$, mean = 2.56, sd = 0.623 – Smartphones, $n = 138$, mean = 2.28, sd = 0.637 (Mann–Whitney U, $p < .05$, Cohen's $d = 0.44$).

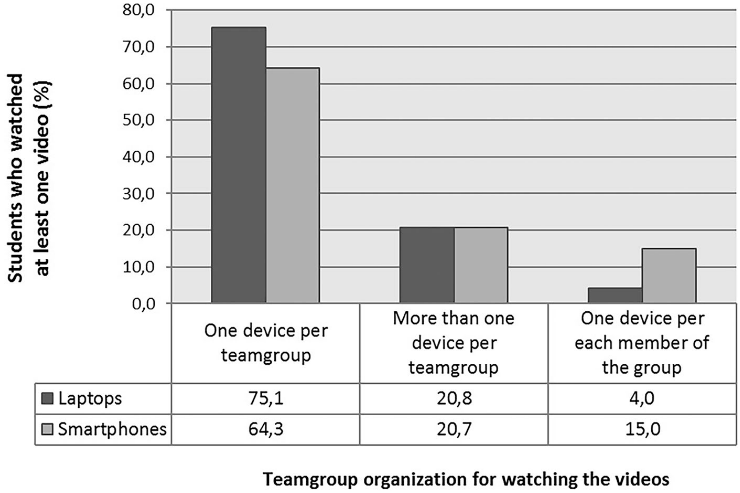


Figure 6. Working teams' organisation for watching the videos depending on the device used. Results from the questionnaire: Laptops, $n = 173$, mean = 1.29, sd = 0.537 – Smartphones, $n = 140$, mean = 1.51, sd = 0.744 (Mann–Whitney U, $p < .05$, Cohen's $d = 0.34$).

Above results were supported by the results obtained from classroom observations, being the differences between the experimental groups statistically significant in both cases as well (the completeness of the visualisations and the teams' organisation for watching the videos).

4.3. Students' experience watching the videos

In order to evaluate the students' experience of using videos during the activity, they had the opportunity to express whether they would prefer using another device than the laptop or the smartphone (depending on the group) in the questionnaire. Moreover, they could indicate whether they found the videos useful to develop the second task.

Regarding the preference of using another device, results show a significant difference between the two groups (see Figure 7). More than half of the students that used laptops (55.5%) stated that they would not have preferred using another device for watching the videos whereas 23.1% of them stated that they would. The numbers are reversed for the case of students

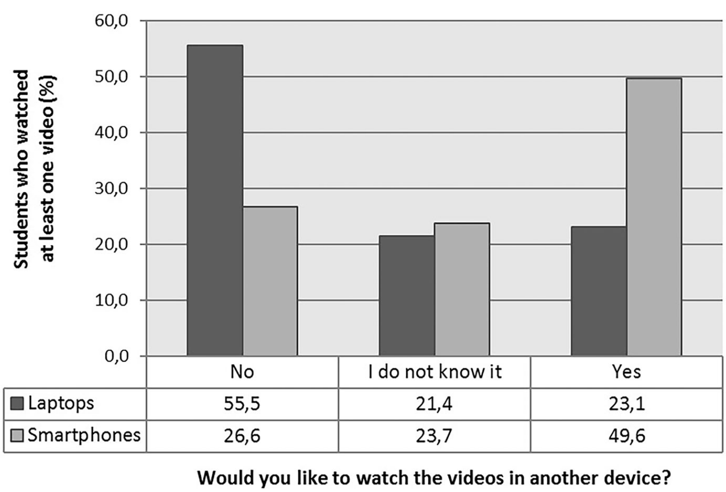


Figure 7. Preference for watching the videos with another device depending on the device used. Results from the questionnaire: Laptops, $n = 173$, mean = 1.68, sd = 0.828 – Smartphones, $n = 139$, mean = 2.23, sd = 0.845 (Mann–Whitney U, $p < .05$, Cohen's $d = 0.66$).

that used smartphones: 26.6% of them indicated they liked the device used to watch the videos and would not have preferred using another device, but 49.6% expressed their preference of using another device. The answers to the question 'Would you like to watch the videos in another device?' were coded as follows: 'No' with a 1, 'I do not know it' with a 2 and 'Yes' with a 3. Statistically, there was a significant difference between the two group (mean = 1.68, sd = 0.828 in laptops group; and mean = 2.23, sd = 0.845 in the smartphones one) tested with the Mann–Whitney *U* test ($p < .05$, Cohen's $d = 0.66$).

Of those 23.1% that used laptops and would have preferred watching the videos in another device: 74% would have preferred watching the video with the class projector, 22% with a smartphone and 4% with a tablet. Of those 49.6% that used smartphones and would have preferred watching the videos in another device: 44% would have preferred watching the video with a laptop/pc, 39% with a class projector and 17% with a tablet.

When participants were asked about their level of agreement with the statement 'I found the videos useful to develop the session's task', results were more positive in the case of the laptops group (see Figure 8). Half of the participants (51%) that used laptops chose the highest level (4) and 40% chose the third level (3). Regarding the results of the smartphones group, only 35% chose the maximum level (4) of agreement while 43% chose the third one (3). Moreover, 22% of the students using smartphones expressed low levels of agreement (1 or 2) while in the case of those that used laptops this only happened for the 9% of the students.

Despite these significant differences, results indicate a general satisfaction regarding the utility of videos to develop the session's task.

5. Discussion

Results reported above support the assumption that the type of mobile device used for watching the videos (laptops or smartphones) affects participants' engagement, behaviour and overall collaborative VBL classroom experience. It was hypothesised that participants using laptops would be more engaged with the videos than those using smartphones. This hypothesis (H1.1) is confirmed, as the number of visualisations of the students that used laptops was significantly higher than those that used smartphones. Comments from participants suggest that having a bigger screen than a smartphone (i.e. laptops' screens), offers more comfort for watching audio-visual content, especially in collaborative learning contexts. Despite this result, it is important to note that 25% of the students in the laptops group decided not to watch videos, mainly due to time constraints. Hence, results suggest that the activities that involve the use of videos must be carefully designed in order to provide sufficient time flexibility for the students to take advantage of this type of resources. These results are in line with Masats and Dooly (2011, 1159), who stated that 'the way in which the video use is embedded within other tasks is relevant to the eventual teaching and learning'.

The study shows a trend of increasing numbers of visualisations in smartphones (H1.2) along the three academic years in which this experimentation was conducted. However, the difference between the numbers

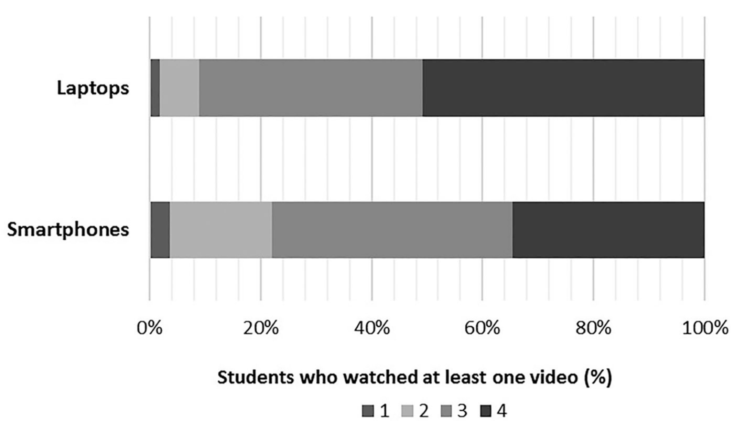


Figure 8. Level of agreement with the statement 'I found the videos useful to develop the session's task' (1 being the lowest and 4 being the highest). Results from the questionnaire: Laptops, $n = 169$ – Smartphones, $n = 136$.

of videos' visualisations along the experiment editions (academic years) is not statistically significant. Further work extending the experimentation along additional academic years would help to better understand whether the smartphones comfortability (in terms of screen size and network connections) will increase in the next years – affecting more significantly students' engagement. Since other researchers pointed out, the screen size can be a problem due to the human visual perception limits, as the attention can be affected depending on the small detail it can be seen (Chen et al. 2003).

Results confirm hypotheses H2.1 and H2.2. Data shows that the type of mobile device used for watching the videos affects students' behaviour during the visualisations. Students that watched the videos using laptops tended to visualise them more completely and in teams than those that used smartphones. A possible explanation for this may be (again) the comfortability of the mobile device, especially related with the size of their screen (usually, being the laptops' screens bigger than the smartphones' screens). However, the percentages of students in the smartphones' groups that watched all the videos completely (37.7%) and were sharing their devices (64.3%, one device per team; 20.7%, more than one device per team) were somehow surprisingly high. Although it may seem difficult to share a smartphone between 4 and 5 people, students found strategies to do it – for instance, physically supporting the smartphone on top of a case (or any other object) and raising the video's volume (or activating the subtitles). Another common case observed was the smartphone shared by a couple of students that also were sharing headphones (a headset cable for each). In fact, the video's audio was a challenge for both experimental groups. While listening videos with a high volume allowed sharing devices, it was at the same time an inconvenient for the other teams in the class (as the different teams' audios could interfere between them making it difficult content understanding for each team). The solutions that students found were (mainly) two: the use of headphones, which it was restricting the sharing of the device to only two students; or the use of subtitles, which in the case of laptops is easier as their screen was bigger. Therefore, as it was suggested by Wang and Shen (2012, 571), 'multimedia mobile content should be carefully chosen to cover all the possible circumstances of the learner'. Nevertheless, results point out that (for now) laptops are a better option than smartphones in case of collaborative activities implying visualisation of videos.

Finally, results also confirm hypotheses H3.1 and H3.2. With respect to hypothesis H3.1, it was found that students with smartphones would prefer using another device to watch the videos (more than those using laptops) – especially laptops or projectors. The type of device used also affected students' perception of videos' usability. Students that felt more comfortable with their device (laptops group) found the videos more useful for developing the proposed task (H3.2). Therefore, it can be stated that the type of the mobile device used during the collaborative activity actually influenced the students' learning experience. Results are aligned with Maniar et al. (2008) who state that firstly, physical screen size of a mobile device does influence learning. And secondly, and even more notable, that the perception of usability can have a direct influence on the acceptance of mobile learning.

6. Conclusions

The aim of the present research was to investigate how the use of different mobile devices (specifically, laptops versus smartphones) influences students' engagement, behaviour and experience when watching academic videos to support collaborative learning activities in the classroom. The study has shown that the use of laptops provides more positive results (than when using smartphones) in terms of students' engagement with the videos, collaborative behaviours and the overall Video-Based Learning experience. The findings suggest that the type of mobile device used in collaborative learning activities that consider the use of videos need to be carefully chosen in order to maximise students' and groups' comfortability. However, the results also show positive trends along the academic years regarding the potential of smartphones to reach important levels of engagement and user satisfaction. Future research should continue monitoring this evolution as well as consider similar experimentation in the frame of other contexts, pedagogies and learning designs that apply VBL.

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2.3 Video-Based Learning in Higher Education: the Flipped or the Hands-on Classroom?

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Video-Based Learning in Higher Education: The Flipped or the Hands-on Classroom?

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Abstract

Higher Education is adopting new ways of teaching, such as Video-Based Learning (VBL) approaches, with the aim of moving away from traditional classroom methodologies towards enhanced learning. The most broadly known method that uses video as a tool for learning is Flipped Classroom. In many cases, the result of introducing videos in a learning design eventually converges in this type of methodology. This research presents a case study that uses a combination of VBL and Project-Based Learning methodologies. The course is face-to-face but there are no lectures; students develop small projects in labs. A set of teaching explanations is recorded in videos provided together with the descriptions of the projects. The objective of this research is to study the behaviour and satisfaction of the students using the videos, their utility as well as the position of the professors. The study was conducted following a mixed methodology, using five different instruments to gather qualitative and quantitative data. Results indicate that the use of video-based learning may not necessarily converge in the use of the flipped classroom methodology. Videos can be used during a hands-on classroom as a support tool that encourages a more autonomous, flexible and significant learning.

Abstract in Spanish

La Educación Superior está adoptando nuevas formas de enseñanza, tales como los enfoques de Aprendizaje Basado en el uso de Videos (VBL), con el objetivo de mejorar las metodologías tradicionalmente utilizadas en el aula. El método más conocido que utiliza el vídeo como una herramienta para el aprendizaje es la clase invertida (Flipped Classroom). En muchos casos, el resultado de la introducción de vídeos en un diseño de aprendizaje converge eventualmente en este tipo de metodología. Esta investigación presenta un estudio de caso que utiliza una combinación de VBL y la metodología de aprendizaje basado en proyectos. El curso es presencial pero no hay clases teóricas. Los alumnos desarrollan pequeños proyectos en el aula. Juntamente con las descripciones de los proyectos a realizar, el alumnado tiene a su disponibilidad un conjunto de vídeos didácticos que pueden consultar durante el curso. El objetivo de esta investigación es estudiar el comportamiento, la utilidad y la satisfacción de los estudiantes en relación al uso de vídeos, así como la posición de los profesores. El estudio se realizó siguiendo una metodología mixta, utilizando cinco instrumentos de recogida de datos cualitativos y cuantitativos. Los resultados indican que el uso del aprendizaje basado en vídeos puede no necesariamente implicar una metodología del aula invertida. También es posible que los alumnos decidan utilizar los vídeos durante las clases prácticas como una herramienta de soporte, fomentándose un aprendizaje más autónomo, flexible y significativo.

Keywords: video-based learning, VBL, flipped classroom, FC, higher education

Introduction

Nowadays Higher Education is adopting new ways of teaching such as ways of Video-Based Learning (VBL) with the aim of moving away from the traditional classrooms. Video lectures have been growing in popularity and their use is increasing both inside and outside classrooms (Giannakos, 2013). “Many higher education institutions and educational technology companies are using them as a main of self-study medium or as tool to enhance the learning process” (Vieira, Lopes, & Soares, 2014).

Despite VBL has a long history as a learning method in educational classes in the past decade, the interest in VBL has increased as a result of new forms of online education, most prominently in the case of Massive Open Online Courses (MOOCs) (Yousef, Chatti, & Schroeder, 2014). VBL has unique features that make it an effective Technology-Enhanced Learning (TEL) approach. Furthermore it seems to support a rich and powerful model to improve learning outcomes as well as learner satisfaction (2014).

Despite this, it is important to note that the mere use of videos in class is not by itself an improvement, since it is necessary to choose an appropriate instructional approach when designing VBL environments (Seidel, Blomberg, & Renkl, 2013). One of the latest methods that use video as a tool for learning is Flipped Classrooms – or inverted classrooms – and, in many cases, it is showed that the result of introducing videos in a learning design eventually converges in this type of methodology.

Flipped Classrooms

The flipped classroom is an instance of VBL model that enables to save time in the classroom by discussing only difficulties, problems, and practical aspects of the learning course (Tucker, 2012). In the flipped classroom model, learners watch video lectures as homework. The class is then an active learning session where the teacher use case studies, labs, games, simulations, or experiments to discuss the concepts presented in the video lecture (Herreid & Schiller, 2013).

Regarding learning theories, Lowell et al. (2013) suggest that flipped classrooms represent a unique combination of these theories once thought to be incompatible. Firstly, active, problem-based learning activities founded upon a constructivist ideology and then instructional lectures derived from direct instruction methods founded upon behaviourist principles. Despite of this, Mason et al. (2013) add that an inverted classroom can play a key role in a modern engineering education by freeing time for learner-centred activities and encouraging students to become independent self-learners. The question that our study lays out here is whether a student-based learning system without using inverted classroom would do emerge unexplored students behaviours.

Effectiveness of VBL and Teaching Methods

The analysis of the VBL research of Yousef, Chatti and Schroeder (2014) showed mixed results in terms of learning outcomes in VBL environments. Despite possible advantages as the high user's rate interaction and learner satisfaction in VBL environments comparing to traditional classroom environments, authors pointed out that several aspects concerning effectiveness in VBL need further investigation:

1. What are the positive and negative attitudes towards using video lectures?
2. How can VBL motivate learners?
3. How can a MOOC as VBL environment personalize the learning experience for learners?

Seems that, a way to improve the effectiveness of the learning experience – with videos or not – is to provide students with a greater degree of freedom to select the educational resources and the learning style that meets their characteristics best. But instead, the previous study showed that most of the reviewed VBL studies followed a teacher-centred approach and only 15% of studies focused on student-centred learning.

According to this, authors denoted that additional research is needed to investigate the benefits of new ways of VBL based on new concepts such as personal learning environments (Greenberg & Zanetis, 2012) and networked learning.

Purpose of Current Study

To explore this context, this research presents a case study that use a combination of the VBL and Project-Based Learning (PBL) methodologies. The classes are face-to-face but there are no lessons: the students develop small projects in labs. A set of teaching explanations are recorded in videos provided together with the descriptions of the projects. The objective of this research is to study the behaviour and satisfaction of the students using the videos, their utility as well as the position of the professors.

Methodology

This research was conducted using a mixed methodology, an option that was considered appropriate because we were faced with complex processes such as behaviour (Creswell, 2005). In the next paragraphs it will be introduced the context of the study as well as the instrumentation, data collection and analysis.

Participants and Sample

Participants were the students of the course "Wireless sensor networks". This was designed as an optional subject in the 3rd and 4th year of the Bachelor Degrees in Computer Engineering, Electronic Engineering and Audio-visual Systems Engineering within the Engineering School of the Universitat Pompeu Fabra (UPF).

The course is quarterly and with a load of about 100 hours of study per student. It took place in April to June of 2014 and the number of students enrolled for that academic year was 17, of which there were only 3 girls. In class the students worked in groups of 2-3 people, specifically there were four groups of two and three groups of three. Two professors were in charge of the course, one of them acting as a coordinator and other as a teaching assistant.

The sampling technique used was not probabilistic due to the participation in the course was not random. The participants were the units available to the investigator: the students enrolled in the course, so the samples of the study are accidental and therefore biased. Hence, there is no guarantee that they represent the entire population to which they belong. Moreover, the size of the sample, as mentioned before, is 17 people and it will not be enough to draw general conclusions. These two issues must be taken into account in the possible generalization of the results (Yin, 2009). However, the main purpose of the study is to have the maximum guarantees to be able to set affirmations from the field work. The aim of this research is not to maximize external validity – generalization to the population reference –, the intention is to maximize internal validity since it is a case study (Yin, 2009).

Procedure

This subject had been conducted in prior academic years without the aid of videos, but during the year of the study the professors developed a MOOC of the course and they decided to use the videos of the online program as part of the traditional classroom. It was a practical course, divided in 7 projects, where students had to develop seven Arduino circuits. Each project had a video composed by three possible parts (Figure 1): (a) Short explanation of the theory by the professor, (b) Demonstration of how the circuit is built, (c) Instructions of how to program the circuit.

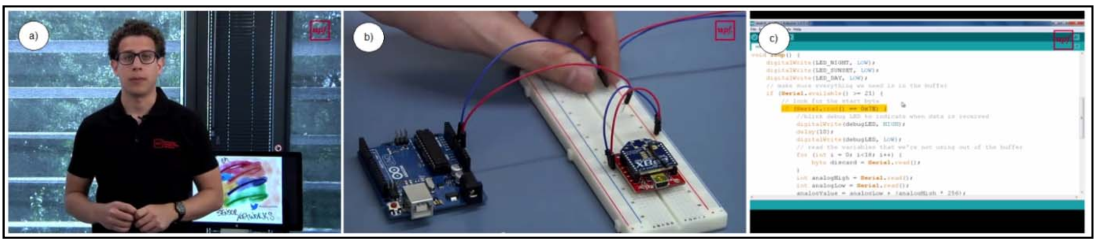

Figure 1. Screenshots from a project's video, where it is showed the three possible types of content explanation: (a) professor's explanation (b) circuit demonstration and (c) programming instructions.

In addition to videos, students could consult a text guide of the course. That document explained all the information of the videos; in fact, it was the basis for audio-visual material. Both course materials were available in a learning environment: Moodle. Students had free access to the environment and they could connect to it by logging in and outside class times. The students were also allowed to consult external material to the subject.

The instructors did not lecture during the classes and they tried to assume the role of facilitators (Smyth, 2011). During classes, the students worked at their pace developing the circuits done in the video. When they needed help, they could request help from the teacher or consult other classmates. When they had completed the circuit example, they had to develop an improved circuit and propose some innovative applications of it.

Every two weeks the video of a new project was published in the Moodle. Despite this, students could work at their own pace, without strict delivery deadlines. The course did not include a written exam. The participants submitted their work as a post entry in their blog and were awarded a badge for completing the project.

Instrumentation, Data Collection and Analysis

The current study used five instruments to gather data from the field work: two surveys, an interview, an observation protocol and two automatic registers. The first online survey instrument utilized for this research was designed to collect information from students regarding the utility and their interaction with the content in the online learning environment: text material and videos. Students answered this questionnaire once for each completed project.

The second online survey was developed to collect general information from students at the end of the course. The objective was to know their satisfaction with the course, especially with videos, as well as their perspectives about the utility of the face to face classrooms. Last survey question referred to whether the use of videos helped them to become more autonomous. All these survey items used a 5-point Likert-type multiple choice response format.

To gather the professor perspective about the course dynamics, the educator was interviewed in the middle of the course. Moreover, the researcher recorded all classrooms in order to observe the participants' interactions off-line. Basically, two kinds of interactions were observed: students with students and students with professor.

Finally, two automatic registers were used to collect quantitative data. On the one hand, the data from the Moodle Log Files have allowed to obtain all times that students have accessed the course materials through the learning environment – date and time were recorded, in addition to indicate what material was accessed. These results could be downloaded in Excel format to facilitate further analysis. On the other hand, the YouTube Analytics tool has led to the number of visits for each video and information related to the corresponding withholding public.

Note the importance of being able to have more than one view of the object of study, from the integration of the two methods in terms of equality – quantitative and qualitative. This study uses triangulation (Neuman, 2006; p.149) to analyse the data.

This is a process that combines strategies, methods or techniques in order to obtain a more accurate – more exhaustive- representation of the phenomenon.

Results

Most of the Interaction with Content (Videos) Occurs within Class

Figure 2 presents the number of student's Moodle actions per hour depending on the project. Two time zones are distinguished, within or outside campus classes. The graph shows that the interaction with the course content – access to videos and text material – mainly occurs during classes' hours.

The graph shows that the actions/h decrease as the course evolves. However, there is an exception to this trend in Project5. The reason for this increase may be due to the content level of this project. Until Project4 students had programmed Arduino IDE and the Project5 first introduced the Python programming language. This new development was associated with an increase in the difficulty of assessing the project and can be one of the main reasons for the rise in the number of interactions with the course content for this particular case.

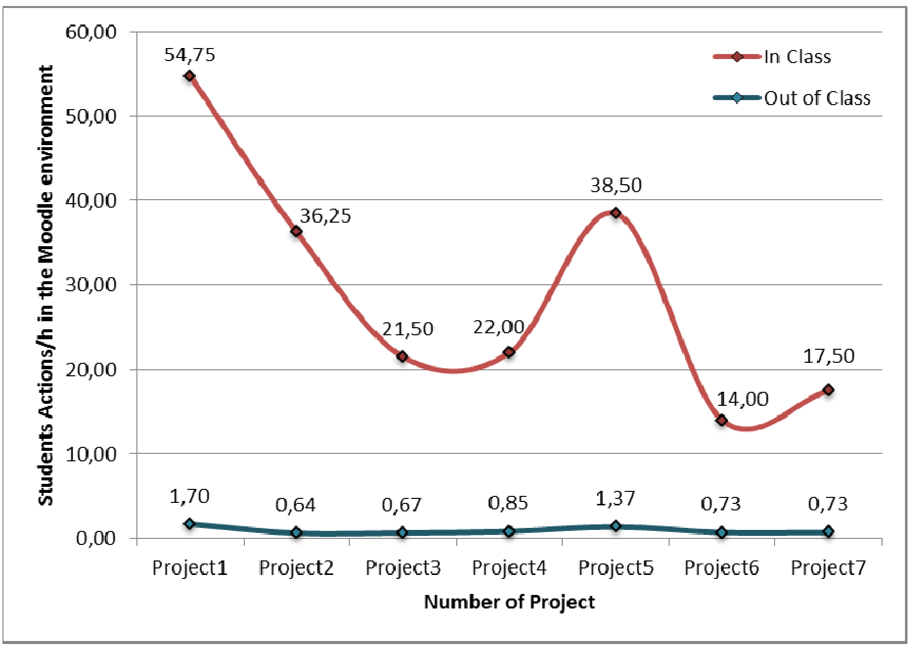

Figure 2. Students actions per hour in the online Moodle learning environment depending on project.

Flexibility in Viewing Videos

Figure 3 reflects the time when the students watched the videos of each project. Every row is a student and the group number to which belongs is also indicated, there are seventeen students divided among seven groups of work and in addition, legend shows which colour represents each video project. The data of this plot was collected from YouTube Analytics tool and from the Moodle Log Files.

Nearly all the students affirm in the surveys that when they watched the videos within class they did it together with another classmate. This would explain that some student have not seen all the videos, because, when they viewed a video with a classmate, a unique student registration of view is shown in the graph.

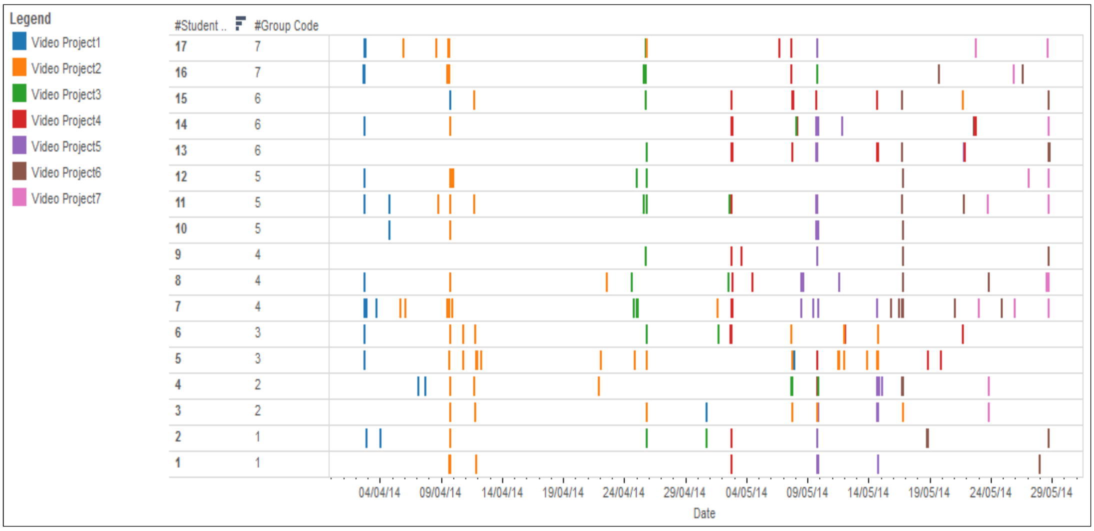

Figure 3. Video views of the students in time depending on project

The main result observed from the figure is the difference in the times at which the participants watch the videos. Each student has seen the video at different moments – even on different days – and most times she or he has displayed the same video more than once. Students show to take advantage of the flexibility in viewing videos, according to their pace when completing the projects (being able to self-organize their schedule depending on their duties in the others subjects, etc.).

Videos have Increased Student's Autonomy

Most of the students stated that the videos have helped them to become more autonomous (Table 1). The main professor also reaffirmed the result during the interview. He observed that the students of this course were more autonomous due to the videos: dependence of the students towards the teacher was lower than in previous editions of the course.

Table 1: Relationship between videos and autonomy of students

Videos have helped you to become more autonomous?	
Strongly agree	73%
Agree	20%
Indifference	7%

The results of the observation protocol, in addition to the surveys indicate that the interaction between the different working groups was low. Interaction mainly occurred among students of the same group or with the teacher. The most frequent questions to the professor were related to the practical course content or programming questions. Finally, student satisfaction results with the course indicated that 93% of students have fulfilled all or practically all their initial expectations as well as they assessed the utility of the videos in 3.64 out of 5.

Discussion

Students interacted with the course content mainly during class hours, despite the fact that they had the opportunity to watch the videos before the sessions. Hence the flipped classroom was not present though it was the expected situation. Students used videos as support material within class while they were working on the projects at their pace.

On the one hand, the incorporation of videos in class allowed students to enjoy a great flexibility to access the professors' explanation. The advantage of this flexibility questions the use of oral teacher presentations in class because of the latter are governed by schedule that means that the students cannot access to this explanation beyond the class in the moments when their application is more significant. These conclusions are somehow in line with claims by other researchers saying that the role of presence-based learning may be re-thought, standard lectures do not take advantage of having the students personally present in the class (Marwedel & Engel, 2014). However, the use of video allows access to content *on demand*. Moreover, the use of videos has helped students to become more autonomous.

In a learning design based on the student as in our case, the flexibility and autonomy that provide videos – used as support material during classes – help students to have more control over their own learning process and, therefore, the role of the teacher as facilitator is reaffirmed.

Limitations

Above mentioned findings must be interpreted in light of limitations of the study. The first limitation of this research is that this is a case study and therefore it is difficult to extrapolate the findings and generalize. In order to counteract this limitation, it has been placed emphasis on achieving a good internal validation of the results. The second limitation is the type of course of our case: a subject in electronics and programming - essentially practical. Classroom attendance facilitates the resolution of practical problems related to circuit assembly and programming more effectively than virtually, since they are very specific problems, difficult to predict. This conclusion is reinforced by the data obtained from the interviews and online surveys.

Other limitations are due to instruments used in research, basically derived from the surveys. This research study required from the volunteer participation and involvement of the students. Every effort was made to reduce the burden on the students. The questionnaires were integrated in the online learning environment to make them easily accessed. In addition, the instructors periodically reminded the importance of collaborating with this research.

Conclusion

Contrary to common belief, the use of video-based learning may not only converge in the use of flipped classroom methodology. It is also possible to use the videos in a hands-on class as a support tool that encourages a more autonomous, flexible and significant learning. The application of a flipped or a hands-on classroom approach depends on diverse aspects, including the nature of the course (with practical or theoretical orientations), the behaviour emerging from the students (depending on their needs and preferences, time constraints, etc.) and the design of the activities proposed by the teachers (strongly requiring students to watch videos in a certain timeframe, e.g. previously to the class, or offering flexibility). Future research considering variations of these parameters will help to understand the benefits and limitations of both approaches and to what extent they may coexists in VBL.

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2.4 From a FutureLearn MOOC to a blended SPOC: the experience of a Catalan Sign Language course

The content of this section was presented at the international workshop *HybridEd: innovations in Blended Learning with MOOCs* (HybridEd 2017) collocated with the *Fifth European MOOCs Stakeholders Summit* conference (EMOOCs 2017) and was published in the online repository of the Universitat Pompeu Fabra:

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From a FutureLearn MOOC to a blended SPOC: the experience of a Catalan Sign Language course

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Abstract. This paper presents a case study of transforming an existing MOOC into a SPOC for being used in a campus course using a blended learning approach with the aim of providing a reflection of the experience and reporting the challenges of the hybridization process. Results point out that blended learning with MOOCs can be a sustainable model for universities as well as a trigger to the change from teacher-centred to student-centred learning.

Keywords: MOOC · SPOC · Blended Learning · FutureLearn

1 Introduction

In April 2016, the Universitat Pompeu Fabra (UPF), launched the 1st edition of the MOOC "Introduction to Catalan Sign Language: Speaking with Your Hands and Hearing with Your Eyes" in the FutureLearn (FL)[1] platform. The course taught the basics of Catalan Sign Language (LSC), the sign language used by the deaf community in Catalonia. Due to the nature of the course, the design of the MOOC was a challenge from different perspectives: (1) Having to change the traditional teaching paradigm of sign languages that is based on teaching vocabulary, face to face (f2f), in small groups, and with a teacher with an omnipresent role. (2) It was a complex technical project: the MOOC had 320 videos and the sign language is not included in automatic video caption (and subtitling videos implies a high level of linguistic knowledge). Thus, the number of people involved in each task increased with respect to a typical MOOC. (3) The multilingual treatment, because sign languages are visual and do not have a written version, offering transcriptions and captions in different languages was also a challenge. And (4) it was a pioneer experience, without precedents in other sign languages. These issues presented an added cost to the development of the course, in terms of time, organization and the need of having a larger team, which would not have been feasible without a strong institutional support. However, the course was a success: 6.059 participants in the 1st edition and 2.505 during the 2nd edition (in November). The MOOC was planned from the beginning

[1] https://www.futurelearn.com/courses/lsc

under the idea of reusing the materials. Hence, during the MOOC planning, the underlying concept was to create autonomous blocks of learning contents that should be reusable in other learning scenarios. These autonomous blocks will work as pieces that could be assembled and connected in many ways. Since UPF is offering LSC teaching in some university degrees, it opened up the possibility of using a private version of the FL MOOC within a blended learning design of campus courses and use the MOOC materials. This type of learning design is documented in the literature as SPOC (Small Private Online Course) [1]. SPOCs are courses based on MOOC-technology that instead of being massive, they are offered for a limited number of participants. Typically, these courses are used within blended learning designs, where the SPOC is hybridized with f2f (or online) regular teaching in a variety of combinations [2]. There are several studies reporting the use of MOOCs and SPOCs in different types of university courses such as remedial courses [3], reinforcement as well as mixing with traditional courses [2]. But it is necessary to highlight the transformation process of the learning methodologies and learning designs itself that implies the development of a MOOC, SPOC or blended learning courses using both of them. Whereas some teachers have started developing a MOOC from the scratch and then used part of it in traditional courses (sometimes with the aim of leverage all the work that implied its development), others have been done the contrary: transforming a traditional course into a MOOC by means of a SPOC [4]. Regardless the chosen approach, some challenges emerge from the process of setting the final learning design. Furthermore is necessary to keep reporting the different types of challenges as well as the success outcomes to facilitate the use of similar experiences. In this context, the aim of this paper is to provide a reflection about the utility of transforming an existing MOOC into a SPOC for being used in a campus course using a blended learning approach. The reflection takes into account the success experience of carrying out the MOOC and it reports the key issues and challenges of the learning design transformation.

2 Blended learning design with a SPOC

The Introduction to Catalan Sign Language (iLSC) is a part of a compulsory subject Introduction to University and Communication of UPF degrees in Translation and Interpreting and Applied Linguistics. With this introduction, students obtain the basic skills they need to be able to communicate in sign language as well as they find in it the strategies to continue the study of LSC in the future. The iLSC course takes ten weeks, has a regular assessment, it represents about 25h of study and it implies a 10% of the final mark of the subject. Is in this context where it was decided to use the SPOC based on the LSC MOOC combined with a specific f2f tutorial activity supported by Moodle. In order to carry out the course, professors had to adapt the MOOC into the SPOC (a private FL instance of the MOOC) as well as planning the hybridization with the regular f2f course. Existing materials of the FL MOOC were the basis of the course but some reorganizations and adjustments of the original FL materials were done: (1) Redistribution of contents (from the 6 weeks of the MOOC to 10 weeks of the SPOC); (2) Adaptation of the number of weekly tasks to do; (3) Reordering of contents taking into account the new course syllabus; (4) Deletion of activities linked to the organization of 6 weeks course; (5) Modification of some activities related to the internationalization of the MOOC; (6) Adaptation of the automatic weekly messages of the FL MOOC. UPF Moodle was used for communicate organizational issues of the SPOC -information about the academic plan, assessment, weekly signed messages and f2f session materials. The interaction with the course content was planned to happen in the FL SPOC which was offered as "invited only" and 258 participants were registered on the FL course directly by teachers. During the course, three f2f sessions were done in groups of 80 students. Interaction and participation in the forums were recommended (not compulsory).

3 Results from the experience and lessons learned

To have access to FL was a very valuable point of the course. Participants appreciated the possibility to keep the registry access to FL to take part of possible future courses. Most part of students followed the contents weekly as planned, but a group of students started the course 2 or 3 weeks after start date. To have the full course opened since the start date has been a good option, in order to allow students to work at they own pace. Regarding the language of the course, English was the language of tuition, and even though no explicit instruction about language had been given to students, most of the comments were written in English and signed in LSC. Only few students did not communicate inside FL platform (teachers strongly recommended students to participate inside FL platform and discouraged alternative communication channels during the course). Abandonment of the course was insignificant and participation was much higher than expected (about 60.4% of learners participated in the online discussions). From the point of view of teachers, the management of the course was very easy and the objectives of the course were achieved. No technical incidences happened. They stated that FL MOOC materials were clearly useful in the blended learning approach as the main learning resources of the iLSC course. Moreover, existing activities were appropriate to offer a global knowledge of LSC basic content and the number of tests was appropriate to the general purposes. Regarding FL, data provided by the platform was clear and useful, but not enough to assess UPF students. For instance, the average test score was not reliable to UPF system (FL calculates the average test taking into account only the tests done by the students), or the impossibility to track the number of videos posted, since videos were included as links in the comments. Among the challenges found during the hybridization process, highlight four aspects also reported by other researchers [3][4]: (1) the importance of the UPF support; (2) the opportunity of having a private MOOC instance facilitated by FL. Without this, it would be necessary to look for alternative technologies to host and articulate the course content with the challenge that this would entailed; (3) the important role of professors -without their willingness to adapt to new teaching situations, it would have been impossible to carry out this experience; (4) the hybridization made possible to realize the course. The course would not have been possible in a f2f format without a high cost (to fulfil the contents in a regular course 17 student groups would be needed, instead of the 3 groups of the SPOC). Finally, although the course was a success, some minor points could be improved: working with two platforms at the same time (FL and Moodle) was not especially useful for the students; the registration process to FL increases the probability of having errors; and the tracking of students' activities were limited by the external platform, not fulfilling the UPF tuition system.

4 Conclusions

The process of hybridization the FL SPOC on LSC has been a successful experience. The key issues for the success were (1) to plan the original MOOC in terms of reuse (2) the enormous flexibility of FL managers to adapt the platform to SPOC needs as well as (3) the multidisciplinarity of the UPF team. This hybrid experience points out that blended learning with MOOCs (or SPOCs) can be a sustainable model to universities since it presents an opportunity of amortizing an important initial investment.

Acknowledgments. This research is partly funded by the Spanish Ministry (TIN2014-53199-C3-3-R). Authors want to thank FL team, UPF LaFactoria+ as well as the professors involved in the project.

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2.5 Breaking the walls of a campus summer course for high school students with two MOOCs

The content of this section was presented at the international workshop *HybridEd: innovations in Blended Learning with MOOCs* (HybridEd 2017) collocated with the *Fifth European MOOCs Stakeholders Summit* conference (EMOOCs 2017) and was published in the online repository of the Universitat Pompeu Fabra:

> Albó, L., & Hernández-leo, D. (2017). Breaking the walls of a campus summer course for high school students with two MOOCs. In HybridEd Workshop, EMOOCs 2017, Leganés, Spain. http://hdl.handle.net/10230/32157

Breaking the walls of a campus summer course for high school students with two MOOCs

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Abstract. This paper presents a case study of integrating two external MOOCs in a face-to-face (f2f) summer course for high school students. The aim of the study is to explore the design challenges emerged from this blended learning approach, the students' learning outcomes and satisfaction with the course content as well as investigating the students' behavior with the MOOCs once the f2f course ended. Results indicate that students learned through the course and were satisfied with the learning design. Moreover, some of them took advantage of the MOOCs once the campus course finished.

Keywords: MOOCs · Blended Learning · bMOOCs · Blended MOOCs

1 Introduction

Integrating MOOCs in a campus course allow students accessing to high quality material from top tutors all over the world as well as the opportunity to participate in a collaborative global environment [1]. The integration can range from a teacher who use her own MOOC in her f2f classes, to more complex forms of hybridization in which the teacher has not produced her own MOOC and the required course materials are drawn from multiple external MOOCs [2]. Different approaches of using MOOCs in a f2f course [4][5] have been reported but there is still a need of sharing these type of experiences as well as their associated challenges using different hybrid learning designs and in different educational contexts [5][6]. This research presents a case study that describes the integration of two external MOOCs in a one-week summer course for high school students. These types of scenarios employing resources from more than one MOOC and with young learners have been particularly underexplored. This research has two purposes: first, studying the challenges emerged from implementing a blended learning design using two different external MOOCs; and second, evaluating the resulting learning design – taking into account students' learning outcomes, students' satisfaction with the course content as well as their use of the MOOCs once the f2f course has finished. Regarding these two purposes, the study aims to answer three research questions: (RQ1) What are the main challenges that emerged from implementing a BL design using two external MOOCs? (RQ2) What are the students' learning outcomes and satisfaction resulting of this learning design? (RQ3)Once the f2f course finished, do students continue learning trough the MOOCs?

2 Methodology

Participants were 30 high school students (14-16 years old, six girls) enrolling in the summer course "Design and program your own video game!" within the Campus Junior (CJ) program at Universitat Pompeu Fabra (UPF). The educational objective of the extracurricular course was to explore the basic principles of programming as well as understanding and implementing the process of designing and developing computer games. The course workload was of 20 hours and took place between 11th and 15th July 2016 – four hours per day. The course used a LMS (Moodle) to articulate the course content with 19 videos from two MOOCs from two different universities (both from Coursera MOOC platform). Six videos were from the MOOC "*Videojuegos: de qué hablamos*" from the Universitat Autònoma de Barcelona (UAB). Whereas 13 videos were from the MOOC *"¡A programar! Una introducción a la programación*" from the universities of Universidad ORT Uruguay and The University of Edinburgh. Both MOOCs were running in parallel to the CJ course and finishing several weeks later.

At the beginning of the f2f course, teachers invited students to register to the two MOOCs. Each concept of the course was explained showing the video (usually an extract of it) in class to all the students (downloaded from Coursera, hosted in a private Youtube channel and embedded in the LMS). In some cases, students were asked to solve some small exercises between the explanations of two concepts. After explaining all the videogame and programming concepts, students were practicing programming with some guides about how to program small videogames. Finally, they designed and programed their own videogames in small workgroups and the last day of the course they presented them to all class.

The current study used five questionnaires to gather data. Once the course started, three questionnaires with the same ten questions (regarding specific content about programming) were used in three different moments of the week: the pre-test questionnaire was delivered the first day (and hour) of the course – before students received the first lecture – to know the initial knowledge of the students. The on-time questionnaire was given to the students during the two first days of the course. But instead of delivering all questions together, students were invited to answer each question just after the concept of the question had been explained by the facilitators trough the MOOC videos. The last day of the course, the post-test questionnaire was presented to students with the aim of knowing which concepts explained during the course they could remember. A fourth questionnaire was delivered to the students to collect their opinion about the use of MOOCs in the f2f classrooms the last day of the course. Moreover, a last questionnaire was sent half year after the course ended in order to know whether they had accessed the two MOOCs used during the CJ.

3 Results and discussion

During the preparation of the course we faced three types of challenges. First, the pedagogical hurdle of showing 19 short videos in class in only two days (with the video length mean of 6 min.). Even though we were playing part of the videos, there was the concern of tiring the audience with so many videos concentrated in such a short time. To deal with this we delivered a multiple choice question after each video-concept (the on-time test) with the aim of softening the process of visualizing the videos at the same time that we were evaluating their learning, becoming a learning game process. The second challenge was related to legal aspects: the limitations of using Coursera courses for not private use. We were planning to project the videos directly from Coursera but we had to change this strategy in order not to violate legal terms. Finally, we asked for permission to the universities owners of the MOOCs to use the videos. We downloaded the selected MOOC videos and uploaded in a Youtube private channel in order to embed them in the LMS of the course. We cited the authors and the origin of all the content without exception. The third difficulty was managing three different platforms – Scratch webpage (students were programming with Scratch[1]), Coursera and the LMS – and at the same time offer them to the students in the most comfortable way. In addition to the MOOCs' videos LMS-embedding, the solution was to setting the links of optional content from Coursera in the LMS as well as the link to the Scratch webpage. In order for the links to Coursera videos to work, it was necessary for the students to have an open window of a browser with their Coursera session started. This links were set in order to engage students continue learning through the MOOCs.

The results from the pre-test, on-time test and post-test, indicate that students have performed better results in the post-test. The mean of correct answers per student in the post-test was 80.7%. Whereas in the on-time and pre-tests were 72.7% and 29.7% respectively. The mean of "do not know" answers per student in the pre-test was 50.7% while this number was reduced to the 2% in the post-test. The percentages of incorrect answers per student were similar in the pre and post-tests: 19.7% and 17.2% respectively. These results point to an increase of assimilated concepts during the course by students hence an improvement of their knowledge. Regarding their satisfaction, students scored the Scratch and videogame videos with a 7.9 and 7.7 out of 10 respectively. Furthermore, 50% of students like and 30% extremely like the use of videos in class whereas 46.7% agree and 33.3% extremely agree with the sentence: videos had been useful to understand the concepts of the course.

In the fourth delivered questionnaire, 10% of students stated that they will continue the Scratch MOOC with the intention of finishing it (13.3% for the videogames MOOC). However 30% of them expressed the intention of continuing it but without knowing if they will finish it (20% in the videogames case). Moreover, half of them (50% Scratch and 56.7% Videogames) indicated that they will just access to the MOOC to check some specific resources. Only 10 % of the students were affirming that they will not follow these MOOCs anymore. Finally, we found that out of those completing the fifth questionnaire (half year later, n=10) at least two students were accessing the MOOCs after the CJ course (one of them for consulting some materials and the other one finished the two MOOCs).

1 Scratch website https://scratch.mit.edu/

4 Conclusions

The type of challenges faced during the learning design process were essentially of pedagogical, technological and legal nature, as other studies have been reported [2][6][7]. The blended learning design used had positive results in terms of students' learning outcomes and satisfaction with the MOOC videos used. The intentionality expressed (of continuing learning through the MOOCs) was more optimistic than the results of what actually happened. Nevertheless, two students took advantage of the MOOCs after CJ. A further analysis considering the data from the MOOCs in Coursera could help to better understand whether students have interacted with the two MOOCs after the CJ course as well as crosschecking with their answers in the questionnaires. Moreover, it could be interesting exploring the results of applying the same design with other type of students (with teachers or graduate students).

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CHAPTER 3

CONCEPTUAL SUPPORT FOR DESIGNING BLENDED LEARNING

This chapter addresses the conceptual part of the second objective of the thesis (Figure 3.1). It presents the conceptualization process of the preliminary design product and design principles: a visual representation model for blended learning designs (Figure 3.2). It is composed of three papers:

- the first (W4, see Section 1.4.3) is an article that gives an overview of the whole co-creation process followed in the articles presented in chapters 3, 4 and 5 (Section 3.1);
- the second (C3) is a preliminary exploration of how to guide teachers in designing blended learning that helped us to conceptualize a first version of the representation (through a workshop with practitioners) (Section 3.2);
- whereas the third article (J2) exposes the conceptualization of the visual representation model from the initial proposal until the final model (through a workshop with experts)—which will serve as basis for the first online version of the authoring tool for designing blended learning (Section 3.3).

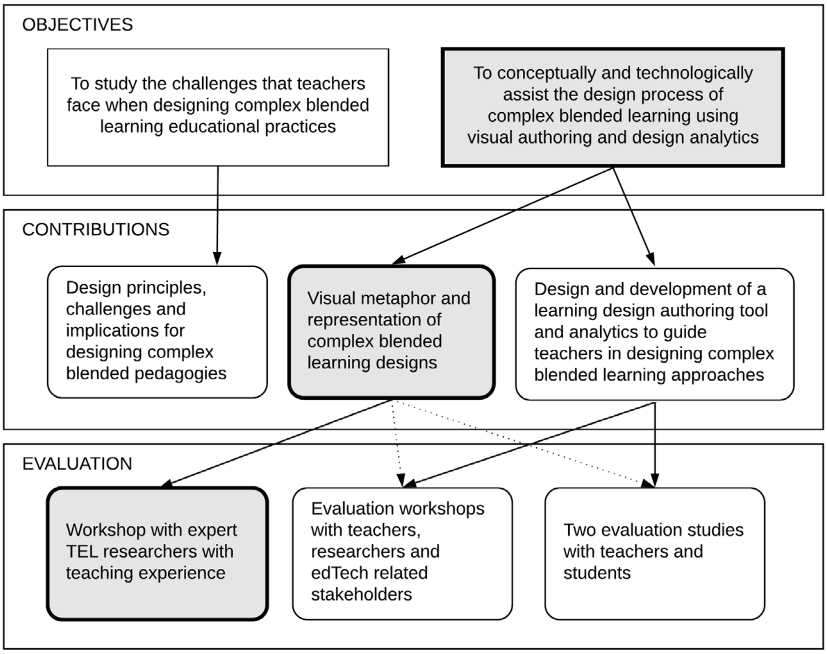

Figure 3.1. Objectives, contributions and evaluation works covered by Chapter 3.

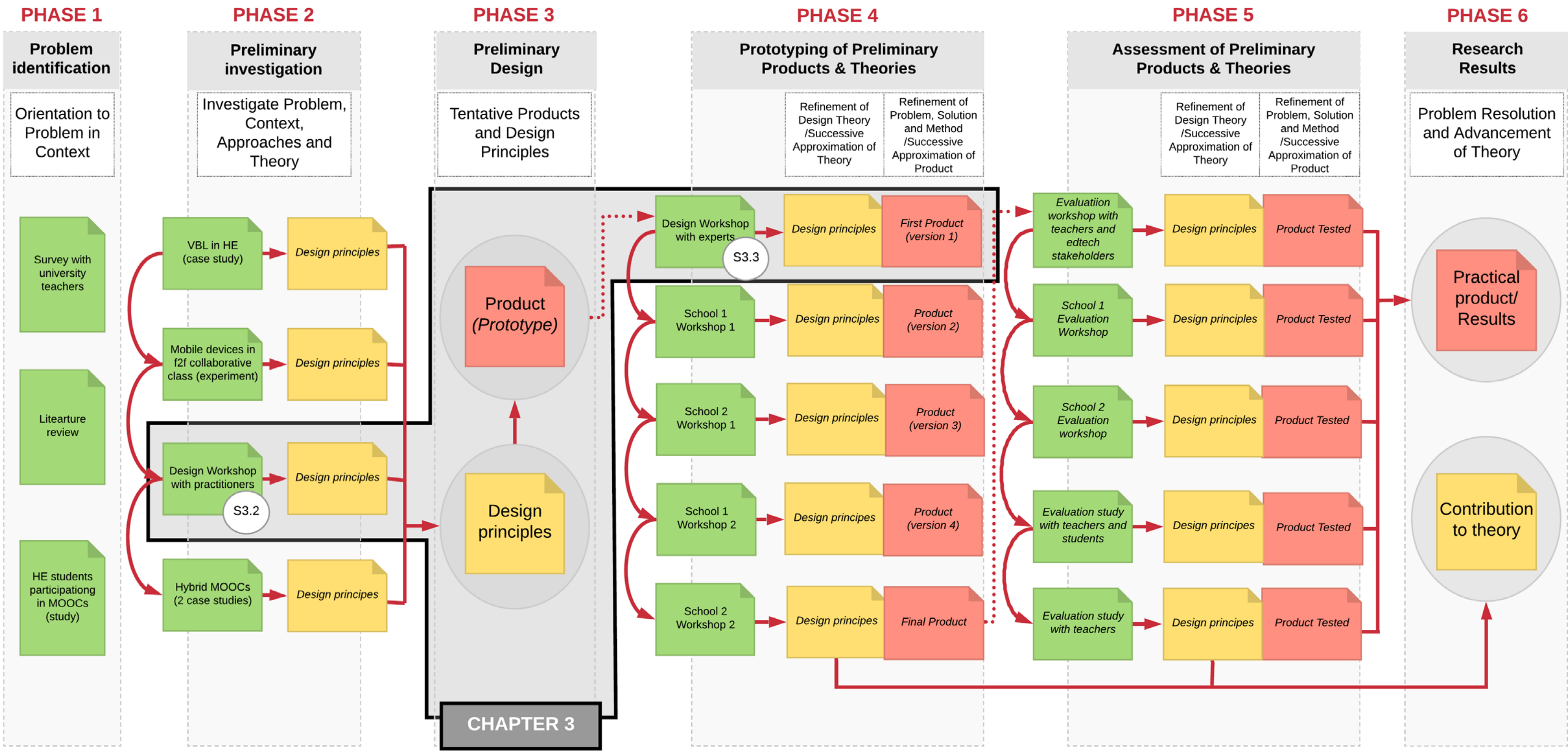

Figure 3.2. Part of the research process covered by Chapter 3.

3.1 Co-creation process and challenges in the conceptualization and development of the edCrumble learning design tool

The content of this section was presented at the international workshop on *Co-Creation in the Design, Development and Implementation of Technology-Enhanced Learning* (CC-TEL'18) collocated with the *Thirteenth European Conference on Technology Enhanced Learning* (EC-TEL 2018) and was published in the following workshops proceedings:

> Albó, L., & Hernández-Leo, D. (2018). Co-creation process and challenges in the conceptualization and development of the edCrumble learning design tool. In A. Piotrkowicz, R. Dent-Spargo, S. Dennerlein, I. Koren, P. Antoniou, P. Bailey, T. Treasure-Jones, I. Fronza, C. Pahl (Eds.), *Joint Proceedings of the CC-TEL 2018 and TACKLE 2018 Workshops*. Leeds, United Kingdom: CEUR-WS.

Co-creation process and challenges in the conceptualization and development of the edCrumble learning design tool

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Abstract. This paper presents the co-creation process followed during the conceptualization, development and evaluation of edCrumble: a learning design (LD) tool which provides an innovative visual representation of the LDs characterized by data analytics with the aim of facilitating the planning, visualization, understanding and reuse of complex LDs. Researchers used several participants' sources and profiles, different methods (including paper and web-based prototyping, questionnaires, interviews, focus groups, role-play games, sharing activities) and workshop types (isolated vs. long-time). Participatory design workshops and activities are described as well as the challenges encountered during the co-design process with the aim of informing other researchers who are thinking of using co-creation. These challenges include the recruitment and motivation of participants, the management of their expectations, the prioritization of the feedback diversity and a short evaluation of the methods used.

Keywords: Co-creation, Learning Design, Authoring tool, edCrumble.

1 Introduction

Co-creation refers to any act of collective creativity which can be used at all points along the product development, from the idea generation but also at all key moments of decision throughout the design process [1]. The practices of co-creation in design (co-design or participatory design) date back to the 70s starting with the user-centred design approach. But nowadays, we are moving from simply designing products for users (user-centred) to designing for the future experiences or purposes of people (co-designing) [1]. Therefore, it is necessary to reconsider the role of designers (design developer, facilitator and generator) to achieve user participation in design [2].

Learning Design (LD) aims to support teachers in the process of documenting their teaching practices, making their learning design ideas explicit and sharable [3]. But despite its potentialities regarding teaching and learning innovations, there is a gap on the adoption of LD by the practitioners [4]. Whereas some initiatives of participatory design have been identified in order to include users' insights on LD solutions [5], more work is needed to explore how the use of co-creation during the conceptualization and development of specific LD tools may contribute on reducing this gap.

ILDE2/edCrumble is a LD tool for teachers of any educational level, which provides an innovative visual representation of the LDs characterized by data analytics with the aim of facilitating the planning, visualization, understanding and reuse of complex LDs [6]. Specifically, the decision-making during the LD process is supported by two types of analytics: resulting from the design of the activities sequenced in a timeline (LD analytics); and aggregated meta-data extracted from several grouped LDs created by multiple teachers within a community (community analytics).

In this paper, we present the process followed during the *conceptualization*, *development* and *evaluation* of edCrumble (https://ilde2.upf.edu/edcrumble/) using participatory design workshops, with the aim of reporting our experience of implementing co-creation. Specifically, we describe the activities used in our approach, identifying and discussing the challenges we found in our case study: including the recruitment and motivation of participants, management of their expectations, the prioritization of feedback diversity and a short evaluation of the methods used.

2 Co-creation in edCrumble

2.1 Participants and Sample

During the co-creation process several workshops were carried out in different contexts: (1) two teaching innovation conferences; (2) one research project event; (3) a collaboration with two schools in the frame of a research project; and (4) a learning innovation project in our university. Participants (140, 40% female) had different profiles depending on the workshop –choice based on the opportunity (see Table 1).

Table 1. Research contexts descriptions and participants' profiles.

Context				**Participants**	
ID	**Dates**	**Description**		**Profile**	**Num.** (#female)
Workshop conference #1	May '16	UCATx conference		Massive Open Online Courses related Staff & Professors.	24 (9)
Workshop project meeting	June '17	RESET project		Expert researchers on TEL - with teaching experience.	15 (5)
Research project with schools	Oct.'17-June'18	CoT project (Recercaixa)	*School #1*	High school Teachers.	10 (6)
			School #2	High school Teachers.	10 (8)
Workshop conference #2	April '18	ITWorldEdu conference		Teachers, Researchers and EdTech related stakeholders.	23 (9)
University local project	March-July'18	Engineering school - Universitat Pompeu Fabra		Undergraduate students	32 (10)
				Professors	26 (9)
				Total	**140** (56)

2.2 Procedure and instrumentation

Co-creation was used during the *Conceptualization*, *Development* and *Evaluation* phases of edCrumble. Participatory design workshops were carried out using several research methods and instruments depending on the workshop and its context (Fig.1.).

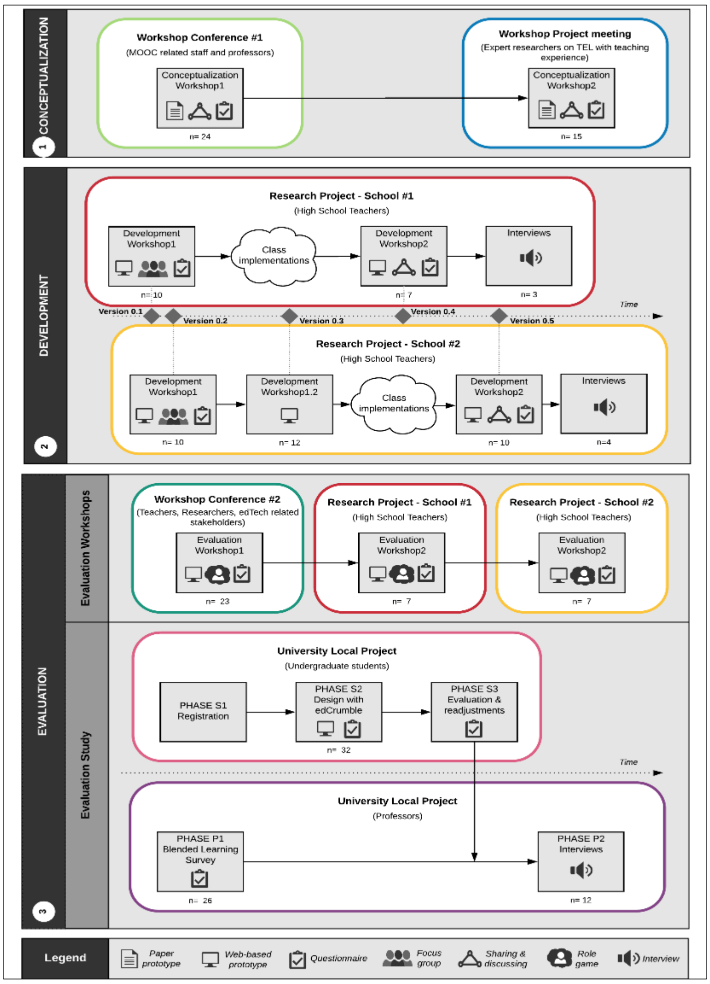

Fig. 1. Co-creation procedure (participatory design workshops' instruments and methods) during the *Conceptualization*, *Development* and *Evaluation* phases of edCrumble. (Access online figures of the paper here: https://www.upf.edu/web/tide/edcrumble_pictures)

The *Conceptualization* phase consisted of two workshops with the aim of defining the edCrumble' main objectives and features (see Fig.1. Conceptualization: conceptualization workshops 1 and 2). Both used paper prototyping activities, where participants were working in groups and completed a final individual questionnaire for sharing their reflections with the researchers.

The *Development* phase consisted of several workshops with two school communities, which were part of a research project (see Fig.1. Development). During this phase, participatory design workshops served for advancing on the development of a web-based prototype of edCrumble using participants' insights and reflections. The same workshops' structure was followed for each school community despite the context was different: in the first school the workshops were about Problem Based Learning (PBL) and in the second school, they were about Flipped Classroom (FC). During this phase, participants worked with different versions of the online prototype and participated on different activities which included focus groups, sharing and discussing activities, questionnaires and interviews.

The *Evaluation* phase consisted of several evaluation workshops and an evaluation study (see Fig.1. Evaluation). In the workshops, participants were involved in a role-play game whereas they were using edCrumble with the aim of evaluating its usability and utility. Apart from the design artefacts resulting from the activities, researchers used a questionnaire for collecting participants' feedback. In the evaluation study, researchers worked in parallel with students and professors for evaluating edCrumble as well as collecting their insights about blended learning and course design. The study included time for working with edCrumble, questionnaires and interviews.

2.3 Co-creation activities during the conceptualization phase

Conceptualization workshop 1. The aim of the workshop activity was to challenge each participant to design a blended-learning course using Massive Open Online Courses (MOOCs). The workshop lasted two hours and the 24 participants were divided into seven workgroups. The workflow of the activity was a five-step process described on [7] which used several paper materials: a LD template, three framework sheets and printed LD examples. Specifically, one step of the LD design template was asking participants to represent their blended LDs using a first timeline model (Fig.2. *left*). This visual representation model was evaluated based on the participants sheets (with the participants insights collected using a questionnaire) contributing in the initial conceptualization of the main element of the edCrumble editor: the timeline.

Conceptualization workshop 2. The main objective of the workshop was exploring with the participants how visually represent blended LDs and how these visualizations can facilitate others' LDs understanding. Researchers prepared two LDs cases descriptions sheets (both were using MOOCs mixed with face-to-face courses) extracted from the literature. Moreover, the main material used was a paper LD template with a new visual model of the timeline with resources' layers designed based on the results from the *workshop 1* and the literature. Below the timeline, in the LD template sheet, there was an empty space for placing paper activity cards (which were drawn and filled in with stickers by the participants following a provided legend) (Fig.2. middle and *right*). The 15 participants were working in groups of two/three people using a LD template per workgroup. The two printed cases descriptions were divided equally between the existing groups, in such a way that half of the groups worked with one of the examples and the other half with the other one. Once each group had a case description sheet, they followed the following steps:

1. Read the case provided and represent it using the LD template sheet –placing the activities and the resources described on the case using the timeline and filling in the activity cards (and place them on the sheet) (Fig.2. *middle*).
2. After completing the LD template with their case (Fig.2. *right*), they had to exchange the completed LDs templates between workgroups and interpret the LD template produced by another group (only looking on the visual representation and without knowing the LD case description of the template received as the exchange occurred between groups that had different LD cases).
3. Finally, each group could check if they had understood well the LD template received by looking on the corresponding case description. Last, participants were asked to complete a questionnaire providing their insights about the process.

Results of this workshop pointed out the main strengths and weaknesses of the visual representation proposed and were useful for discussing whether the timeline and layers provided by the template were valid for designing hybrid courses. The outputs of the workshop helped to improve the visual representation and have a more solid base to start the development of the online version.

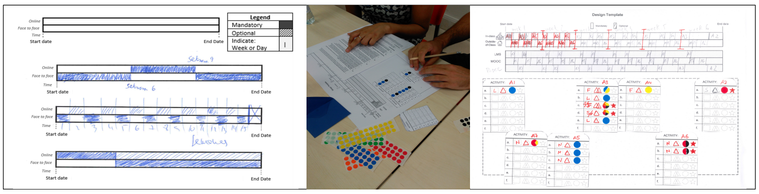

Fig. 2. Paper template of the *workshop 1* with three templates filled in by the participants (left); Participants of the *workshop 2* completing a paper LD template (middle); Scanned paper LD template resulting from the *workshop 2* -with the timeline and the activity cards (right).

2.4 Co-creation activities during the development phase

Researchers prepared a first online prototype based on the results obtained during the conceptualizing phase (a web-based tool which provides an editor to work with the evolved timeline model on an interactive way). The aim of the participatory design workshops of this phase were prototyping and assessing the preliminary versions of the authoring tool with the participants of two school communities (Fig.3.). The following steps were carried out in each community.

Development workshop 1. In which teachers had to design a LD using the online prototype of edCrumble, with the help of the researchers (participants were asked to come to the workshop with a concrete LD idea). It was a 2h workshop with the following steps: (1) Introduction to edCrumble; (2) Work with edCrumble designing a LD for being implemented within their classrooms (a PBL or a FC design); (3) Focus group where researchers asked questions about the experience that participants had with the use of the tool, discussing their strengths and weaknesses. (4) Last, participants were asked to answer a research questionnaire individually.

Development workshop 1.2. In the case of the School #2, they had another 2h workshop because they needed more time for designing the interventions using the tool and be prepared for implementing the LDs in their classrooms. In this case, researchers took observation notes of teachers' using the tool for usability improvements.

Class implementations. Teachers implemented their LDs in class. During this step, which took between 4 and 9 weeks, researchers were available online for solving teachers' doubts regarding the use of technology selected for using in their class.

Development workshop 2. In this workshop, which took 1-2h depending on the school, teachers followed three steps: (1) Working with edCrumble for documenting the LDs implemented at class, adding the design changes suffered by the real implementations; (2) Sharing their implementation experiences and a joint reflection about the possible redesign of their original LDs considering the lessons learned; (3) Last, participants were asked to answer a research questionnaire individually.

Interviews. We carried out seven semi-structured face-to-face interviews (three teachers from School#1 and four from School#2 –due time and resources constraints we could not interview all 24) of about 45 minutes each. The interviews consisted of a series of open-ended questions (see details in [4]) that invited participants to share their perspectives regarding (1) how they used to design and document their educational practices before knowing our tool and (2) how was the design process they followed during the workshops using edCrumble.

Results from this co-creation phase gave rise to a series of design principles (collected in [4]) and facilitated the development of the tool through different prototype versions (see Fig.1. Development phase). Workshops 1 and 1.2 reported about the LD process using the tool. Whereas workshop 2 allowed to study how was the use of edCrumble for redesigning teachers' own LDs and for understanding others' LDs.

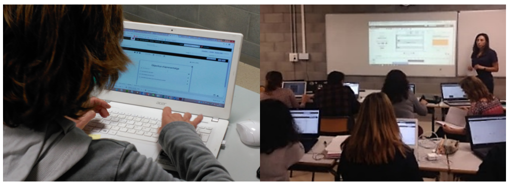

Fig. 3. Development workshops' participants working with the online prototype of edCrumble.

2.5 Co-creation activities during the evaluation phase

Evaluation workshops. Each workshop consisted of a role-play game where participants were placed in groups of 2-4 people. Each group of participants represented an imaginary school and each participant of each group represented a teacher of a topic (simulating different educational communities). The role-play game had two main parts (individual and in group) which each of them had three steps.

The individual activity (at "imaginary" teacher-role level) consisted of: (1) Design of a short teaching unit with the ILDE2/edCrumble online version –a printed LD was provided by the researchers for each teacher role (see Fig. 4. *left*); (2) Analyse the data resulting from the elaborated LD; and (3) Sharing the design created within the ILDE2/edCrumble community. Whereas the group activity (at "imaginary" school-role level) implied: (1) Grouping several designs to generate community analytics; (2) Solving an educational challenge; and (3) Discussing results with all participants.

At the end of the workshop, researchers asked participants to fill in a research questionnaire for evaluating edCrumble. Last, participants were asked to discuss in groups about the educational problems which they think edCrumble can solve as well as those not solved by the tool but can or should be addressed in future versions.

Fig. 4. Printed LDs for each teacher role during the *evaluation workshops* (left); Participants of the *evaluation study* working with edCrumble online version (middle and right).

Evaluation Study. The evaluation study had the following phases (see Fig.1.):

1. PHASE S1 (Registration): students registered voluntarily for the study indicating 3-5 subjects of their bachelor's degree which they would like to report.
2. PHASE S2 (edCrumble design work): researchers assigned the subjects to the students registered depending on their preferences. The workshop was about 2h:
   a. 10 minutes: students signed the consent form and a document with information about their bank account (they received 15€ as complementary compensation).
   b. 15 minutes: researchers explained the aim and procedure of the study and did a short demonstration of how to document a course plan in edCrumble.
   c. 80 minutes: students worked with edCrumble in their computers to introduce the course plan on the system (Fig. 4. *middle and right*). Students were asked in advance to come sufficiently prepared to be able to report the course's LD.
   d. 15 minutes: students filled out the first research questionnaire which had two main objectives: (1) ask students about their opinion about blended learning and course design; and (2) evaluate edCrumble.
3. PHASE S3 (evaluation and design readjustments): based on the subjects introduced, researchers prepared a second questionnaire with the aim of crosschecking the different designs introduced on the system, so each subject could be validated by other students. After one week, students received the second research questionnaire by email, and based on their responses, researchers readjusted the LDs in the edCrumble system (validating the LDs reported).
4. PHASE P1 (blended learning survey): professors answered a questionnaire about blended learning and course design.
5. PHASE P2 (design interviews): based on the subjects introduced by the students and the responses of the professors' questionnaire (phase P1), researchers made a list of possible professors of interest on being interviewed. Interviews were carried out with the aim of discussing the resulting visual representation of the LD obtained with the edCrumble and if they would introduce some changes based on the information received from the study (using the tool).

3 Discussion and lessons learned

3.1 Participants' recruitment process and motivation

Being recruiting participants a challenging task, we used several sources to recruit them: two local teaching innovation conferences and the frame of three research projects. The project with the schools was the unique case where we had the opportunity of having the same group of participants during more than one workshop. In the other cases, participants only attended one workshop, being difficult for them to appreciate the complete picture of the whole co-design process and feel that they were part of something beyond the isolated activity in which they participated. Moreover, in each of these workshops, we needed to save workshops' time for explaining the research context and ask them collaboration (permission for collecting their data). Whereas in the case of the project with the schools, we only needed to do this task at the beginning of their first workshop (saving time in the rest of the workshops). Nevertheless, working with the same teachers during a long-time period (nine months) was also challenging in terms of keeping their motivation with the activities. Specially, because the workshops were during the academic course, after classes. Due to their restricted availability, we adapted ourselves to their schedule when negotiating the dates and times (sometimes shortening the workshops' time or avoiding weeks where they had more work) despite they were agreed collaboration partners in the framing of the research project (with a complementary compensation to the schools).

Both strategies (isolated and long-time period workshops) had advantages and inconveniences, but we believe that this combination has been the key to be able to carry out the co-creation process during all phases. Since we have been able to schedule the workshops on the fly (higher degree of flexibility) bearing in mind the needs of our research along its whole process (it would have been difficult to elaborate a completed plan from the beginning). Furthermore, having different participants' sources have allowed us to work with different stakeholders, including a group of experts in TEL during the conceptualization phase which added value to our process.

3.2 Managing workshops' time and participants' expectations

Due to our context, the workshops had to contribute something to the participants beyond participating in a co-creation process –in almost all workshops we did, the co-creation was not the unique goal: e.g., how to design blended learning with MOOCs or with data analytics (conference workshops), learning PBL and FC methodologies (schools' project) etc. This was good for attracting participants, but it was challenging in terms of managing the limited time and expectations. While we were teaching something to the participants, we had to collect data and fitting the corresponding co-creation activity (using edCrumble somehow). The hardest point was managing participants' expectations, finding a balance between their collaboration in our research and our contribution to them in terms of learning something in the activities (especially because time was always very limited:1-2h). E.g. during the development phase, it was a bit demanding for participants learning a new software and creating a LD. For this reason, in the case of the *evaluation workshops* we used a role-play game (LDs were already prepared). Therefore, they felt more relax, since they could enjoy the tool without feeling pressured to have their own LD ideas in parallel.

3.3 Potential and challenges of the co-creation methods used

Table 2 shows a summary of the pros and cons of the methods selected with the aim of enriching our lessons learned and serve others thinking on similar scenarios.

Table 2. Evaluation of the methods used during the edCrumble co-creation process.

Method	Pros	Cons
Paper proto-type	Reducing development time-effort. High flexibility in the expression of ideas by the participants.	Time/cost consuming (preparation of the materials, analysis of the resulting paper artefacts). Participants engagement depending on their profile (some people are reluctant to collaborate in activities that require crafts).
Web-based proto-type	High satisfaction of the participants at the end of the process in feeling that they have collaborated in creating something real. Possibility of collecting system' data for the analysis (e.g. log files).	Need of managing frustrations during the early phases (early-prototype errors and usability low developed, sense of losing time…). Developing time and cost consuming.
Questionnaire	Valuable individual time for participants reflection and expression of their ideas and opinions.	Finding a balance between the time needed to carry it out (workshop time consuming) and the number of items to get the necessary data.
Focus group	High flexibility in the expression of ideas by the participants. High quality data	Qualitative analysis with high time consuming.
Sharing & discussing	Participants can discuss their own cases and exchange experiences (learning from others).	Depending on the num. of participants, high amount of time is needed. Need of moderate the discussion when short time available (keeping the focus, ask relevant questions, select only representative cases for sharing…). Qualitative analysis with high time consuming.
Role-play game	Reducing participants' required effort on preparing their cases (saving workshop time).	Participants not experiencing their own cases.
Interviews	High quality data High flexibility in the expression of ideas by the participants.	Participants' limited availability (in our isolated workshops: difficult to have the opportunity to keep in contact with participants and ask them collaboration; in our project workshops: teachers' time limitations). Qualitative analysis with high time consuming.

3.4 Prioritization of feedback diversity

Despite the feedback collected was very diverse during all process, the most challenging phase regarding its prioritization was during the development of the online tool. We had to be able to analyse the feedback after each workshop and prioritize it to prepare a new version for the next workshop. The prioritization process was always a balance between considering the feasible points to be developed in the time we had until the next workshop, and that a direct proposal from the participants would always be included to motivate them to continue in the process (since during the use of the first versions it was quite frustrating for them to use a system that was not yet very usable). Having new versions of the prototype in each workshop allowed us to advance considering participants' insights and engaging them in the co-creation process.

4 Conclusions

During the co-creation process of edCrumble, researchers used several participants' sources, different methods and participatory design workshop types (isolated vs. long-time). Co-creation had a positive impact in the design and decision-making process of our research, but it also presented some challenges. We hope that this experience and the challenges documented can help other researchers who are thinking of using co-creation in the design of teacher tools.

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3.2 Blended learning with MOOCs: towards supporting the learning design process

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Blended learning with MOOCs: towards supporting the learning design process

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Abstract

For some time now, universities have been making a significant effort to develop Massive Open Online Courses (MOOCs). One way to leverage the effort invested in developing and carrying out MOOCs is to use the online courses or parts of them in traditional brick-and-mortar courses that are delivered on campus. There are several learning design strategies that consider the combination of face to face (f2f) learning in university courses with one or more MOOCs, though teachers are generally only familiar with the most typical approaches – for instance, the flipped classroom. The variety of combinations and possibilities offered by this type of education constitutes a new learning design space whose full potential is underexplored. The aim of this research is to present and explore the affordances offered by an authoring tool devoted to support the design of blended uses of MOOCs and its impact in the resulting learning designs. A workshop has been carried out with the objective of supporting participants in exploring the possibilities of using MOOCs in combination with the courses typically offered on university campuses. Participants were mainly university teachers as well as academic and administrative staff responsible for supporting the development of MOOCs. Results indicate that the authoring tool can support the process of learning design involving blended learning scenarios with MOOCs and can contribute to expanding the knowledge of this type of learning in teachers.

Keywords: MOOCs; blended learning; blended MOOCs; bMOOCs; hybrid MOOCs; hMOOCs; learning design; higher education; teachers

1. Introduction

Massive Open Online Courses (MOOCs) are shaking up institutions of higher education, forcing them to rethink their traditional face to face (f2f) teaching practices, and pushing them to increasingly consider new educational scenarios in which blended learning approaches make use of MOOCs (Andone, Mihaescu, Ternauciuc, & Vasiu, 2015; Bruff, Fisher, McEwen, & Smith, 2013; Holotescu, Grosseck, Cretu, & Naaji, 2014; Rayyan et al., 2016; Emanuel & Lamb, 2015).

The use of MOOCs in blended learning practices can bring pedagogical benefits to students as well as offer challenging opportunities to teachers "for improving their knowledge in their own area of expertise and for improving their competencies and skills for adopting new models of open educational practices" (Holotescu et al., 2014; Dunn, 2015). Although universities are the ones who usually provide some of the resources and part of the support to carry-out new MOOCs, most of the time professors themselves are the ones who first propose the idea and lead the development – often without receiving any recognition for the extra work. Moreover, the costs of developing MOOCs are much higher than the costs of developing most f2f classes. Therefore it makes sense to take advantage of these investments by amortizing or reusing the materials of the online course in traditional brick-and-mortar courses delivered on campus as a way to achieve a blended class (Dunn, 2015).

There are several learning design strategies that consider this combination (Delgado-Kloos, Muñoz-merino, Alario-hoyos, Ayres, & Fernández-Panadero, 2015; Albó, Hernández-Leo, Barcelo, & Sanabria, 2015), though generally professors are familiar with only the most typical approaches – for instance, the flipped classroom (Tucker, 2012). The variety of possibilities offered by this type of education constitutes a new learning design space whose full potential is underexplored. The hybridization can range from a teacher who has her own MOOC and wants to use it in her classes on campus, to more complex forms of blended learning in which the teacher has no MOOC of her own and the required course materials are drawn from multiple external MOOCs, as well as from other online sources (Bruff et al., 2013). Moreover, there is a need for sharing educational practices involving the use of MOOCs in blended practices in order to offer more quality learning opportunities to learners since few cases comparing the results of such experiences have been documented (Rayyan et al., 2016; Albó, Hernández-leo, & Oliver, 2015).

Furthermore, we are facing a new stage in which teachers have begun to act as learning designers – designing their own teaching experiences according to the specific educational needs and objectives of their teaching contexts and needing some guidance in the reflective practice of teaching (Laurillard, 2008). Aligned with the emergence of this new stage, the field of learning design (LD) specifically addresses these challenges by providing guidance of how to implement and adapt a particular LD as well as facilitating the sharing of best educational practices (Dalziel, 2015). A LD which comes in many forms and levels of detail provides a model through which the specific intentions of a particular learning context are articulated (Lockyer, Heathcote, & Dawson, 2013). Specifically, this approach has been found useful "for faculty to document their own practice, for instructional designers to document the practices of those they may work with, and for both faculty and designers to interpret the practices of others" (Agostinho, 2011). Educators intending to use MOOCs in blended classes "should consider how to best incorporate each online element into their overall pedagogical strategy, including how interaction with those elements is to be incentivized" (Emanuel & Lamb, 2015).

In this context, this paper explores design elements which may be helpful in supporting teachers during the process of designing hybrid experiences using MOOCs, and contributes to research upon which an authoring tool devoted to supporting the design of blended uses of MOOCs will be built. A workshop – "the most common way of attempting to develop academic capability" (Salmon & Wright, 2014) – was offered to teachers with the aim of testing a proposed design workflow which will form the basis of the authoring tool. The workflow presented was centred on the LD in order to spur the thinking of teachers surrounding how new strategies could be applied to existing subject designs (Bennett, Lockyer, & Agostinho, 2004).

2. Purpose of current study

The aim of this research is to study what variations of blended learning with MOOCs are emerging from the higher education context as well as which design elements – including existing hybrid MOOC frameworks, models, patterns and metrics – are necessary in order to build the basis for an authoring tool that can help professors during the learning design process.

3. Methodology

This study was conducted using convergent mixed methods research design (Creswell, 2002) – due to the nature of the data collected, which were both quantitative and qualitative – to analyze the workshop results and understand the research problem. In the following paragraphs the context of the workshop as well as the instrumentation, data collection and analysis will be discussed.

3.1 Participants and sample

This paper presents the results of a workshop held at the University of Barcelona at the UCATx 2016 annual conference. UCATx is a MOOC platform resulting from a joint venture between the Catalan government and universities. Among the 24 people who attended the workshop, 52% were staff responsible for supporting the development of MOOCs in their universities; 33% were university teachers from ten Catalan universities; 5% were university students; 5% were researchers; and 5% were university staff with no direct responsibility around MOOCs. Out of the 24 participants, ten were involved in f2f teaching and seven in MOOC production or instruction.

The sampling technique used was not probabilistic as the participants at the workshop attended voluntarily when they registered for the conference. Despite the sampling being accidental, the group's main characteristics are shared with those of the population of interest of the current study: people connected and experienced with MOOCs who are interested in learning how to use them in blended learning approaches on campus, which was the main topic of this year's UCATx conference. On the other hand, the size of the sample is not large enough to draw general conclusions and must be taken into account in the possible generalization of the results. However, the main purpose of the study is to ensure that the results obtained from the field work are consistent and coherent, which then maximizes internal validity as it is a first iteration of an ongoing design-based research within a larger research project.

3.2 Procedure and materials

The workshop lasted two hours and participants were divided into seven workgroups. The workflow of the activity was a five-step process (see Fig. 1.) based on the H-MOOC framework by Pérez-sanagustín, Hilliger, Alario-Hoyos, Delgado Kloos, & Rayyan (2016). This framework assesses the MOOC-based hybrid initiatives based on two factors: the institutional effort to apply the initiative and the alignment with the curriculum. Once the framework is defined, the authors place the four basic hybrid models within the four quadrants of the framework: (1) MOOC as a service; (2) MOOC as a replacement; (3) MOOC as a driver; and (4) MOOC as an added value. Additionally, using the same H-MOOC framework, they also classify the six models of Delgado Kloos et al. (2015) plus two more models (Pérez-sanagustín et al., 2016), resulting in eight models in total: (1) Canned digital teaching with remote tutoring; (2) Canned digital teaching with face-to-face (f2f) tutoring; (3) Local digital prelude; (4) Flipped classroom; (5) Canned teaching in f2f course; (6) Remote tutoring with f2f course; (7) Canned teaching with remote course; and (8) Remote tutoring in remote course.

The aim of the workshop activity was to challenge each participant to design a blended-learning university course using MOOC(s) assuming that the MOOC(s) used during the design are already available.

The course could be either online or face to face. The possibilities for using massive online course(s) in the blended-learning approach were totally free and ranged from the MOOC(s) being only an optional supplement to the basis of the university course. Materials used during the workshop were: at least one LD template for each participant (see Fig.1a); three H-MOOC frameworks (see Fig.1b, 1c, and 1d) printed on A3 sheets in order to share them with the rest of the members of each workgroup; and at least one LD example for each of the 8 hybrid models mentioned above per workgroup. The three framework sheets were placed one above the other according to the workshop workflow order. Also, each workgroup had a translucent A3 sheet placed on top of the three framework sheets, which allowed participants to draw on it during the different stages of the activity. Next, the five-step workflow process is described:

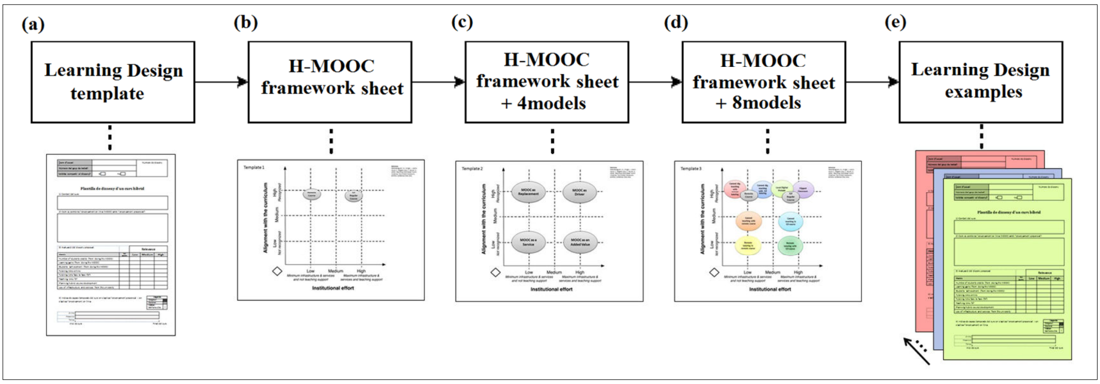

Figure 1: Five-steps workshop workflow and materials.

(a) Learning Design template. During the first step, participants had to think about their own blended learning design with MOOCs. The LD template, which was divided into six sections, was provided in order to help them during this process of getting the first idea for their learning designs. Participants had to fill out the first four sections of the template: (1) describing the context of the course; (2) specifying how the combination between the MOOC(s) and university course will be made; (3) evaluating the proposed design by indicating the relevance – low, medium, high, does not apply – of the following specific metrics: number of student credits; learning gains and student achievement (from doing the MOOC); online tutoring and f2f time; f2f teaching time; planning hybrid course development and use of university infrastructure and services; and (4) drawing a temporal diagram indicating the online and f2f teaching time. Each participant had to try to fill out at least one LD template with one idea. Afterwards, they had to share their designs within the workgroup and discard the designs that were very similar.

(b) H-MOOC framework sheet. In the second step, they had to place the resulting designs from the previous step in the H-MOOC framework sheet by drawing an identification number inside a circle for each LD. It is worth noting that they were not drawing directly onto the framework sheet but instead on a translucent sheet placed on top of that.

(c) H-MOOC framework sheet + four models. In this step, first of all, participants had to put the second sheet under the transparent one: the H-MOOC framework with the four hybrid models. Thus, after changing the sheet, they could see the positions of their designs in relation to the positions of the four models and check whether, in some cases, designs and models overlapped. After checking if they agreed with the model or models closest in the framework to each LD, they could adjust the LD positions to get closer to the desired model – drawing the ID number again inside a circle and indicating the change in posi-position with an arrow.

(d) H-MOOC framework sheet + eight models. As before, it was time to switch to the third sheet while keeping the translucent sheet above. After the sheet change, they could see the positions of their designs in relation to the positions of the eight models and check whether, in some case, designs and models overlapped. A short description of the eight models was provided to participants to check whether they agreed with the results. After checking if they agreed with the model or models nearest to each LD, they could adjust the LD positions again in the framework to get closer to the desired model – drawing the ID number again and indicating the change in position.

(e) Learning design examples. Finally, real examples of the eight hybrid models were provided in order to provide more information about the applicability of the models. Participants were invited to consult the examples of the closest models to the positions of their LDs and adjust the characteristics of their design by filling out the last two sections of the LD template and editing the other sections from the first step of the process.

3.3 Data collection and analysis

First, this study used an online questionnaire to gather the data from the participants throughout the workshop activity process. After completing each step of the workflow, participants had to answer some questions from the questionnaire. Additionally, the completed LD templates as well as the translucent sheets – with the participants' LDs and changes in position within the framework sheet – also provided useful data. Finally, five researchers took notes throughout the design process while they were observing the activity. In order to ensure that our findings and interpretations were accurate, this research uses triangulation of the data – both quantitative and qualitative - gathered from all four sources.

4. Results

Before discussing the specific results, it is necessary to note that each participant completed one LD template. However, after they shared their designs within the workgroup and discarded those which were very similar, the participants worked with, in the end, 20 LDs, on which the following results are based. Furthermore, the context of the results, where participants received support from three types of analytical instruments characterizing the learning design in progress – the H-MOOC framework; the models, either in groups of four, or eight; and real LD examples of the eight models – should be highlighted.

4.1 Providing design support from an holistic framework and models had an impact during the design process

Based on the questionnaire responses and the translucent sheets where all participants placed their initial designs in the H-MOOC framework depending on its two dimensions – the institutional effort to apply the initiative and the alignment with the curriculum – during step (b) of the workshop workflow, it can be stated that 11 participants out of 20 (55%) completed this step without reporting any issues, whereas nine of them (45%) had some problems during the process. Among the challenges that they encountered, it is worth noting their difficulties in understanding the x-axis, representing the institutional effort to apply the initiative, of the H-MOOC framework. Moreover, it was found that the y-axis, representing the alignment with the curriculum, was not relevant for some groups such as those, for example, in lifelong learning contexts.

Fig.2 is a visualization of the positions of all 20 LDs as well as their changes in position in the seven translucent sheets collected. In addition to the drawings – and in order to crosscheck the data related to the design locations – the questionnaire included specific questions in each step on whether they had changed the positions of their designs in the framework after consulting the models. As a result, in step (b) of Fig.2, it may be observed that the initial positions of the LDs, which were placed before the models had been revealed to the participants, in the H-MOOC framework were well distributed. However, after the 4 models were revealed and discussed during step (c), 18 out of 20 (90%) of the participants changed the position of their designs in the framework (see Fig.2 step (c)). Finally, after doing the same with the description of the 8 models, 15 out of 20 (75%) changed their positions from the previous step (see Fig.2 step (d)). It can be stated that, after this step, most of LDs were placed in the upper-right corner of the H-MOOC framework, were *Flipped Classroom* and *Local Digital Prelude* models were situated.

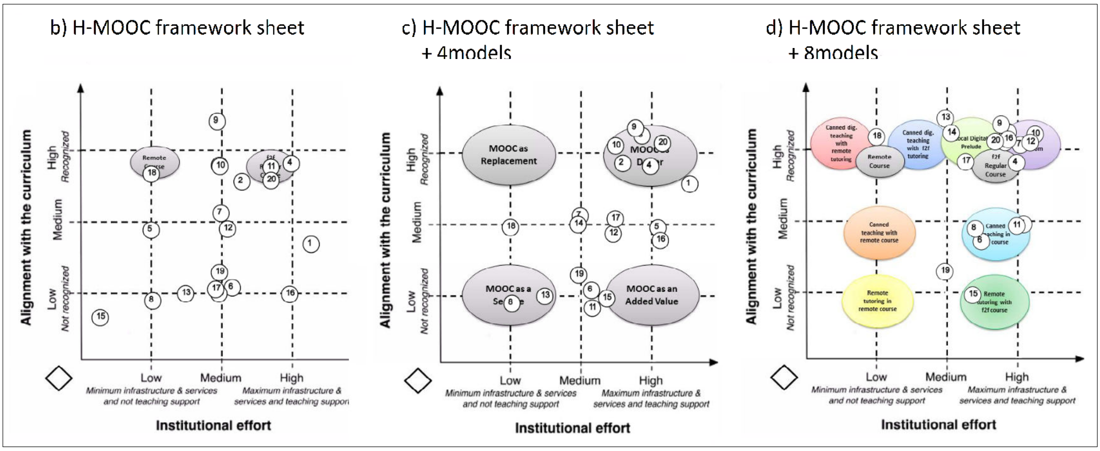

Figure 2: Participants' learning designs (LD) positions within the H-MOOC framework during the steps (b), (c) and (d) of the workshop workflow. Each LD has been represented by an identification number inside a circle.

The movements of participants' LDs in the templates during the steps (b, c, and d) of the workshop workflow can be interpreted as a process of rethinking, recognizing and repositioning their initial LDs 'ideas whereas they are taking into account the information provided by the H-MOOC framework and models. Aligned with this finding, after participants completed the step (d), they had to indicate in the questionnaire the level of utility of the models consulted during the design process (see Table 1). Most of participants agreed (40%) or strongly agreed (30%) that models had been useful help them in redesigning or being convinced with their LDs – with a resulting average of 3.85 points out of 5.

Table 1: Utility level of the models

Models have been useful help me in redesigning or being convinced with my LD		
Level of agreement	#	%
5. Strongly agree	6	30
4. Agree	8	40
3. Neither agree nor disagree	4	20
2. Disagree	1	5
1. Strongly disagree	1	5
Mean: 3.85 out of 5	*n=20*	*100*

4.2 Providing design support from LDs examples of the models had an impact on the final designs

Fig.3 shows the behaviour of the participants during all the steps of the workshop workflow – the results from the steps (a-d) have been described above. How it can be seen in the graph, after consulting the LD examples during the step (e) of the design process, four out of 20 (20%) participants changed their LD's positions in the H-MOOC framework sheet. Moreover, 13 out of 21 (62%) wrote modifications on their LD templates regarding their initial designs. They adjusted the characteristics of their design by filling out the last two sections of their LD template and editing the other sections from the first step of the process adding small changes, deciding between two models, changing the initial model, redefining metrics and so on.

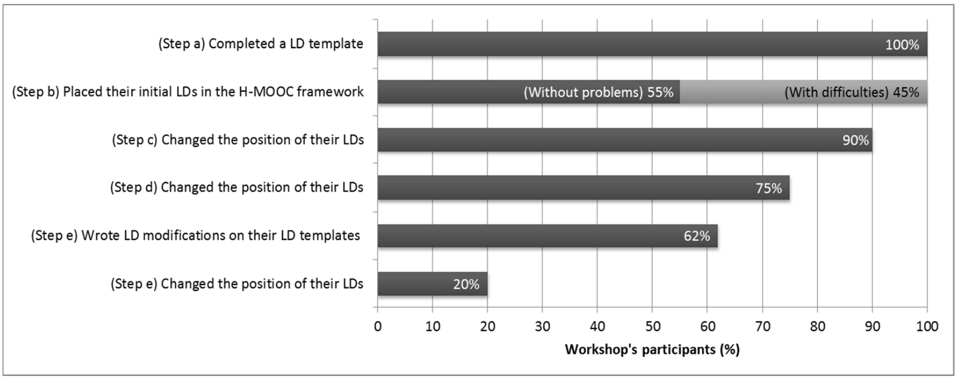

Figure 3: Participants' behaviours during the 5 steps of the workshop workflow.

In addition to this, it has been found significant differences (*t-test* for equality of means was performed with a two-tailed value of p being 0.027) in behaviour between different participants' social profile. The number of LD's movements on the sheets during the design process was higher in the case of university teachers. University staff – responsible for supporting the development of MOOCs – did 1.2 movements on average whereas university teachers change their LD's positions 1.86 times.

Returning to the analysis of the impact of the LD examples, once participants completed the step (e), they had to indicate in the questionnaire the level of utility of the LDs examples consulted during the design process (see Table 2). Most of participants agreed (30%) or strongly agreed (45%) that LDs examples had been useful help them in redesigning or being convinced with their LDs – with a resulting average of 4 points out of 5 – these are better results compared with the level of utility of the models. This result is supported by the LD movements done after the step (e) as well as the annotations in their LD templates mentioned before.

Table 2: Utility level of the LDs examples

LD examples have been useful help me in redesigning or being convinced with my LD		
Level of agreement	#	%
5. Strongly agree	9	45
4. Agree	6	30
3. Neither agree nor disagree	2	10
2. Disagree	2	10
1. Strongly disagree	1	5
Mean: 4 out of 5	*n=20*	*100*

Fig.4 presents the LD's positions regarding the models during the step (d) – where participants had known the eight models – and the step (e) – where real examples of the models had been provided. As it can be seen in the graph, after the step (d), 45% of the participants had their LD overlapping one model whereas 50% of them were hesitating between two models. Moreover, 5% had their LDs between more than two models. However, after participants consult the LD examples of the models, 75% of them had their LD overlapping a unique model and only 25% had their LD between two models. This result indicates that LD examples of the models had an impact in the final decision of choosing the model to use in their LD, supporting the above findings.

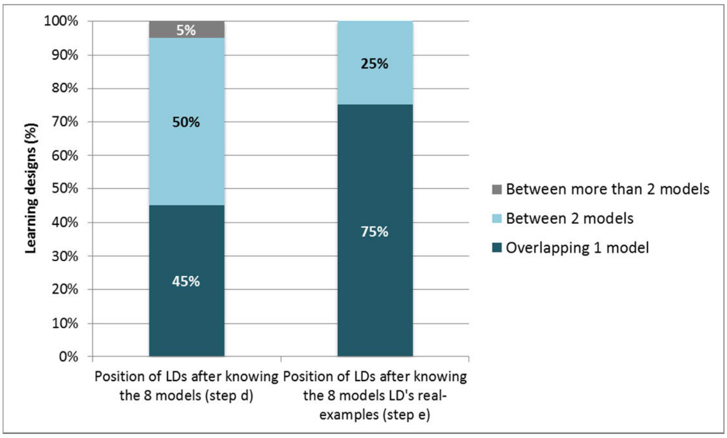

Figure 4: LD's positions regarding the models during the steps (d) and (e) of the workshop workflow.

The Table 3 shows the final models selected after consulting real examples of LDs. Flipped classroom (FC) and Local digital prelude (LDP) were the two models more selected by the participants – 25% of the participants selected the first one and 20% the second. Moreover, 20% of the participants end the workshop activity placing their LDs between these two models. At the end, it can be seen that 65% of participants selected one or both models – FC or LDP – after consulting the examples. The third model selected by more participants was Canned teaching in f2f course (20%), followed by Remote tutoring with f2f course (5%) and Remote tutoring in remote course (5%). Finally, one participant placed their LD between Canned digital teaching with remote tutoring and Canned digital teaching with f2f tutoring.

Table 3: Models selected after the step (e) of the workshop workflow

Models selected after the step (e)	Frequency	Percentage	Accumulated percentage
Flipped classroom (FC)	5	25	25
Local digital prelude (LDP)	4	20	45
Between FC and LDP	4	20	65
Canned teaching in f2f course	4	20	85
Remote tutoring with f2f course	1	5	90
Remote tutoring in remote course	1	5	95
Between Canned digital teaching with remote tutoring and Canned digital teaching with f2f tutoring	1	5	100
Total	20	100	

5. Discussion

Although this research is still in its early stages – it is a first iteration of an ongoing design-based research within a larger research project – results indicate that the five-step design workflow presented can be used as a basis for supporting teachers in the design for blended learning experiences using MOOCs. Providing three types of analytical instruments characterizing the learning design in progress (H-MOOC framework, models and real examples) can support the design process and help teachers in redesigning or being convinced of their initial LDs. The workflow introduces a process that goes from a broad – general framework – to specific – real examples of the models. This way of working is used by other disciplines that use design processes (Laurillard, 2008). If the process would had begun backwards, teachers would had to consult all the models and examples from the beginning – without knowing the learning context – with the result of increased time consuming and less understanding of all the possibilities. The five-step workflow acts as a filter, by guiding teachers towards providing the most relevant information for them during the design process, at the same time that promotes design thinking.

In the first step of the process, all the participants completed an LD template to write the first sketch of their LD. During the second step of the workflow, the H-MOOC framework presented has provided to them a holistic context where teachers have placed their LDs. During this step, teachers were placing their LDs on the framework while at the same time they were reflecting about the objectives of their LDs regarding the two dimensions of the framework. Basically, the difficulties found in this step are related to definition of the two dimensions of the H-MOOC framework, as they address issues related to institutional concerns. Further research is necessary in order to find other dimensions of possible frameworks focused on teachers' interests as well as informal learning contexts.

During the third and fourth steps, participants were moving the positions of their LDs around the framework, whereas they knew the different models provided. The movements can be interpreted as a result of design thinking, process of reflection about their own designs while they are designing. In each step, teachers had to think if they agreed or not with the new information characterizing the ongoing designs – which it was changing in each step – and act in consequence – moving or not the positions of their designs. In line with this result, participants stated that models had help them to redesign or being convinced of their LDs. Supporting this finding, Laurillard (2008) suggests the use of models, arguing that "any theory of learning will necessarily generalize at some level, leaving to the teacher the task of interpreting the general for the specific case". In addition to that, results indicate that the variations of blended learning with MOOCs emerging from the higher education context are the most known models: basically the flipped classroom and Local digital prelude. Despite this, highlight that seven out of eight models were considered at least by one participant - only the model Canned teaching with remote course was not finally selected. Moreover, is necessary to add that those who placed their LDs between two models could be a sign of hesitating but also a possible intention of wanting to combine both in one single LD – which presents a need for exploring new models.

In these steps, some behavioural differences have been found depending on the social profile of the participants. Teachers could be more motivated to participate in the workshop as they could apply the knowledge learned directly in their classes or in real blended learning experiences – as a result they did more movements of their designs showing this motivation. On the contrary, university staff may assist the workshop to get knowledge in order to help other teachers in their universities during the learning design process – so they had no classes to directly apply their blended LDs done during the workshop. As a consequence, they showed less motivation and did fewer movements of their LDs.

Finally, in the last step, it has been proved the usefulness of the LD examples of the models provided acting as a trigger for thinking about adjusting – writing modifications in their LD templates and selecting their ultimate models – their final LDs. Results indicate that teachers have been found more useful the LD examples than the models provided. Some authors have been reported similar findings, Bennett et al. (2004) states that "teachers seem to find specific examples of learning designs –those that retain information about the original context for the design– more valuable than generic designs". Whereas Lockyer et al. (2013) interprets this statement suggesting that "teachers can use specific, detailed learning designs as examples and are able to adapt the ideas to their own context". To sum up, models have provided more specific context of the shape of teachers' designs whereas considering the real LD examples have been decisive to them to define the final design and wrote the final ideas to the initial LD templates.

6. Conclusions

The preliminary study presented in this paper shows that the use of design elements characterizing the design in progress – including existing hybrid MOOC frameworks, models and examples – can support the process of learning design of blended learning scenarios with MOOCs contributing to expand the knowledge of this type of learning to teachers. Moreover, the five-step workflow presented can be the basis of an authoring tool to support the learning design process as well as promoting design thinking.

However, further research is necessary in order to provide different hybrid MOOC frameworks depending on the educational contexts and stakeholders as well as considering new variations of the FC approach. Also there is a need of identifying the most relevant design elements for different domains in order to provide standards required for evaluating the quality of blended courses (Antoanela, Mustea, Holotescu, & Herman, 2015). Further studies with more participants can provide more evidence of how the behaviours differ in varied types of participants with the aim to offer personalized support to each social profile group. Moreover, it is necessary to explore more documented case studies of blended learning designs with MOOCs (Rayyan et al., 2016), which can act as new shareable examples of LDs – in this line, more investigation is needed into how generic versions of LDs are abstracted from the contextualised exemplars (Bennett et al., 2004) - and some of them probably can become future models. On the other hand, connected research has been done in the area of connecting LDs examples with Learning Analytics (LA) of the real experiences (Michos & Hernández-Leo, 2016) to support re-design processes.

Acknowledgments

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3.3 Conceptualizing a visual representation model for MOOC-based blended learning designs

The content of this section was accepted to a JCR-indexed international peer-reviewed journal and is in press:

Albó, L., Hernández-Leo, D. (2019). Conceptualizing a visual representation model for MOOC-based blended learning designs, *Australasian Journal of Educational Technology* (in press).

Conceptualizing a visual representation model for MOOC-based blended learning designs

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This paper reports a study about how MOOC-based blended learning (BL) designs can be visually represented to facilitate their comprehension and sharing. We have carried out an iterative co-creation process with different stakeholders to conceptualize a visual learning design representation model within the context of blending MOOCs with f2f courses. The data analysed comes from questionnaires and the generated representations. Results indicate that the representation allows educators to easily visualize the overall structure of the learning designs and the relationships between the different design elements, providing a context for fostering reflection and decision making during the planning of MOOC-based BL designs.

Introduction

There is a growing body of research that describes the significant impact that Massive Open Online Courses (MOOCs) have had on universities in terms of introducing changes to their forms of teaching and learning (Andone, Mihaescu, Ternauciuc, & Vasiu, 2015). Specifically, the use of MOOCs as part of face-to-face (f2f) regular university courses has emerged as a new form of blended learning (BL). MOOC-based BL designs have spread taking different forms and combinations (Albó & Hernández-Leo, 2017; Delgado-Kloos, Muñoz-merino, Alario-hoyos, Ayres, & Fernández-Panadero, 2015; Pérez-Sanagustín et al., 2017). But there is still abundant room for further progress in the sharing of these types of blended learning practices in order to explore their full potential as well as offer more quality learning opportunities to learners.

Whereas several studies support that BL has a positive impact on teaching and learning effectiveness (Garrison & Kanuka, 2004; López-Pérez, Pérez-López, & Rodríguez-Ariza, 2011; Means, Murphy, & Baki, 2013; Moskal, Dziuban, & Hartman, 2013), other authors highlight that "the studies of effectiveness lack consistency in what constitutes BL environments, and what outcomes are being compared" (Siemens, Gašević, & Dawson, 2015). Thus, there is limited evidence on which pedagogy or technology influence learning outcomes in BL scenarios (Arbaugh, 2014; Littlejohn & Pegler, 2007). Furthermore, and by extension, very little is currently known about the best ways of designing effective MOOC-based BL (Bralić & Divjak, 2018). Research in this line largely appear in the form of case studies composed of long text descriptions, which often provide design recommendations based on the lessons learned. Yet, they sometimes omit details about how the blended schema has been articulated (e.g. structure of the course, activity descriptions, technology used, or pedagogy applied). This hinders the final practitioners who want to understand the reported case, learn from it or even replicate it – encumbering the effective sharing of the BL practices as well as the evaluation and comparison of the final outcomes. Therefore, some studies report the need of providing support to practitioners who are willing to implement BL and helping them to face the challenges which arose during the process (Albó & Hernández-Leo, 2017; Moskal et al., 2013; Porter et al., 2014).

In this respect, the field of learning design (LD) might provide some light as one of its main aims is to provide support on "how to represent teaching practice in an appropriate form to enable teachers to share ideas about innovative online pedagogy and think about the process of design" (Agostinho, Bennett, Lockyer, & Harper, 2011). The use of a systematic way of representing BL designs would facilitate their comprehension and would allow the sharing and comparison between the outcomes of the different blended LDs to study their effectiveness in a more accurate way and to finally lead to an improvement of these types of practices. Thus, the main aim of this paper is to investigate how MOOC-based BL designs (as an example of complex blended learning) can be represented visually to facilitate their comprehension and sharing. The paper focuses on the following general research questions:

- G-RQ1: What are the necessary learning design elements to visually represent MOOC-based BL design?

- G-RQ2: How can these learning design elements be articulated in a visual representation to facilitate comprehension of the whole design?

To address these questions, we have carried out an iterative co-creation process with different stakeholders to conceptualize a visual BL design representation model for educators within the context of mixing MOOCs with f2f courses. The iterative process is composed of three cycles: 1) an evaluation of a first model proposal, 2) an evaluation of the second model proposal, 3) the formulation of the final model based on the evaluation results.

Visual representation of MOOC-based blended learning designs

Studies over the past two decades have provided important information on how to represent learning designs (Persico et al., 2013). While most of the frameworks used by the practitioners for describing teaching practices are text-based (Conole & Wills, 2013; Goodyear, 2004), some researchers highlight the potential of visual approaches for representing learning designs (Agostinho, 2011). Conole & Wills (2013) identified three benefits of visualization: (1) it can support teacher's design thinking; (2) it helps make the design explicit and sharable to others; and (3) it provides a way of representing and articulating the design process. These are part of the reasons why the representation we seek in this paper should be mostly visual. However, visual representations also present some challenges regarding the level of abstraction, which we have also considered during the conceptualization of our model. In some cases, graphical solutions can be too abstract for easy interpretation by educators and the time needed to use this type of representation can make their use not worth it – a similar abstraction challenge is well described in the case of pattern language by Winters and Mor (2009). Thus, it is necessary to find a balance between the capability of the graphical elements of the visual representation to be able to represent the educational practices and level of abstraction.

Most representations combine visual representations with text-based support. However, very few consider and highlight the BL concept as a challenge to be represented. In the meantime, debate continues on providing a definition of BL. Heinze & Procter (2004), define BL as follows:

> Blended Learning is learning that is facilitated by the effective combination of different modes of delivery, models of teaching and styles of learning, and founded on transparent communication amongst all parties involved with a course. (Heinze & Procter, 2004)

Littlejohn and Pegler (2007) present the concept of blended e-learning by defining it as a hybrid model that allows coexistence of conventional f2f teaching methods and newer e-learning activities and resources in a single course. Nonetheless, the authors argue that the term can often refer to proportion of e-learning (blended learning), the mix of media (media blend), or the way in which activities are used together (activity blend). They further add that there is also another way of looking at blending: as a combination of on-campus and off-campus activity – arguing that "the level of student experience with e-learning as well as their location relative to campus can be important factors in determining how, where and when to blend e-learning with conventional teaching". Other researchers claim that, by definition, education has always been blended and they highlight time and synchronicity as the primary elements of the learning environments (Norberg, Dziuban, & Moskal, 2011).

Turning to the key elements of an LD, most representations draw upon common model elements like activities (or tasks), people or actors (students and tutors) and resources. Thus, LD representations aim to define how these elements are related to each other, for example by defining how the activities are sequenced and which actors and resources are involved in them. To achieve this objective, Littlejohn & Pegler (2007) argue that sequencing requires a 'timeline'. Likewise, more authors highlight the importance of the time element in designing for learning, stating that a learning sequence is essentially time-based and that it demands a plan (Dalziel, 2003, 2015; Laurillard et al., 2013; Pozzi, Ceregini, & Persico, 2016). . Reinforcing the above arguments, a study by Lai, Portolese, and Jacobson (2017) has demonstrated that activity sequencing can have a meaningful impact on deep learning and transfer. Accordingly, we think that our model should have time (e.g. a timeline) as one of its main elements (according to which activities and resources are sequenced).

Regarding the resources, it is important to emphasize that in no case the particular representation of the use of MOOC-resources was considered when conceptualizing the representations listed above (even if in some cases they considered technology-enhanced learning interventions). We argue that the complexity of planning and representing BL which incorporates MOOCs is underexplored. Whereas problem-based learning (PBL) designs are considered by Littlejohn & Pegler (2007) as complex blended because of their non-linear sequencing of activities, planning MOOC-based blended courses also presents some challenges regarding time representation. MOOCs are bound to specific time offerings, they usually have registration periods and run during periods with their corresponding starting and end dates (there are cases when MOOCs remain open-ended or present other time configurations), often defined by the MOOC platform or by the owner of the course. Thus, these time constraints add complexity to the planning of MOOC-based blended courses, especially when a professor wants to use an external MOOC and needs to combine it with the schedule of their f2f course. In this context, time becomes an even more important factor as a key part of the design process as well as for planning the blended elements in advance. Thus, we argue that MOOC-based blended learning designs can be considered as complex blended learning, which need to be carefully planned, resulting in positive institutional transformation when this (together with receiving proper support) occurs (Moskal et al., 2013; Porter et al., 2014). Therefore, a visual representation of the MOOC-based blended learning designs is deemed necessary as it could help advance the planning and sharing of these types of educational practices by educators.

Methodology

Participants and sample

This study has the aim of defining the main structure and elements for the visual model in collaboration with the practitioners and experts. Thus, we carried out two workshops in different contexts scheduled according to opportunity: a teaching innovation conference and one research project event. Participants had different profiles depending on the workshop and, in total, 39 people attended (36% female) (table 1).

Table 1
Research contexts descriptions and participants' profiles

Context			Participants	
ID	**Dates**	**Description**	**Profile**	**Num. (#female)**
Workshop with practitioners	May 2016	Local teaching innovation conference	MOOCs related staff & university professors.	24 (9)
Workshop with experts	June 2017	Members of a research project event	Expert researchers on TEL –also with teaching experience.	15 (5)
			Total:	**39 (14)**

Of the 24 practitioners who attended the first workshop, 52% were staff responsible for supporting the development of MOOCs in their universities; 33% were university teachers; 5% were university students; 5% were researchers, and 5% were university staff with no direct responsibility around MOOCs. All participants were from ten Catalan universities (six public and four private) and attended the workshop voluntarily when they registered for the conference. Despite the sampling being 'accidental', the group's main characteristics are shared with those of the population of interest of the current study: people connected and experienced with MOOCs who were interested in learning how to use them in blended learning approaches on campus (Albó & Hernández-Leo, 2016).

In the case of the workshop with experts, participants were 15 researchers from four universities (three of them from different regions of Spain) and most of them had expertise in BL and/or LD (figure 1). Moreover, eleven participants had experience in teaching at undergraduate and/or graduate levels whereas two of them also had experience at high school level and another two in adult education. Only one participant indicated they had experience in primary school and another one in vocational training. Regarding the years of teaching experience, three of them had one year of experience, four participants had between six and nine years of experience and most of them (seven) had more than 10 years of teaching experience.

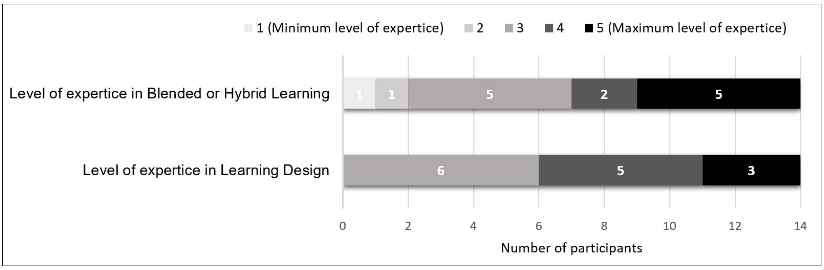

Figure 1. Participants' expertise level (workshop with experts)

Despite the model aiming to serve teachers as designers of (MOOC-based) blended learning scenarios, other roles such as institutional MOOC production of instruction staff may also be involved in this process. This is why all these stakeholders, as well as experts, are involved in the co-design process of the model.

Procedure and instrumentation

During the conceptualization phase of the visualization model, researchers applied co-creation (Albó & Hernández-Leo, 2018) and carried out two participatory design (PD) workshops using paper prototyping (Muller & Druin, 2002; Novick, 2000) activities (resulting in potential artefacts to be analysed). Participatory designers act as facilitators, empowering users in making their own decisions (Clement, 1994). As literature reports, including end-users as active participants in the technology design process (using PD techniques) can be both an effective means for improving technology designs (in our case the design of a visual representation), and a valuable resource in Design-Based Research (DBR) frameworks (Bonsignore et al., 2013; Muller & Druin, 2002). In our study, participants were sharing and discussing in groups and completed a final individual questionnaire for sharing their reflections with the researchers (figure 2). Firstly, researchers developed a first visual representation model proposal based on the existing literature about BL, which was used by the participants during the first workshop. Secondly, at the end of the first workshop, the first model was redesigned based on the workshop results (also with the support of the literature) leading to a second model which was used in the second workshop. Ultimately, the results of the second workshop allowed researchers to elaborate a final model proposal (see the red boxes in figure 2).

In order to evaluate the two intermediate models, we formulated three evaluation questions, listed as follows:

- E-RQ1. To what extent is it possible to represent a MOOC-based blended LD using the model?
- E-RQ2. Which are the main strengths and weaknesses of the model?
- E-RQ3. To what extent is the visual model helpful for understanding others' learning designs?

The above evaluation questions allowed us to identify which were the design elements that could contribute to clarify and facilitate the design comprehension, and in the process, to discard the ones which could confuse its understanding (answering G-RQ1). This was also aimed at validating the articulation potentialities of these elements within the intermediate models to propose a final articulation in the end (answering G-RQ2).

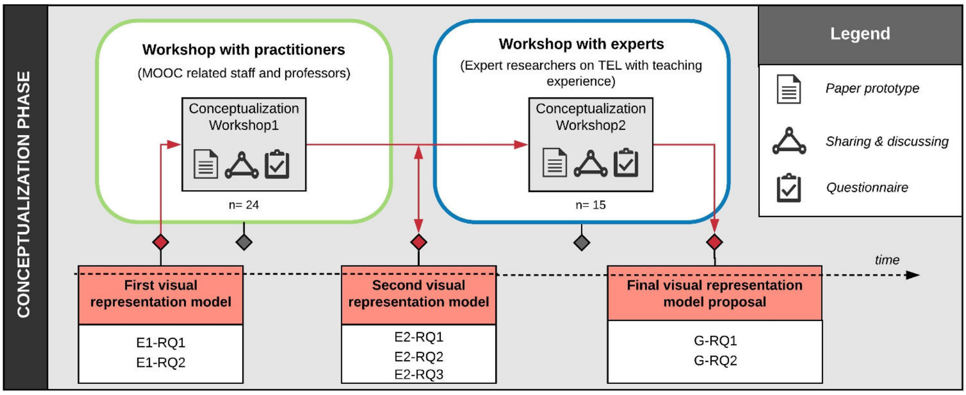

Figure 2. Conceptualization phase procedure and instrumentation.

The aim of the first 2h workshop was to challenge each participant to design a BL course using MOOCs. The workflow of the activity was a five-step process described in detail by Albó & Hernández-Leo (2016) and involved the use of printed materials. Specifically, one step of the workshop was asking participants to describe their own blended cases and represent them using the first visual model.

The main objective of the second workshop, on the other hand, was exploring with the participants how to visually represent blended LDs and how these visualizations can facilitate others' LDs understanding. In this event, participants did not work with their own cases. Instead, researchers prepared two cases' descriptions sheets (using MOOCs mixed with f2f courses) extracted from the literature (see the cases' descriptions on Appendix 1). Moreover, the main material used was a paper template with the second visual model. The template (figure 3) included the timeline as the main element of the visual representation and an empty space for placing paper activity cards below it. These cards were to be drawn and filled in with stickers by the participants using the legend provided.

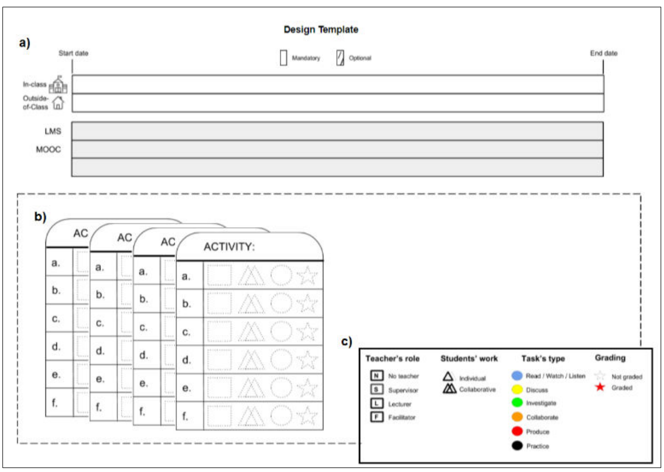

Figure 3. Material for the workshop. a) Printed visual LD model template in A3 paper, b) Activity cards, c) Legend for completing the activity cards with stickers

The second workshop lasted an hour and the 15 participants were working in groups of two/three people using a template per workgroup. The two printed cases' descriptions were divided equally between the existing groups, in such a way that half of the groups worked with one of the examples and the other half with the other one. Once each group had a case description sheet, they went through the following steps:

1. Read the case provided and represent it using the template sheet -placing the activities and the resources described in the case, using the timeline, and filling in the activity cards (and placing them on the sheet) (figure 3).
2. After completing the LD template for their case (figure 4 left), exchange the completed templates between work groups and interpret the template produced by another group, by only looking at the visual representation and without knowing the LD case description of the template received as the exchange occurred between groups with different cases.
3. Finally, each group could check if they had understood the template received by looking at the corresponding case description. Lastly, participants were asked to complete a questionnaire providing their insights about the process.

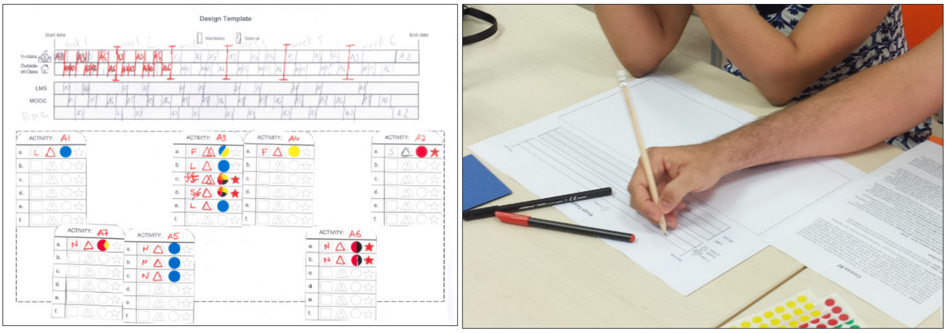

Figure 4. Design template completed (left) and participants filling it during the second workshop (right).

Data collection, analysis and ethics

In both workshops, the artefacts generated by the participants served as research data for the study. In the case of the workshop with practitioners, researchers collected the design templates which included the context and description of the participants' cases as well as their LDs representations using the first model. Similarly, the design templates of the workshop with experts (which used the second model) were collected for their analysis. Furthermore, at the end of both workshops, researchers requested participants to complete an online questionnaire to get their insights about the design process using the models (figure 2). In the questionnaire of the first workshop, researchers used an open-ended question to ask whether participants had found difficulties representing their cases using the model provided and to seek for suggestions for improving the model. The questionnaire of the second workshop had six questions presented as follows:

1. What difficulties did you find during the design process? (E-RQ1)
2. Indicate your level of agreement with: "The visual representation helped me to understand the learning design explained in the sheet" (E-RQ1)
3. What do you think are the main strengths of the visual representation? (E-RQ2)
4. What do you think are the main weaknesses of the visual representation? (E-RQ2)
5. Do you think it provides a useful summary of a learning design? (E-RQ1/RQ3)
6. What suggestions would you recommend to improve the visual representation? (E-RQ2/RQ3)

All questions were open-ended except the second one, which was a five-level Likert scale of agreement. The first question aimed to identify the main difficulties of using the provided model for its later improvement. The second question served to evaluate the model is usefulness for others. Finally, the last four questions –extracted from Agostinho (2011)– addressed the assessment of the representation usefulness. The resulting qualitative data from the questionnaires were coded with inductive thematic analysis driven by the research questions of each phase and were cross-referenced to justify interpretations. The main topics were then categorized in order of dominance and triangulated with the artefacts, resulting in a more in-depth analysis for corroborating the overall consistency of the findings.

The data collection and analysis have followed ethical considerations avoiding harm to participants, respecting confidentiality and ensuring that their participation was voluntary. At the beginning of the two workshops, researchers explained the context of the study and sought informed consent from the participants. In the case of the first workshop (where participants were expressing their own blended learning cases), researchers asked them explicit permission for sharing the generated artefacts. Therefore, only those designs for which they gave permission have been published in the final instance (anonymized) and used in this study (17 learning designs).

First model evaluation

The first model is based on a timeline composed of two layers: online and f2f learning (figure 5). The granularity of the representation is variable, and it is defined between the start and end dates of the module, course, or activity, depending on what the teacher is willing to describe. Within the timeline, the teacher can paint completely dark the parts of the timeline where the activity is mandatory or make stripes to indicate the parts of the timeline where the activities are optional for the students. In both cases, painting the corresponding layer is needed depending on whether the activity is online or f2f. In the case of this study, the online layer refers basically to online work which happens in a MOOC/s since participants of the workshop would report MOOC-based BL cases. By contrast, the f2f learning layer refers to the ‘brick and mortar’ classes at the university.

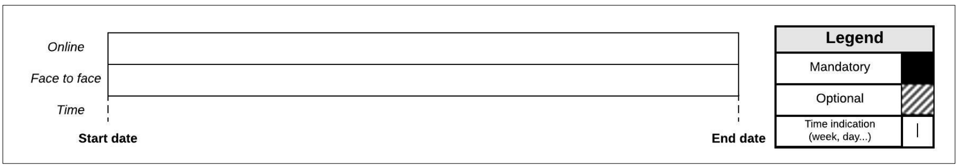

Figure 5. The first version of the model

The use of the timeline as one of the main elements of the visual representation is justified based on the discussion at the beginning of this paper. Furthermore, the two layers distinguishing between online and f2f refer to the definition of BL provided by (Littlejohn & Pegler, 2007). The importance of setting the obligatory nature of the activities is supported by the insights by Kirkwood and Price (cited by Littlejohn & Pegler, 2007) who stated that “where the use of new media is optional or incidental, students will typically not value material presented”. Thus, the blended elements could be undervalued, which would affect the overall design effectiveness evaluation. Therefore, we argue that it is an important factor to consider and visualize in the representations of BL designs to ensure an accurate comparison of the final outcomes.

The first evaluation aimed to provide an understanding of the potentialities and weaknesses of the first model and used the evaluation questions E(1)-RQ1 and E(1)-RQ2.

Results and discussion

All participants were able to represent their cases using the visual model provided with no major challenges (E1-RQ1). The questionnaire collected only three minor suggestions from the participants for improving the LD template without making direct reference to the visual representation model.

Turning now to the specific information gathered from the LD templates, the most striking result to emerge from the data is that the cases reported present a certain variability regarding how the MOOCs were integrated into the f2f course. The complete design descriptions and their corresponding educational contexts can be seen in Appendix 2 (Table A2-1). Interestingly, only looking at the text information provided by the participants in the LD template, it has been challenging to group them into similar cases, as from the description and context provided in some designs we did not find enough similarities to be able to put them in a specific group. Surprisingly, the visual representations compiled facilitate the LDs’ classification according to known pedagogical models much faster and easier (figure 6), allowing for the recognition of the existing variability in the designs in a totally visual way. Looking at the visualizations generated by the participants made it much more effective to classify the designs than only reading the description and context provided (what in some cases was confusing).

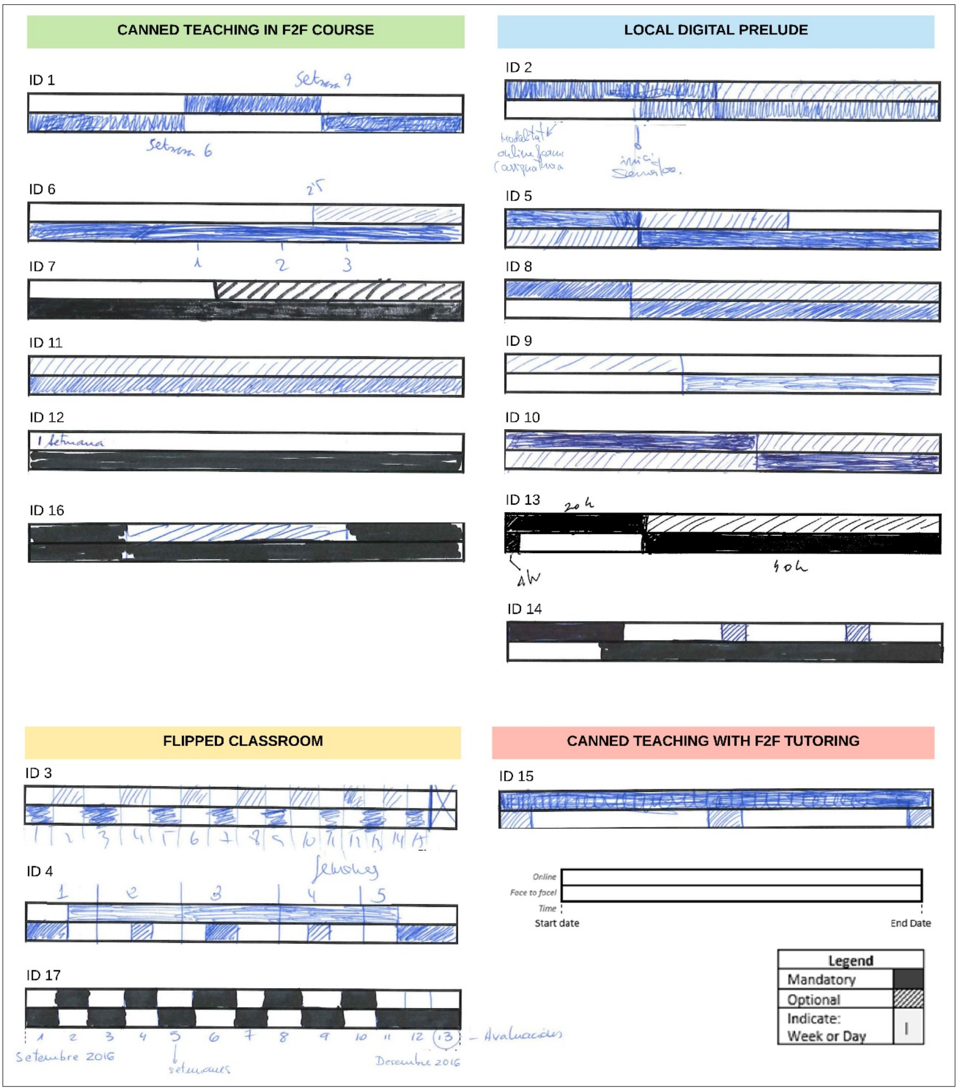

Figure 6. Representations' artefacts from the first workshop (visually classified according to their pedagogical model).

The four models of figure 6 have been extracted from other researchers' experiences with MOOC-based blended learning designs (Delgado-Kloos et al., 2015). One of the main strengths of the visual representation model (addressing E1-RQ2) is that it allows us to understand how the f2f teaching and the online work using the MOOC are related in terms of time, thus facilitating the identification of the models in a visual way. Lastly, the classification in figure 6 has been done only based on the visual representations and then researchers checked the corresponding LD text descriptions to corroborate the results. Only in three cases out of 17 (IDs 1, 4 and 12), the visual representations were somehow confusing, and it was necessary to consult the LDs descriptions provided as a complement to the visual representations to finally decide in which model they would be classified. An implication of this is the possibility that anyone can relate an LD to an example of a specific model without the need to be an expert (strength, E1-RQ2), facilitating the search for similar designs in a visual, easy and effective way, and avoiding long descriptions.

Regarding the weaknesses of the visual learning design representation, some limitations of the model have been detected (E1-RQ2). Firstly, it is challenging to visualize cases where the blended part differs from combining brick and mortar courses with online teaching from the MOOC. E.g., an online course from a distance university which uses MOOCs, where the f2f contact is left for non-formal hours – although this case can be considered as MOOC-based blended learning, it is not possible to represent it using the first model as it has only an online layer and it would be necessary to have more than one (i.e. one for the online course and another one for the MOOC). This is the case of representation ID 2 (figure 6) where the participant indicated, in the annotations next to the visualization, that she used the f2f layer to represent the online formal teaching part of the course. Secondly, it is important to highlight that although the simplicity of the model makes it easy to use and understand (strong point), at the same time it is a limitation in the sense of providing detail and depth in the information regarding the represented LD. In addition, the model stays in the surface layer of the MOOC-based blended courses as it does not allow for more depth into the representation of online activities which may occur in the f2f sessions, but which use other online sources different from the MOOC (virtual learning environment related activities, online educational applications, etc.).

Summarizing, the results show that it is possible to use the first visualization template representing MOOC-based learning designs (E1-RQ1)., The main strengths of the first model include providing a visual, easy and effective way of representing the blended LDs which facilitate their understanding and classification according to existing blended models. However, it has some limitations related to its flexibility and the lack of detail in descriptions or represent combinations of different types of blended elements beyond the f2f sessions with the MOOC (E1-RQ2).

Second model evaluation

In the second model, three main changes have been made from the first model. Firstly, instead of having an online and f2f learning layers, it has in-class and out-of-class activity (Littlejohn & Pegler, 2007). Secondly, below these two main layers, there are the resources layers (figure 7, layers in grey) which are extendable and can be defined by the designer depending on her needs. Lastly, below the activity and resources layers, there is an open space to place the activities detailed descriptions (using the corresponding template, figure 7). These modifications have been introduced to overcome the limitations of the previous model in relation to: (1) the representation of different types of blended learning which occur in the same course (online activities or resources beyond the MOOCs); and (2) the lack of detailed information about the design (and its activities and resources) that the first model provides. By contrast, in accordance with the positive results from the first model, in the second model, it is still possible to indicate whether the blended activities will be mandatory or optional by placing time indications.

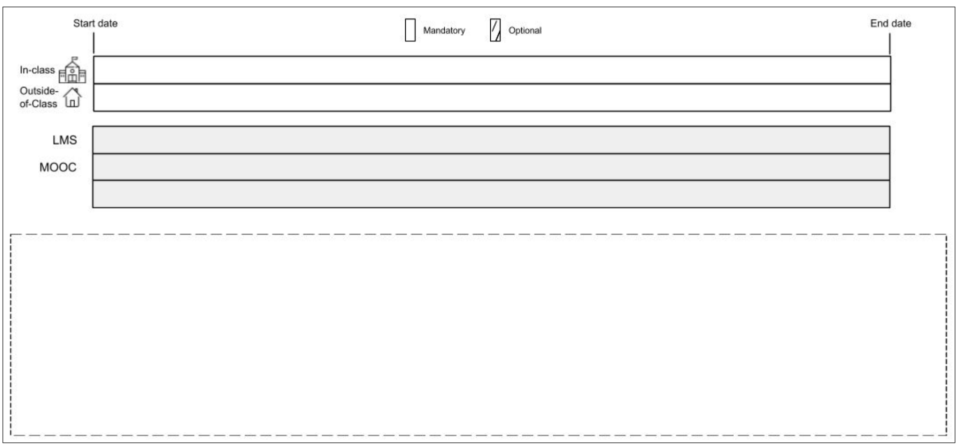

Figure 7. A second version of the model

Furthermore, in line with providing more detailed designs, researchers have conceptualized an activity template (figure 8) which can be used to describe in more detail the activities placed on the timeline, and can be situated on the open space of the bottom part of the model (figure 7). For each activity, a name or ID and several tasks which are composed (a., b., c., etc.) should be indicated. For each task, the designer can provide four descriptors: (1) the teacher's role (no teacher, supervisor, lecturer or facilitator); (2) the students' type of work (individual or collaborative); (3) the type of task (read/watch/listen, discuss, investigate, collaborate, produce, practice); and (4) the grading mode (not graded or graded). While the types of tasks have been extracted directly from the literature (Laurillard, 2012), we have defined the other descriptors according to the definitions and views from the specific literature about BL.

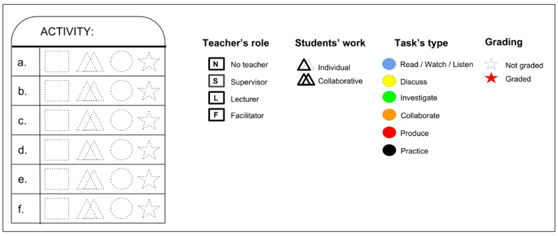

Figure 8. Activity template (card) with its corresponding legend

The second evaluation aimed to provide an understanding of the potentialities and weaknesses of the second model answering the three evaluation questions E(2)-RQ1, E(2)-RQ2 and E(2)-RQ3.

Results and discussion

Whereas figure 9 shows the timelines and resources layers of the LD templates filled out by the six participants' teams, figure 10 presents the activity cards. The two parts of the templates collected have been separated into two figures to facilitate their analysis and comparison (see an example of a complete LD template in figure 4 left).

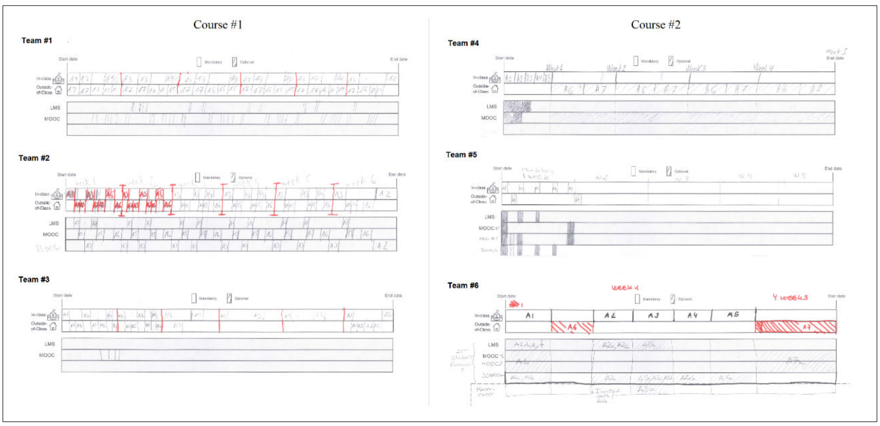

Figure 9. Completed timelines and resources layers extracted from the design templates.

The first step for filling out the visual model template was being able to separate the timeline in weeks depending on the cases' descriptions. From figure 9, we can observe that all teams representing the Course #1 separated the timeline into six weeks correctly. Moreover, they placed the activities in each corresponding week depending on whether they were in-class or out-of-class exactly how the case was described. By contrast, not all the teams representing the Course #2 used the timeline in the same way. Interestingly, teams #4 and #5 separated the timeline into five weeks proportionally, leaving little space for placing the in-class activities during the first week. On the other hand, team #6 separated the timeline in a non-proportional way, using as much space as possible to describe the activities of the first week and indicating the remaining four weeks in a shorter space. This finding may suggest the need for removing the limitation of the paper prototype model (where participants have a static space for representing their LDs) and offering the possibility of a web-based visual model (allowing zoom in and zoom out the timeline and facilitating the allocation of different activities, especially when they are numerous). Regarding the use of the resource layers, three teams used extra layers beyond the LMS and MOOC ones. Closer inspection of the representations shows that all the participants who indicated resources, aligned them according to the activities in which they were used, as well as indicating whether they were mandatory or optional. Overall, these results indicate that all the teams were able to use the timeline correctly as well as the resources' layers. In general, the visual representation was used in the expected manner. The results show that it is possible to represent a MOOC-based learning design using the model (E2-RQ1) and that the limitation of the first model –regarding the representation of several online resources in the same blended course– has been solved.

In addition, the results obtained from the representation of the activities (figure 10) indicate that all the teams were also able to use the activities' cards codes and filling out the different task descriptor details. However, some variations between the interpretation of the activities by the teams could be identified. Moreover, we can observe that, in three teams (#2, 5 and 6), allocating the type of the task was challenging for the participants because they found that one task could have multiple values for the same descriptor. To face this challenge, they decided to cut pieces of the task circles to create composite tasks – e.g. team #2 (A3: a, c, d; A6: a, b; and A7: a).

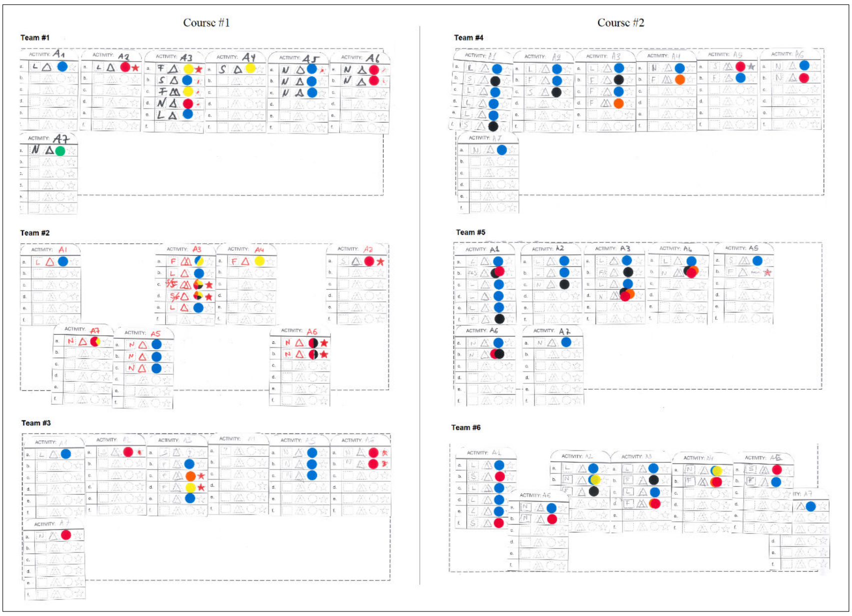

Figure 10. Completed cards' activities extracted from the design templates.

A possible explanation for these results might be that the participants could have had difficulties in understanding and interpreting the provided cases descriptions during the limited time of the workshop. Another explanation could be that the codes for describing the tasks were not clear enough. Lastly, from the use of the activities, we can see that two participants placed the activities' cards in the order in which they appear in the timeline (Teams #2 and #6) whereas the other participants put their activities' cards in numerical order (Teams #1, #3, #4, #5). This is a result which suggests confusion on how to use the open space for placing the activities' cards.

The most surprising aspect of the data from the questionnaire is that 63% of the reported difficulties were related to the LD case descriptions provided (see the complete analysis, the corresponding categories and participants' excerpts in Appendix 2, table A2-2). In most of the cases (6) participants found the explanations of the cases not clear enough. Three of them highlight the difficulties regarding the allocation of the tasks' descriptors in the activities due to the unclear descriptions of the cases, while the other three faced troubles allocating the activities in the timeline for the same reason. On the one hand, this result is encouraging as it is not directly related to any limitation of the visual model. But on the other hand, it indicates that the examples of cases provided to the participants need to be improved for the next workshops. Adding a last note to this, if the participants would have been describing their own LDs, they would have had more flexibility on separating the tasks and the problem would have been minimized. Otherwise, 32% of the difficulties were related to the activity tasks' descriptors, specifically to three of them: the teacher's role, the students' type of work and the type of task. Regarding the challenges found in selecting the appropriate type of task, other researchers who tested the Learning Designer tool (which also uses Laurillard's activities taxonomy) reached similar findings, stating that the activities may correspond to more than one existing type (Prieto et al., 2013). In the case of the other descriptors, sometimes they were not clear enough to be correctly used or some items were missing for describing certain cases (e.g. difficulties for differentiating between the supervisor and facilitator roles; or deciding whether a lecture is a collaborative or individual task).

These results corroborate the findings from the artefact analysis which pointed out that the use of the timeline and the resources' layers did not present difficulties of use to the participants, but the cases and the activities' cards were the focus of doubts. Regarding the model, further work is required for rethinking and improving the tasks' descriptors and for developing guidelines for using the open space to place the activities .

In the case of the second question of the questionnaire (E2-RQ3), half of 14 participants who answered the question, strongly agreed or agreed (4 and 3 respectively) that the visual model was helpful to understand others' LD. However, three participants were neutral, while three disagreed and one strongly disagreed with the statement. These findings may be somewhat limited by the difficulties participants experienced in understanding and representing their cases due to the unclear descriptions and the difficulties they had using the activities' descriptors (adding a certain bias to the results). More research is therefore needed here, using an improved version of the representation model.

Regarding the main strengths of the model (E2-RQ2), researchers identified six categories according to the frequencies obtained (see the complete analysis, the corresponding categories and participants' excerpts in Appendix 2, table A2-3). Most participants (7) recognized as a main strength of the model the fact that it provides an overall idea of the whole LD in a simple view. Others (4) highlighted the potentialities that the model has in facilitating organization (planning), reflection about the design and in taking LD decisions. The last strengths detected were: its ease of interpretation (2); its potential for communicating the work to others (1): the time representation and separation of in-class/out-class activities (1); and the visual representation of the activities (1).

By contrast, the main weaknesses of the model (E2-RQ2) identified by the participants were: the tasks' types allocation (4), in line with the results discussed above; the limitation of the model for representing complex designs (2); the lack of provision of details (2); the time needed to learn the model and its codes (2); the need for alignment of the activities' descriptions with the timeline and the resources (1); and lastly, that the use of the timeline is open to errors by users (1) (the complete analysis, the corresponding categories and participants' excerpts in Appendix 2, table A2-4). From these results, we can state that although the aim of adding the descriptions of the activities in this second model was to eliminate the limitation of the first model in terms of providing more details in the design, this aspect still needs to be improved. A web-based model (as was already suggested before) could overcome the limitations of the current model (e.g. offering automatic error feedback and control, especially regarding the use of the timeline, which is now subject to errors as it is a paper prototype). Furthermore, a web-based model could visually align the various elements, such as the timeline, resources and activities, automatically.

Interestingly, a common view amongst participants was that the visual representation provides a useful summary of a learning design (Appendix 2, table A2-5), a result aligned with the main strength of the model reported above. All the responses to the fifth question were positive except for one occasion (to which the answer was "partially"), although some of the participants added some appreciations to their answers: the model is especially useful for complex designs, that it could be refined, or that teachers would need to be trained for using these kinds of representations.

In the final part of the questionnaire, respondents were asked to answer the question of how the visual representation model could be improved. The answers were classified into six categories:

1. Providing more flexibility for representing the tasks.
2. Improving the visualization with significant icons, colour representation and metaphors.
3. Providing an online version of the model.
4. Facilitating the alignment between the activities placed on the timeline and the activity templates at the bottom of the model. .
5. Providing the content of the activities within the visual representation.
6. Rethinking the teachers' roles provided.

See the complete analysis, the corresponding categories and participants' excerpts in Appendix 2, table A2-6.

Final model proposal

Figure 11 presents the final proposal of the design layers of the visual model. Answering G-RQ1, the main element of the model is a timeline which is composed of two activity layers and an extensible number of resources-medium layers. Due to the results obtained in the two evaluations presented in the paper, we have decided in the end to use the in-class/out-of-class representation, we have argued in the previous discussions, it allows for the representation of different online type of resources (beyond the MOOC) which can be used in both places (in and out of class). Moreover, in the final proposal, we can distinguish between the resources and the resources medium layers (which indicate the medium through which the resource is provided to the student). For example, a book (resource) would be placed in a physical resource-medium layer (as would other physical resources as paper sheets, laboratory material, etc.), whereas a MOOC medium layer could contain a video, an online test or a web-text resource among others. Regarding G-RQ2, activities are sequenced on time and situated on the place where they occur (in class or out of class). Resources are aligned with the activities where they are used and placed in the corresponding resource medium layer, informing how they are available (physical resource, online resource -virtual learning environment, web, cloud, etc.)

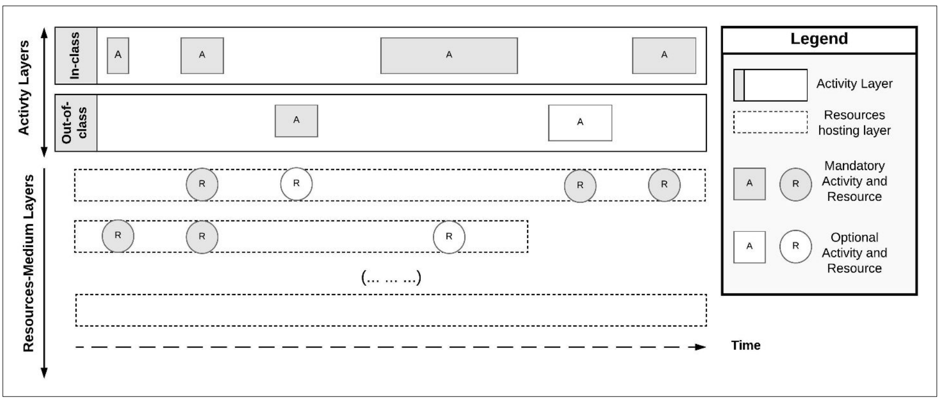

Figure 11. Final proposal: visual representation model for blended learning designs

The results of the last evaluation have led us to the following decisions regarding modifications to some of the tasks' descriptors, as follows:

- Teacher's presence: teacher available f2f, online or not present.
  This has been simplified based on the categories used in the Learning Designer tool (Laurillard, Kennedy, Charlton, Wild, & Dimakopoulos, 2018), and adapted adding the category of 'teacher available online'.
- Students' type of work: individual, in groups or the whole class.
  We have added a new category for being able to represent, for example, the case when the whole class is attending a lecture -the same approach as Dillenbourg (2015) in the orchestration graphs.
- Type of task: remembering, understanding, applying, analysing, evaluating and creating.

This has changed from Laurillard's categories (Laurillard et al., 2018) to Blooms' taxonomy's cognitive levels (Krathwohl, 2002). This allows for the indication of each task in terms of its associated cognitive process levels, avoiding confusion when there is a possibility of representing a task with more than one level.

- Grading mode: graded task, not graded, or task for auto-evaluation.
  We have added a category 'auto-evaluation', but further research is necessary to evaluate these categories and address the different possibilities of assessment.

From this study's findings, we argue that with this final model, the designer can consider the impact on space (e.g. the physical location of the students), the impact of time (synchronous or asynchronous) and the level of interaction in a visual way, three concerns which Littlejohn & Pegler (2007) identified as necessary for taking design decisions and making final learning design choices.

Conclusion and future work

The results of the study presented in this paper show the main strengths and weaknesses of the visual representations proposed and were useful for analysing whether the elements provided by the model (the timeline with the activity layers, the resource layers and the activity descriptors) were valid for visually representing and designing MOOC-based blended learning courses. The outputs of the workshop have helped to improve the different versions of the model to come up with a final model proposal which allows for a represention of blended courses in a visual way. These results show that the representation allows educators to easily visualize the overall structure of the learning designs and the relationships between the different design elements, providing a context for fostering reflection and decision making during the planning of MOOC-based BL designs. Future work includes the implementation of the model into a learning design authoring tool, where an actionable version of the model will be developed, and a complete computer-supported authoring experience based on the model will be evaluated. The aim of the study was conceptualizing a model for visually representing MOOC-based blended learning designs. Yet, it would also be interesting to go further and test whether the model would allow to represent other complex blended cases beyond the use of MOOCs and beyond the higher education context. Moreover, further research might explore whether the representation model can also be useful for the students, as it has the potential of showing what teachers but also what students are expected to do –which may help them visualize the total workload at a glance and better plan their courses and be more effective in their learning process. Thus, it can contribute to one of the most important challenges that BL courses need to face: facilitating the necessary alignment of expectations between instructors and students (McGee & Reis, 2012).

Moreover, future work needs to explore whether and how the model can express "synchronicity" in a more visual way (Littlejohn & Pegler, 2007; Norberg et al., 2011) and address the requirement of providing a context to the visualization beyond the fact of representing the activities (e.g. providing details about the topic of the course, the number of students, the educational level, etc.). As Goodyear (2004) states, "context is important in helping constrain and communicate the nature of both problem and solution", avoiding over-generalisation. Besides, it would be interesting to investigate how to connect the learning outcomes with the visual representation (Bralić & Divjak, 2018). More broadly, research is needed to determine which impact the model can have in the planning process as well as whether it can serve to communicate learning design ideas to others, promoting their sharing among teachers' communities.

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APPENDIX 1

Courses' cases descriptions

Course #1

Context: This course implemented a blended model of learning by merging content from an online MOOC (Massive Open Online Course) with in-class, team-based instruction as part of required undergraduate circuit theory course.

Course duration: 6 weeks course

MOOC dates: available during all the 6 weeks.

In-Class Activities

A1. Special class session: the 1st f2f session

a. The first class session (number 1) was a presentation of the course by the teacher.

A2. Final exam: the last f2f session

a. The last class session (number 12) was the final exam (part of course grade)

A3. Regular class sessions: 75 minutes, twice a week (the first and the last week just once a week, 10 in total)

a. **Mental ramp-up period (10 minutes):** Professor asks questions about students' activity to gauge students' understanding while grad students collect weekly "student online activities survey" and summarize results for the professor to be discussed on that day's class session.
b. **In-class mini-review lecture (20 minutes):** Based on the grad students' survey analysis of online topics marked as "difficult to understand" or "hard" by students that week, the professor reviews the more difficult concepts in class. If no topics emerge as difficult, the professor solves a sample problem that embodies the most important concept of that week's topic. In addition, a summary of the online lectures are distributed to all students twice a week.
c. **Group quiz (20 minutes):** Students work on a group quiz as a team of three. Professor leads and answers questions on strategies for how to solve different types of problems. The group quiz is collected and graded as part of overall course grade. The last 5 min, professor reveals some of the best strategies to solve problem and the solution is distributed among students in class.
d. **Individual quiz (20 minutes)**: The individual quiz is given to each student to gauge their understanding of subject material. The quiz is collected and graded as a part of students' final course grade. The last 5 min, the best strategy to solve this type of the problem is discussed (students and professor) with the solution distributed to the students in class.
e. **Preview for next class session (5 minutes):** Preview by professor of next class' material.

A4. Optional class sessions: 60 minutes, once a week (not including last week, 5 in total)

a. An optional, Friday, one-hour, F2F walk-in session (i.e., optional recitation office hour) held weekly by the professor.

Outside-of-Class Activities

A5. Mandatory work in the MOOC: 30 minutes, twice a week (begins just after the first special f2f session and ends before the last f2f regular session)

a. **Watch edX the topical mini-lecture video** of up to 10 minutes and answer embedded questions online.
b. **Read** assigned sections of the edX online textbook. (15min)
c. **Watch edX videos** of MIT faculty arguing with each other in presenting and modeling competing alternative solutions to a single problem. (5min)

A6. Mandatory work in the MOOC: 60 minutes, once a week

a. **Solve edX problem sets and submit answers online** for automated grading by edX. (30min)
b. **Complete edX online lab experiments and submit answers online** for automated grading by edX. (30min)

A7. Mandatory work: after each class session, 10 minutes

a. Finally, after each class session, students were given (or could download) an assessment handout for the next class session that asked each student to evaluate their understanding or level of difficulty (i.e., "easy", "elementary", "intermediate", "hard", "advanced") for each of the edX topics to be covered in the next class session. If a student rated a topic as "hard" or "advanced", he or she was required to briefly explain what was difficult or confusing. Students were required to complete this survey before coming to each class and give it to the Graduate Assistants at the beginning of each class session. The two Graduate Assistants compiled the results of these surveys during the first ten minutes of each class so that the professor could focus on the most difficult topic areas during the F2F mini- review lecture.

Assessment

The student course grades are based on:

- Online activities (Assignments and labs) **(20%)**
- Team quizzes **(15%)**
- Individual quizzes **(15%)**
- Final comprehensive exam **(50%)**

Case based on:

Ghadiri, K., Qayoumi, M. H., Junn, E., Hsu, P., & Sujitparapitaya, S. (2013). The transformative potential of blended learning using MIT edX's 6.002 x online MOOC content combined with student team-based learning in class. *Environment*, *8*, 14.

Course #2

Context: This course presents a case study of using two external MOOCs in a face-to-face (f2f) summer course for high school students. The course used a LMS (Moodle) to articulate the course content. For supporting the theory part, 19 videos downloaded from two different MOOCs (both from Coursera MOOC platform) were embedded in the LMS. Six videos were from the MOOC #1 "Videojuegos: de qué hablamos" from the Universitat Autònoma de Barcelona (UAB). Whereas 13 videos were from the MOOC #2 "¡A programar! Una introducción a la programación" from the universities of Universidad ORT Uruguay and The University of Edinburgh. Both MOOCs were running in parallel to the f2f course and finishing several weeks later. One of the added value of the course was offering students continue learning through the MOOCs after the f2f course finished.

Course duration: 5 days of mandatory f2f course more 4 optional weeks following the two MOOCs online.

MOOC #1 dates: Starting at the same time of the f2f course and ending 4 weeks later.

MOOC #2 dates: Starting at the same time of the f2f course and ending 4 weeks later.

In-Class Activities

A1. First day: f2f class session (9:30 - 14:00)

a. **Course Welcome and introduction (60 minutes):** Teachers were introducing the course content and did a Scratch presentation/demo to the students (using the Scratch online platform).
b. **Getting to know activity (30 minutes):** Students had to create a Scratch account (individually in the Scratch online platform) and do a short animation with Scratch presenting themselves. Teachers were around the class helping with the students' doubts.
c. **Introduction to Coursera MOOCs (30 min):** Teachers introduced Coursera platform and the two MOOCs to the students (using Coursera online platform)
d. **Introduction to computer games developing (30 min):** The theory concepts of the course related with videogames were explained showing the 6 videos from the MOOC #1 (usually an extract of it) in class to all the students (downloaded from Coursera, hosted in a private Youtube channel and embedded in the LMS). Teachers were playing the videos and showing only the selected parts (stopping when was necessary) as well as commenting some key parts of the videos.
e. **Introduction to programming (90 min):** First part of the concepts related with programming were explained showing 7 videos from the MOOC #2 (usually an extract of it) in class to all the students (downloaded from Coursera, hosted in a private Youtube channel and embedded in the LMS). Teachers were playing the videos and showing only the selected parts (stopping when was necessary) as well as commenting some key parts of the videos.
f. **Exercices between videos of tasks *d* and *e* (10 min):** After each video of the tasks "d" and "e", students were asked to solve a multiple choice online question in the LMS related with the concept in order to check if they had understood it. Teacher was clarifying the concepts when the results of the question were bad (he/she was checking the results just after the students were submitting them).

A2. Second day: f2f class session (9:30 - 14:00)

a. **Introduction to programming (part 2) (90 min):** Second part of the concepts related with programming were explained showing 6 videos from the MOOC #2 (usually an extract of it) in class to all the students (downloaded from Coursera, hosted in a private Youtube channel and embedded in the LMS). Teachers were playing the videos and showing only the selected parts (stopping when was necessary) as well as commenting some key parts of the videos.
b. **Invited talk 1 (30 min):** an expert about computer games developing came to the class to do a short lecture.
c. **Collaborative activity about Scratch (30min):**
d. **Individual Scratch practice (90 min):** students were practicing programming using Scratch (in the online platform) individually, following several computer games

samples that teacher uploaded in the LMS of the course. Teachers were around for attending students' doubts.

A3. Third day: f2f class session (9:30 - 14:00)

a. **Makey-Makey presentation (60 minutes):** A teacher was introducing the Makey-Makey gadget to the students by a demo with examples.
b. **Individual Scratch practice (90 min):** students were practicing programming using Scratch (in the online platform) individually, following several computer games samples that teacher uploaded in the LMS of the course. Teachers were around for attending students' doubts.
c. **Presentation of the Sensors in Scratch (30 min):** teachers made a demonstration of using Scratch sensors (using the online Scratch platform).
d. **Collaborative work preparing the final project (90 minutes):** students were grouped in teams of 3-4 people. Students had to work collaboratively within their teams in order to develop their own computer game with Scratch (using the online Scratch platform).

A4. Fourth day: f2f class session (9:30 - 14:00)

a. **Invited talk 2 (30 min):** an expert about 3D graphics came to the class to do a short lecture and a demo of how to design a computer game 3D character.
b. **Collaborative work preparing the final project (240 minutes):** Students had to continuing working collaboratively within their teams in order to develop their own computer game with Scratch (using the online Scratch platform).

A5. Fifth day: f2f class session (9:30 - 14:00)

a. **Presentations of the final projects (240 min):** each team of students presented their developed computer game in front of the other students in class. Teacher was asking several questions (regarding the development process) after each presentation.
b. **Farewell (30 minutes):** Teachers gave the course certificate to the students and invited them to keep learning about programming and computer games through the two MOOCs in Coursera platform.

Outside-of-Class Activities

A6. Optional work in the MOOC #2: between the first and the second f2f sessions

a. Students were invited to watch 4 optional videos from the MOOC #2.
b. And try to develop (individually) two optional games (appearing in the "a" task optional videos) in the online Scratch platform.

A7. Optional work in the MOOCs: once the f2f course finished

a. Students were invited to follow the 2 MOOCs during the 4 weeks after the f2f course.

Assessment

- There was no formal assessment as it was a summer course. Students had to deliver a final game developed in teams and present it the last day of the course.

Case based on:

Albó, L., & Hernández-Leo, D. (2017). Breaking the walls of a campus summer course for high school students with two MOOCs. In *HybridEd Workshop, EMOOCs 2017*, Leganés, Spain. http://hdl.handle.net/10230/32157

APPENDIX 2

Table A2-1
Blended learning designs descriptions by 17 participants

ID	Context description	How is online teaching (MOOC) combined with f2f education?
1	Introduction to quantitative methods and programming for students of Economics and Administration and Business Management degrees.	The MOOC is used to propose exercises and / or complementary material to the students, while in the classroom they develop the theoretical aspects and solve doubts.
2	Technical subject of data analysis. Administration and business management degree in an online university.	MOOC: Basic statistical concepts and techniques. Virtual classroom space: Complex activities, application of real cases, resolution of doubts, deepening...
3	A MOOC on "strength training", in a core subject of sports training of the degree in Physical Activity and Sports Science (CAFE)	The MOOC is a part of the f2f subject to vary the teaching methodology and try to make the theoretical part of the subject more attractive. Given the high number of students in the classroom and not very high interest in the theoretical class.
4	Training course for trainers. Objective: to promote online innovations for the f2f teaching.	Within the section of activities there is a previous knowledge base that is delegated in a session of MOOCs available (preparation of online activities, use of teaching videos). This section of activities is the basis for design by teachers: to develop their own activities and redesign their face-to-face courses.
5	Subject on proteins (biotechnology).	The MOOC is used to teach the basic and theoretical part of the subject and to be able to do the practical part directly in f2f format (MOOC: 1/3).
6	Resources and activities of Moodle for teachers. Collection of referential resources (videos) with practical examples.	f2f sessions combining MOOC content to expand applicability.
7	Subject with many 1st grade students groups (12 ECTS credits).	In the classroom, more generic contents are made. On the online platform (MOOC), more specific contents are given on the various topics discussed to promote the collective creation of knowledge among the various class groups - allow students with similar interests to get in touch with peers from their own and other universities.
8	Digital video editing course	The MOOC would be used as an introductory part of the course to expose the basic concepts of the digital edition of video to level the knowledge of the participants, and that they can arrive prepared to the f2f teaching to address and delve into the practical part.
9	Subject of a university course. Knowledge leveling MOOC course before starting a subject (for example, finances) in the case of classes with students that come from different disciplines.	The MOOC is a complement to face-to-face classes. What has been seen in face-to-face classes is deepened.
10	Master's degree. Optional subject: teacher training in law.	Take advantage of contents and experience in the classroom to work with the flipped classroom.
11	Primary school teaching degree. Optional subject of the ICT mention.	I propose the MOOC as a voluntary complement to expand knowledge, as a space for debate, as a supplement.
12	Fundamentals of taxation, Compulsory subject of the degree	Complementary to existing material. Application of the concept of tax progressiveness.

	in Administration and Business Management (ADE).	
13	Training course to teach in English at the university.	The MOOC provides explanatory videos on the material of the course. The f2f part of the course allows to attend the specialty of each teacher, their needs in a specific subject. It allows quality personal attention with the trainer and colleagues.
14	A course on the characteristics of Catalan literature of the XVIII century.	The MOOC would be compulsory for the students, who would have to do it before the f2f classes began. The course would give students the theoretical basis on the context of Catalan literature of the XVIII century so that the classroom can be more practical and focused on the subject itself. During the course there will be optional content in the MOOC.
15	Postgraduate course in Emotional Education and Welfare. Blended. Make some modules in a MOOC format to serve as an introduction.	They do not combine much. The idea is that it is totally virtual and that at most, there would be feedback from students in training, conferences or in the development of postgraduate courses.
16	Within a subject of introduction to ethics. Introduce a part of the content that is more practical.	A part of the syllabus that aims to be more interactive (bioethics, examples and problems) is derived to the students to follow the MOOC that will collect practical cases presented in videos.
17	Master in Neuroscience and Nanotechnology. Compulsory assignment of 5 ECTS credits, "Characterization and manipulation of the nanoscale".	Each topic of the MOOC is used as introductory material of the same topic of the f2f course. The questionnaires implemented in the MOOC are worked on in class and the subject is broadened. The new questions or extension material could be incorporated into the MOOC to enrich it with different levels of difficulty: MOOC/f2f feedback.

Table A2-2

Difficulties found during the design process extracted from the questionnaire responses (14 participants)

Meta-category	#	Categories	Freq.	Selected excerpts from the research questionnaire
LD example sheets	1	Examples descriptions	6	"The precision of the descriptions was not enough in some cases." "Some explanations were unclear (for example, activity A4)."
	2	Tasks' types allocation	3	"In some cases, it is unclear which type of activity (investigation, production, discussion) should we choose since it's rather a mix"
	3	Activities allocation in the timeline	3	"The main difficulty faced was at organizing the activities in timeline and deciding how many times a specific type of activity should be repeated in other weeks or not." "(…) sometimes was difficult to assume how to divide the space according to the number of activities which we had"
Activity tasks descriptors	4	Student's work (individual vs. collaborative)	2	"In class sessions with Q&A, whether the activity can be classified as collaborative or not." "In a lecture (listening), is this collaborative or individual? (…)"
	5	Teachers' roles not clear	2	"It was also difficult to differentiate between the role of teacher as supervisor and facilitator."
	6	Tasks' types not clear	1	"The taxonomy for learning tasks and for teacher roles was not clear. I was specifically missing a task category of reproducing knowledge."

	7	Collaborative task over-described	1	"Sometimes the triangles for collaborative activity were merging with the orange colour of the collaborative activity."
Model elements alignment	8	Alignment between activities and timeline	1	"It was not clear how we should arrange the activity cards in the open space that was available in the page. It was necessary to align very well the activities in time among them, and then align them with the resources"

Table A2-3

Strengths of the visual representation. Questionnaire responses and frequencies from 14 participants

#	Categories	Freq.	Selected excerpts from the research questionnaire
1	Overall idea of the whole LD in a simple view (capacity of synthesis)	7	"You can see the whole course design at a glance." "High level overview of complexity level of tasks." "Rapid identification of what is going on in the process." "you can obtain, in a simple view, things that can be useful to have account for a teacher (i.e., how is the course structured, what are the main role of the teacher, what kind of the activities are more extended in the course"
2	Good for organizing, reflecting and taking LD decisions	4	"It allows you in a glance to decide the type of activities you wish to introduce in your course and balance them well during your design." "It gives a good template to structure the course not only being aware of the main components of the course, but also type of activities, when there is grading, along with the temporal sequence of all components." "You can (…) understand what resources are needed, and better organize the time inside and outside the class."
3	Easy to interpret	2	"Easy to interpret."
4	Good for communicating ideas to others	1	"I think it is good way to organize your own work and communicate it with others."
5	Time representation and separation of in-class/out-class activities	1	"Time representation, good separation of in-class/out-class activities."
6	Visual representation of the activities	1	"I think the visual representation is very representative with the teacher´s roles and the tasks for make with the different colours (produce/collaborative...)"

Table A2-4

Weaknesses of the visual representation. Questionnaire responses and frequencies from 14 participants

#	Categories	Freq.	Selected excerpts from the research questionnaire
1	Type of tasks allocation	4	"The taxonomy of the colours, as it is very difficult to divide an activity in "pure" read or produce or practice. Maybe inserting a percentage would be useful."
2	Limited for not complex designs	2	"It seems it cannot be used to represent more complex designs (e.g. alternative paths depending on the results of a given activity)."
3	Lack of details provision	2	"Some details of the design might be missing: number and size of groups; flow of generated artefacts; assessment methods"
4	Learning curve	2	"I think that teachers should be trained in order to interpret this kind of visual helps. There is a need to know well the coding system"
5	Activities not aligned with the timeline	1	"Details of the activities are not organized along with time, but in the other panel."

6	Timeline open to errors by users	1	"Timeline of course is too open to errors by users."

Table A2-5

Questionnaire responses and frequencies about whether the representation provides a useful summary of a learning design (14 participants)

Do you think it provides a useful summary of a learning design?	Freq.
"Yes."	6
"Yes, for complex designs."	1
"Yes, at the coarse grain. At the fine grain, not very much."	1
"Yes, it does. I would not say summary. It is just a concise representation of learning design. Summary may miss some components, but the provided visual representation does not miss anything. It just put them all together in a more concise way."	1
"I think that it includes all main elements of a design in a comprehensive way. Some elements cannot be 'decrypted' very easily, at a glance."	1
"Yes, although it can be refined."	1
"Yes, exactly the word summary could describe what I did during this design process. A summary could help to see how dependencies between the activities and what students and teacher are expected to do."	1
"Yes, but as I mentioned before I think that teachers need to be trained in this kind of representations."	1
"Partially."	1

Table A2-6

Recommendations for improving the visual representation. Questionnaire responses and frequencies from 14 participants -the answer of one of them was classified in two categories

#	Categories	Freq.	Selected excerpts from the research questionnaire
1	Provide flexibility for representing the tasks	4	"... the system might be flexible enough to modify some aspects of the coding allowing teachers to include new ones." "... some activities may have an individual part and a collaborative part, and this is not easy to be depicted with the current visual representation."
2	Improve the visualization with significant icons, colour representation and metaphors	4	"Better colour representation." "Maybe use more friendly icons."
3	Provide an online approach for the visualization	3	"... a zoom in/zoom out approach in which the detail of the activities can be seen in place according to time would be more comprehensible." "In a textual format maybe is difficult to add more things but in a digital format you can probably click on the activity and then select the activity task with the different colours etc."
4	Facilitate the alignment between the activities and the timeline	2	"The cards with the description of the activities are collected in the big canvas, but maybe they should be explicitly connected with the activities in the timeline…"
5	Provide the content of the activities within the visual representation	1	"...giving a summary with combination of visualizations and the content of the activities will help others to see the overall design and what is described in the activities."
6	Rethink the teachers' roles types	1	"Some of the codes for the teaching roles were not completely clear."

CHAPTER 4

TECHNOLOGICAL SUPPORT FOR DESIGNING BLENDED LEARNING

Chapter 4 addresses the technological part of the second objective of the thesis (Figure 4.1). It is composed by three articles which address the prototyping of preliminary products and theories phase of the DBR process (Figure 4.2):

- the first (J5, see Section 1.4.3) shows the development process of the authoring tool (carried out through participatory design workshops with two school communities) (Section 4.1);
- the second (C4) is a demonstration article which briefly describes the final version of the tool (Section 4.2);
- and the third (C5) presents the design principles extracted during the development phase (Section 4.3).

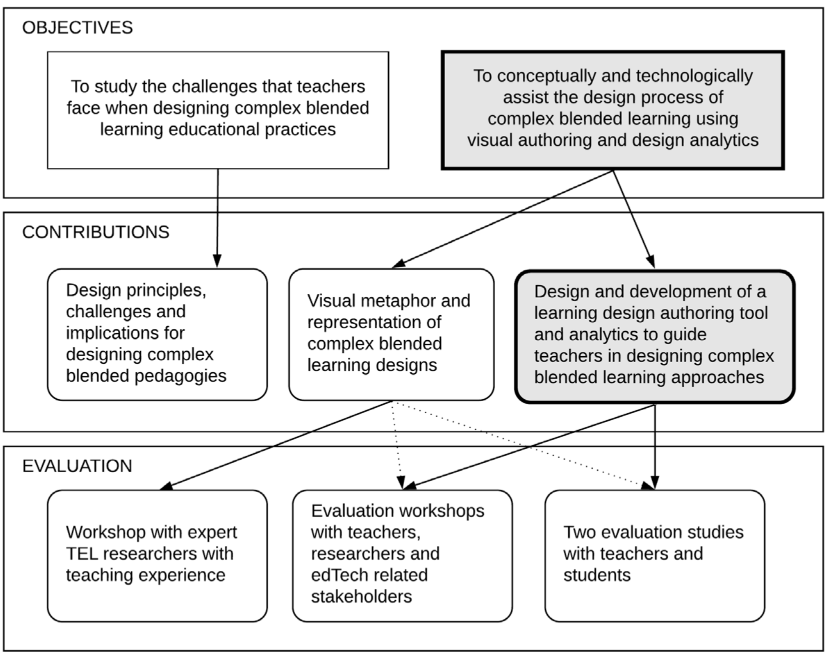

Figure 4.1. Objectives and contributions covered by Chapter 4.

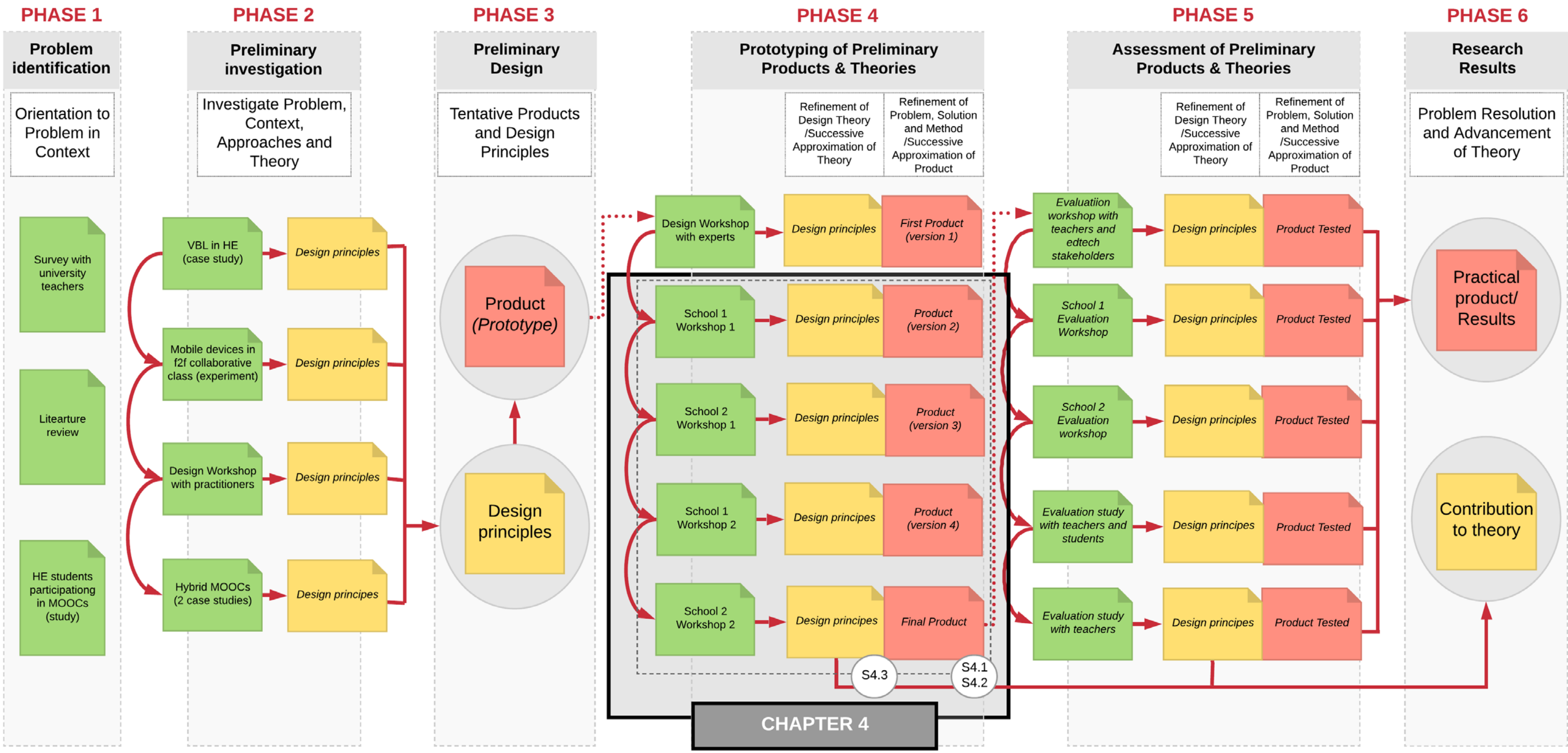

Figure 4.2. Part of the research process covered by Chapter 4.

4.1 Co-creating a web-based visual representation model for authoring blended learning designs

The content of this section was submitted to a JCR peer-reviewed journal and is under review:

Albó, L., Hernández-Leo, D. (2019). Co-creating a web-based visual representation model for authoring blended learning designs (Submitted to Journal).

Co-creating a web-based visual representation model for authoring blended learning designs

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Abstract. This paper reports the co-creation process carried out during the development of a web-based visual representation model for authoring blended learning designs. The results of several participatory design workshops with high school teachers of two school communities have allowed to advance the development process through iterative cycles of refinement and improvement. The authoring tool resulting from the co-creation process supports teachers in the planning and visualization of complex blended learning scenarios (including hybrid massive online courses, flipped classroom and problem-based learning designs). Our experience contributes to the research community with a case study on using co-creation in technology-enhanced learning, where we discuss the challenges and opportunities found during the implementation process of this collaborative and participatory approach.

Keywords: Co-creation, learning design, authoring tools, blended learning

1 Introduction

Innovation in education is time-consuming and it is challenging to develop it in an effective way [1]. Innovative approaches and best practices are usually presented in a way that is difficult to understand by the large mass of educators [2]. In this context, the Learning Design (LD) field has emerged as a paradigm which aims to provide a general descriptive framework for representing educational practices in a way that can be shared effectively [3]–[5]. This approach has been found to be useful for several stakeholders related with educational institutions (faculty and instructional designers) to document their (best) practices and interpret the practices of others [4]. But despite its potentialities regarding teaching and learning innovations, there is a gap on the adoption of the LD approach by the practitioners [6]. Whereas some initiatives of participatory design have been identified in order to include users' insights on LD solutions for reducing its adoption gap [6], [7], more work is needed to explore the use of co-creation during the development process of specific LD tools.

Co-creation refers to any act of collective creativity which can be used at all points along the product development, from the idea generation but also at all key moments of decision throughout the design process [8]. The practices of co-creation in design (co-design or participatory design) date back to the 70s starting with the user-centred design approach. But nowadays, we are moving from simply designing products for users (user-centred) to designing for the future experiences or purposes of people (co-designing), integrating society in the innovation process [8]. Therefore, it is necessary to reconsider the role of designers to achieve user participation in design [9].

In this paper, we report the co-creation process carried out during the development of a web-based visual representation model for authoring blended learning designs. Our case study aims to contribute to the research community with an experience on using co-creation in technology-enhanced learning, discussing the challenges and opportunities found during the implementation process of this collaborative and participatory approach.

2 Design Authoring Tools for Blended Learning

For some time now, several authoring tools have been conceived to support teachers in the process of documenting their teaching practices, making their learning design ideas explicit and shareable. [10], [11] present and compare a variety of tools that have been developed to guide the decision-making process in LD. In this line, [3] groups the LD tools in two different types: "pedagogical planners" and "tools for visualizing designs". The author argues that whereas pedagogical planners can guide and support practitioners in making informed design decisions (while they are planning their teaching practices), tools for visualizing designs can be used to visualize and represent learning designs.

Planning and visualization support are especially relevant when implementing innovative pedagogy models as problem-based learning (PBL), flipped classroom (FC) or hybrid Massive Open Online Courses (hybrid MOOCs). Yet, those cases are considered by several authors as complex blended scenarios [12], [13].

On the one hand, previous research has established that activities or learning sequences are essentially time-based and require a plan [14]. Specially in blended scenarios, when learning is facilitated by the effective combination of different modes of delivery, models of teaching and preferences for learning, and founded on transparent communication amongst all parties involved with a course [15]. In these cases, it is highly recommended to elaborate a plan which provide an effective orchestration of the individual components in advance [12]. Moreover, teachers need to be well prepared and organized as well as prepare students for it [16]. Likewise, it has been found that students in their blended learning experiences appreciate especially the detailed study plan, the pacing guide, as well as having access to material well organized and easy to find, with all different parts being segmented into short, discrete sections [17].

On the other hand, some authors [12] point out that there is a significant move towards a more seamlessly blended experience of multiple media within a single course (or even inside a single learning activity). But, at the same time, practitioners are not well supported in the reflective practice of teaching (from which the innovative teaching ideas can come from) that would require these complex blended scenarios [1]. Thus, in front of educational practices that present some difficulty for being understood and shared (due to the diversity and the complex articulation of the elements that compose them) more intuitive visual representations of learning designs are needed [4], [18].

As explained earlier, in blended learning is necessary to carefully consider how to best incorporate each online element into their overall pedagogical strategy including how interaction with those elements is to be incentivized [19]. [20] defends that "from both the staff and student point of view, it is most important that the students make valuable use of their time when present at the University". The same author stated that, if well designed, this time can enhance the opportunities for both social contruction [21] and conversational learning [22]. But, among a large amount of models, frameworks and tools raised from the field, the LD_lite approach to LD is one of the few that focuses specifically on supporting teachers in the design of blended e-learning [12]. In the same vein, we have conceptualized a visual model for blended learning which addresses the specific case of hybrid MOOCs [13]. But more research is necessary in order to explore whether the existing LD solutions can support practitioners who attempt to implement the complex blended pedagogical models listed above (FC and PBL among others). Moreover, despite the available options and the potentialities regarding teaching and learning innovations that the LD field can bring to the education landscape, there is a gap on the adoption of the existing LD tools by the real practitioners [6], [23], [24]. To address this issue, we argue that initiatives of participatory design which include users' insights [7] may contribute on reducing this gap. In this line, more work is needed to explore how the use of co-creation during the development of specific LD tools can foster the adoption of LD aims.

3 A Visual Model for Representing Blended Learning Designs

Figure 1 shows the blended learning visual representation model [13] on which we based the study presented in this paper. The model is composed by activity and resources-medium layers and a timeline. The activities can be placed on the 'in-class' or in the 'out-of-class' activity layers depending on where and when occur. Whereas the resources, which are aligned with the activities where they are used, can be placed in the different resources-medium layers. A resource medium indicates how the resource will be available for the users (teachers and/or students). For instance, a book (resource) would be placed in a physical resource-medium layer (as other physical resources as paper sheets, laboratory material, etc.), whereas a MOOC medium layer could contain a video, an online test or a web-text resources among others [13]. The resources layers duration depends on the period where they are available or 'open' for the students. Activities and resources can be mandatory or optional. The blended learning visual model also defines how to represent the activities, mainly using the following four descriptors:

1. *Teacher's presence* (available face-to-face, online or not present).
2. *Students' type of work* (individual, in groups or the whole class).
3. *Type of task* (remembering, understanding, applying, analyzing, evaluating and creating)
4. *Grading mode* (graded task, not graded or task for auto-evaluation)

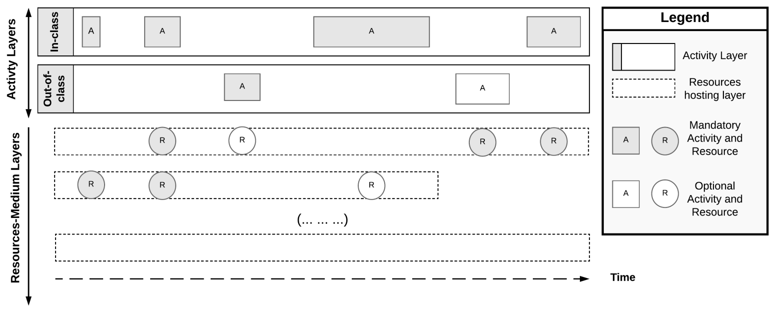

Fig. 1.. Blended learning visual model. Extracted from [13].

During the conceptualization of the blended learning visual model, we identified the need of going beyond a theoretical paper-based representation to a more practical and interactive visualization. Thus, we decided to develop a web-based version of the model in order to provide practitioners the opportunity of using it interactively and online. The main result of the development process has been an authoring tool named *edCrumble* [25], whose development has been carried out following a design-based research approach, with the whole cycles described generally in [26]. The tool aims to support the visualization and planning of complex blended learning practices bringing together the advantages of both types of tools “pedagogical planners” and “tools for visualizing learning designs”. The final interface of the tool’s editor is described in the following figure (figure 2).

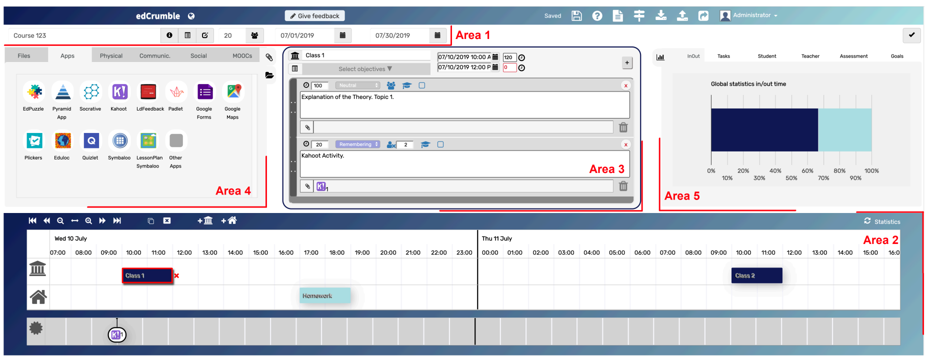

Fig. 2. Authoring tool interface areas.

The top area (figure 2, area 1) allows users to provide general information about the design context. The area 2 is an online version of the visual blended model (figure 1) with the in-class/out-of-class main layers and the resources-medium layers (in the example of figure 2, it can be seen a timeline with two activities and a medium layer ‘web’ with a *Kahoot* resource on the first in class activity). On the center (area 3), it appears the activity selected from the timeline that user may want to edit or explore. Once an activity is selected, the user can set up the corresponding learning objectives and add the tasks that compose it. Indicating and editing for each task: the time allocated, the corresponding four descriptors from the blended model, a description of the task, and the associated learning resources. The design of the activity representation interface (area 3) is based on the activity's interface used by the Learning Designer authoring tool [5]. Moreover, on the left, there is the resources' area (area 4), which is divided on several resources' categories (files, apps, physical, communication, social and MOOCs). The user can drag and drop a resource to the task of an activity and edit its characteristics: title, description, target (teacher or student resource), medium layer (miscellanea, Learning Management System, MOOC platform, web, physical artifact or cloud storage) and medium name. After adding a resource in an activity, a visualization of an icon associated to this resource appears automatically in the timeline, placed in a new layer depending on the resource-medium type [25]. Finally, the analytics area (area 5) provides users analytics (visualizations) extracted from the meta-data of the produced design.

Hence, the main objective of this study is to report the iterative co-creation process followed from the paper-based version to the web-based model (authoring tool). Within this aim, the co-creation process reported in this paper addresses the following research questions regarding the development process for advancing on the visual representation for blended learning designs:

- (RQ1) To what extend the visual representation model for hybrid MOOCs can be used by and/or adapted to other complex blended scenarios such as PBL and FC?
- (RQ2) To what extend the visual model can serve as the baseline of a web-based authoring tool for the visualization and planning of blended learning designs?

4 Methodology

This research uses mixed methods design [27] since we believe that both quantitative and qualitative data together will provide a better understanding of our research problem than either type by itself. Specifically, we use an iterative co-creation process with high school teachers (participatory design workshops) following a design-based research approach [28].

4.1 Participants and sample

Participants were 24 high school teachers from two school communities which had different organizational cultures (see table 1 in the appendix). Whereas the school #1 (whose teachers will be identified in this paper with the code U1-*teacherID*) is an urban school with a top-down management, the school #2 (teachers will be identified using the code U2-*teacherID)* is a rural school with a cooperative organizational form. We assumed that teacher norms and practices could differ between different educational institutions and thus can enrich our analysis [29]. Participants had between 4 and 38 years of teaching experience, but the average number vary depending on the school, being 12.6 years in the school #1 and 20.4 years in the school #2. Table 1 in the appendix shows the participants' demographics in detail. Participants from both schools participated voluntarily to the project.

4.2 Procedure

Several participatory design workshops were carried out (between October 2017 and February 2018) for serving in the advancing on the development of a web-based prototype of edCrumble using participants' insights and reflections [26]. The aim of the participatory design workshops was prototyping and assessing the preliminary versions of the authoring tool together with the participants of two school communities. The same workshops structure was followed for each school community despite the context was different in order to address the first research question: in the first school the workshops were about PBL and in the second school they were about FC. During the co-creation process, participants worked with different versions of the online prototype and participated on different activities which included focus groups, sharing and discussing activities, questionnaires and interviews (see figure 3).

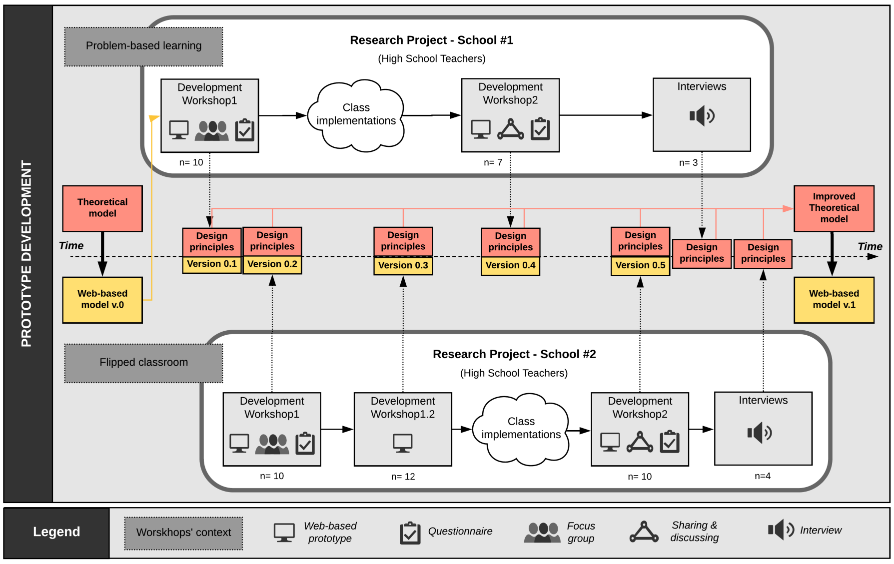

Fig. 3. Co-creation process during the development cycles: procedure and instrumentation.

Researchers prepared a first online prototype based on the visual blended learning model [13]: the first version of the authoring tool (see web-based model v.0 box in figure 3). From this starting point, the following steps were carried out in each school community:

- **Development workshop 1.** In which teachers had to design a learning design using the online prototype, with the help of the researchers (participants were asked to come to the workshop with a concrete design idea). It was a 2h workshop with the following steps: (1) Introduction to the tool; (2) Work with the tool designing a learning design for being implemented within their classrooms (a PBL or a FC design depending on the school); (3) Focus group where researchers asked questions about the experience that participants had with the use of the tool, discussing their strengths and weaknesses. (4) Last, participants were asked to answer a research questionnaire individually.

- **Development workshop 1.2.** In the case of the School #2, they had another 2h workshop because they needed more time for designing the interventions using the tool and be prepared for implementing their designs in their classrooms. In this case, researchers took observation notes of teachers' using the tool for usability improvements.
- **Class implementations.** Teachers implemented their designs in class. During this step, which took between 4 and 9 weeks, researchers were available online for solving teachers' doubts regarding the use of technology selected for using in their class.
- **Development workshop 2.** In this workshop, which took 1-2h depending on the school, teachers followed three steps: (1) Working with the tool for documenting the designs implemented at class, adding the design changes suffered by the real implementations; (2) Sharing their implementation experiences and a joint reflection about the possible redesign of their original designs considering the lessons learned; (3) Last, participants were asked to answer a research questionnaire individually.
- **Interviews.** We carried out seven semi-structured f2f interviews (three teachers from School#1 and four from School#2 – due time and resources constraints we could not interview all 24) of about 45 minutes each.

4.3 Instrumentation, data collection and analysis

The current study used several instruments to gather data from the field work: two questionnaires, focus groups, interviews and observation notes. The first questionnaire was designed to collect information regarding the use of the first versions of the web-based tool, with the aim of identifying the strengths and weaknesses as well as the difficulties encountered during its use. Thus, allowing to be able to identify the most necessary improvements to be done in the next versions. It was composed of the following four open questions:

- (Q1-1) What difficulties did you find during the design process using the online tool?
- (Q1-2) What do you think are the main strengths of the online tool?
- (Q1-3) What do you think are the main weaknesses of the online tool?
- (Q1-4) What suggestions would you recommend to improve the online tool?

Moreover, in the case of the first questionnaire delivered in the school #2 two more questions were added regarding the visualization of design analytics provided by the prototype:

- (Q1-5) Have you ever looked at the graphics (on the right side of the tool) while you were editing?
- (Q1-6) If you have looked at the graphics, did you find difficulties in understanding them? What difficulties?

The focus groups carried out during the first workshops had the same research objective of the first questionnaire. This instrument permitted to get group discussions and views, complementing the individual insights from the participants expressed in the questionnaires and allowed us to get a more accurate interpretation of their text-based responses. The second questionnaire (delivered during the development workshops 2), primarily assessed the tool regarding its potentialities for documenting designs, learn from others' learning designs and reflect during the design process. Following, the questions are listed (all questions were open-ended except the third one which was a five-level Likert scale, 1: strongly disagree, 5: strongly agree):

- (Q2-1) Indicate in what percentage you have been able to document your implementation with the tool:
- (Q2-2) If you answered a number less than 100% to the previous question, explain why.
- (Q2-3) Indicate your level of agreement for each of the following phrases in relation to the design tool:
    - It helped me to document my implementation.
    - It helped me to understand the implementations of other peers.
    - The documentation of my implementation using the tool helped me to reflect on my own design.
    - The documentation of other implementations using the tool has helped me reflect on implementations of other peers.
    - The analytics provided by the tool helped me to reflect on my own implementations.
    - The analytics provided by the tool helped me to reflect on implementations of other peers.
- (Q2-4) Do you think that the design tool allows you to document and visualize a complete learning design?
- (Q2-5) Have you missed some functionality of the design tool that would have helped you to better document your design?
- (Q2-6) Did you miss any design tool functionality that would have helped you better understand the designs of other colleagues?

Finally, the interviews consisted of a series of open-ended questions (see details in [31]) that invited participants to share their perspectives regarding (1) how they used to design and document their educational practices before knowing our tool and (2) how was the design process they followed during the workshops using the tool. The resulting qualitative data from the questionnaires, focus groups and interviews were coded with inductive thematic analysis driven by the research questions of each phase and were cross-referenced to justify interpretations. The main topics were then categorized in order of dominance and triangulated with the different instruments results in a more in-depth analysis for corroborating the overall consistency of the findings. Researchers state that the data collection and analysis have followed ethical considerations avoiding harm to participants, respecting confidentiality (anonymizing the data collected) and ensuring that their participation was voluntarily (they could withdraw at any time without need to justify their decision, as well as they had the right to omit answers to any question). At the beginning of the project, researchers explained the context of the study and seek informed consent from the participants who were willing to participate.

5 Results and Discussion

5.1 Results from the development workshops 1

The first question from the questionnaire (Q1-1), delivered during the development workshops 1) aimed to identify the main difficulties which participants found during the use of the first edCrumble's versions (0 and 0.1). The main topics from the qualitative analysis are listed in the appendix (Table 2) with the frequencies depending on the school community as well as the corresponding participants' answers excerpts. Specifically, five answers from the participants expressed difficulties regarding the slow edition process using the tool (the 33% of the difficulties gathered from the question Q1-1). Thus, the biggest drawback during the use of the tool was regarding the slow edition related with the activities and tasks. Specially, functionalities which can facilitate avoiding repetitive work were missing (like copy, paste, repeat, etc.). The next topics with most frequencies (13% of the answers each), were related with the timeline management, the tool inputs and outputs limitations as well as the need for a major activity types visualization awareness.

The questions Q1-2 and Q1-3 contributed to identify the main strengths and weaknesses of the first online prototype versions *0* and *0.1*. Results from the qualitative analysis identified four main topics regarding the main strengths highlighted by the participants (topics' frequencies and participants' excerpts are detailed on the table 3 of the appendix):

- *Visual representation* (VR) – present in the 35% of the answers: participants stood out that the visualization provided by the tool allows to see the whole design sequence at glance, controlling how all the elements of a learning design are related with each other in a visual way.
- *Organization and planning* (O/P) – 35%: opinions from the participants expressed that the tool allows to structure a learning design in a systematic way, enabling to plan the different activities along the time of a learning sequence (showing all the necessary information regarding the organization process).
- *Reflection and awareness* (R/A) – 17%: participants highlighted that the tool allows to reflect on the design process and enables the awareness of the different elements and decisions made on the learning designs expressed within it.
- *Support and guidance* (S/G) – 13%: according to the teachers who participated in the study, the tool help and guide during the design process. It supports users in taking design decisions in the generation of teaching-learning activities as well as in the choosing of the possible resources available to use.

The strengths provided by the participants about the web-based tool are aligned with those resulting from the evaluation of the paper-based prototype in [13]. Thus, the strengths found regarding the paper-based model are reinforced by the those found in the web-based model, pointing to a high level of consistency between the two versions and verifying the work done in the co-creation development process. Moreover, the strengths identified are in line with the objectives that the tool aimed to fulfill in the second research question (RQ2): supporting the visualization and planning of blended learning.

Whereas, five main topics were identified regarding the main weaknesses of the web-based tool, listed as follows in order of most frequency obtained (answers' frequencies and participants' excerpts are detailed on the table 4 in the appendix):

- *Tool's development limitations* (TdL) – present in the 55% of the answers: this weakness refers to usability issues and new features which still need to be developed in the tool. Mainly, they are related with the difficulties found and the future improvements already detected and addressed on the previous discussion. This result was already expected since this is an evaluation of a very early version of the tool.
- *High time investment* (HtI) – 27%: three participants highlighted the high amount of time needed to be able to plan or document a complete learning design using the tool. This weakness is related with one of the difficulties identified in the previous discussion which needs improvement: the slow edition of the design in general.
- *Need of support* (NoS) – 9%: one participant stood out the need of having support for learning how to use the tool. Despite the low ratio of participants who expressed this need, researchers considered to address this weakness and developed several video tutorials as well as pop-up tips and messages (see *Imp23* in Table 6 on the appendix) embedded in the editor in the last version (v.1). This solution was developed as soon as possible since it must be noticed that the tool is intended to be used autonomously by teachers, beyond workshops led by experts (where participants can receive direct support). Thus, the tool ought (and aims to) be very easy to use.
- *Educational polices* (Ep) – 9%: a teacher expressed the fear to the risk that the design process would be bureaucratized through the use of the tool. For example, leaders of organizations could ask teachers to plan and systematically document their learning designs mandatorily in order to control their work, instead of promoting the use of the tool for fostering the exchange of teaching practices (within and among the communities of teaching) and learn from the experiences of other teachers.

Interestingly, most of the weaknesses identified from the paper-based model [13] have been overcome with the online version. However, it is still necessary to reduce the need of support for understanding and using the tool and to revise some of the activity types descriptors (e.g. the type of collaborative activity; see the proposed *Imp10* in table 6 of the appendix).

Once identified the main strengths and weaknesses of the tool, the next question of the research questionnaire (Q1-4) aimed to directly collect suggestions from the participants to improve the tool. Table 5 in the appendix presents the list of proposed improvements by the teachers grouped by five topics: platform configuration; tool inputs and outputs; timeline management; interoperability of the tool; and the slow edition. Most of the suggestions have already been related with a limitation described in the above results.

In the case of the first questionnaire delivered in the school #2, two more questions were added regarding the visualization of design analytics provided by the prototype. The first question (Q1-5) asked participants whether they had ever looked at the graphics while they were editing. Five out of six participants answered positively. But when researchers asked whether they had found difficulties for understanding the graphs (Q1-6), three out of the five participants expressed issues to understand the graphs (e.g. U2-6 expressed 'I do not know if the graphs made reference to the total or to each activity') and another one argued that she did not paid much attention to them. Only one participant stated that she did not find difficulties for understanding the graphs, but she concerned about the need of had filled out all the design data to be able to extract conclusions from them. These findings were in line with the discussion raised during the focus group activity in the school #1. In which they also stated that they had understood easily the color code used in the graphs which was related with the tasks' descriptors colors. Notwithstanding, the visualization of the analytics provided with the graphs was not a priority in the development workshops 1, as researchers prefer to evaluate the timeline and activities' representation. Thus, these two questions were merely exploratory to get insights for small improvements (see appendix, *Imp22* in table 6) to be able to discuss the analytics in the second group of workshops.

Finally, the focus groups were useful for understanding some of the above discussed issues. Some teachers from the first school, asked to have more features to gain agility in the edition: configure pre-settings states when creating a new activity (duration, etc.) and a new task (see appendix, *Imp2* in table 6); they would like that the task could be ordered once created (*Imp 20*); they would like to see the whole design together in one view on the timeline, e.g. hiding the time between the activities (*Imp18*); they want to see the titles of the activities in the timeline's activities (*Imp25*). Moreover, they think that is necessary to have a summary of the design as a printable document, e.g. to bring it to the class as a guideline (*Imp6*). As well as, they really asked to have an 'student' mode visualization, for sharing the interactive timeline generated by the tool with their students -e.g. for projecting it to the class and discuss the plan all together- (*Imp16*). Lastly, some teachers discussed their visualization preferences regarding the timeline comparing with the visualization options provided by Google on its calendar application (day, week, month…).

Moving to the teachers of the second school, they started the focus group expressing that they liked the tool. Specially they liked its flexibility, as they think that it allows you to go into detail and write the design in deep, or to be less detailed and describe the design in general terms (depending on each person). Then, researchers introduced the topic regarding the possibility of sharing the visualization with the students, need which raised in the previous focus group with the other school. Despite they also agreed that it is a good idea, they added some interesting reflections about it. They pointed out that it is important to balance which portion of the design must be shown to the students, because showing all the course work (that you expect from them to do) at a glance, may overwhelmed them (especially in the course level when they need to prepare the exams to access university, as they are under more pressure). The tool can help them get organized but also can become a focus of tension and stress. Moreover, a teacher commented that if students know in advance what they will do in class, the 'creativity' factor may be lost as students can move forward to what teacher wants to do in class. They think that, sometimes, can be interesting that students do not know what will be done in class, to surprise them (this encourages learning and creativity; moreover, if they do not know what will be done in class, they are more attentive). One possible solution that teachers proposed would be to limit the time frame that students can see on the timeline (e.g. only showing one week before the class day with the objective that it ends up being an organization tool for students also).

At the last part of the focus group, teachers commented that the editor displays too much information at the beginning, which can overload the user (as the editor shows all its sections at the same time). Participants suggested to only show the 'content and general settings' menu (see figure 2, area 1) when a user creates a design, hiding the 'timeline' (displaying it when the user introduce the start and end dates) as well as the 'resources' and 'analytics' sections (displaying a button to expand them under request of the user); also, making bigger the 'selected activity details' section – see appendix, *Imp26* in table 6. Regarding the analytics provided by the tool, teachers think that it would be very interesting and necessary to be able to visualize the workload outside the classroom at the group level (e.g. out-of-class workload of several subjects that take place at the same time). They comment that at the individual level of the course (analytics of a single design) it is easy to control the workload outside the classroom, but the challenge is how to know if, at the same time, students have more work from other subjects which are running in parallel. In this line, edCrumble could facilitate a possible solution to this problem, allowing to generate aggregated analytics from several designs (community analytics, see *Imp24*). Teachers expressed and highlighted that it would be great for them having this feature, which would allow them to have a joint agenda for controlling the out-of-class workload of the several subjects within a course (they would also like to export it to a Google calendar, in line with the *Imp4*). Moreover, they commented that if they would have this information at the school level, it would allow them to redesign their courses depending on the overall workload of the students outside the classroom (e.g. sometimes putting work they had proposed to do outside the classroom, inside the class time). Interestingly, in the case of the schools of this study (high schools), teachers mentioned that they do not have stipulated the number of hours students have to do outside of the classroom. But at university level, professors do need to define how many hours (credits) students must do in total per subject (inside and outside of class), thus, we think that this feature may be very convenient for them as well. Furthermore, in the interviews, this discussion continued. Mainly, the reflection raised was regarding the potentialities of community analytics in order to avoid repetition of methods among teachers of the different subjects of the same course. For instance, if every teacher uses FC (e.g. asking students watch videos out of class), the positive effect of the pedagogical method can be reduced as students may be overloaded of watching a lot of videos at home. Community analytics could be helpful to offer awareness of these situations and allow teachers to redesign considering also the others' designs, improving the quality of a complete course.

5.2 Results from the development workshops 2

The second questionnaire delivered in the development workshops 2 (after teachers implemented in their classes the learning designs planned with the tool) allowed to evaluate the online prototype versions *0.3* and *0.4*. Despite 13 participants from both school communities answered the questionnaire (out of the 17 participants who attended the workshops 2), three of them expressed that they could not implement their designs in class, neither document their design ideas using the tool. Thus, only ten participants were considered in the analysis of the second questionnaire's results. Out these ten, only two were able to document the 80% of their designs using the tool. Three participants documented between 50 and 75% of their designs whereas five participants only were able to document less than 20% (results from the Q2-1). The main reason they mentioned for not being able to complete the 100% of the documentation was the lack of time (Q2-2), results consistent with the literature. As prior studies have noticed [6], time/workload factors can influence the use of a tool due to the teachers' lack of time for designing and documenting their teaching practices. In the case of the school #1, one participant (U1-9) highlighted that in her case, the implemented PBL design changed considerably respect to the initial design documented in the workshop 1 using the tool. Thus, she had not enough time to update the changes into the tool for the second workshop. In this line, participant U1-1 argued that her PBL design was very long (13 class sessions) and for this reason she had no time to document the completed design into the tool. Surprisingly, participants did not mention any difficulty related with the pedagogical method used (PBL or FC), apart from stating that the long duration of the PBL designs was the reason of not having time to document them completely (in some cases). Hence, the findings reported here appear to support the assumption that the blended model [13] can be used beyond the MOOC-based approach, being able to represent complex blended designs as those using PBL and FC methodologies (answering the RQ1). Nevertheless, considerably more work will need to be done to reduce the time needed for documenting designs using the tool in the different steps of the teaching-learning cycle (some improvements discussed above have a direct relation with this issue). Moreover, in the case of the school #2, two participants (U2-4 and U2-6) indicated that they had problems for saving her work during the edition and they lost part of her design already introduced on the tool. Notice that, during the workshops, the school #2 were using laptops connected to Internet by WiFi (which sometimes presented slow connection speed) whereas the school #1 used desk computers with Internet cable connection. In order to address this issue, in the last version (v.1), the tool incorporated an automatic saving to avoid unwanted loss of information (every time user does an action, the tool evaluate whether it is necessary to save the work done automatically). Since in the versions previous to v.1 users needed to save their work manually (see appendix, *Imp13* in the table 6).

Figure 4 shows the results regarding the participants level of agreement for each of the formulated sentences in the question Q2-3. The sentence with a highest level of agreement was the c (40% of participants agree with and 50% strongly agree), related with the potentialities of the tool about enacting teachers' reflection on their own designs. This finding is consistent with the evaluation obtained during the first workshops, as one of the identified strengths of the tool was related with the promotion of reflection and awareness among teachers. The second most agreed sentence was firstly the *e*, which also relates to the reflection process but specifically which is promoted by the analytics provided by the tool. And secondly the *b*, which refers to the potentialities of the tool design representation in facilitating the understanding of others' work (70% of agreement/strongly agreement in both cases). Result aligned with one of the strengths of the model identified in the conceptualization phase [13] which is its potential for communicating the work to others. Regarding whether the analytics provided helped teachers to reflect on the others' implementations, 40% agreed with and 20% strongly agree. Whereas only 50% agreed or strongly agreed regarding the tool helpfulness in documenting the designs. These results are likely to be related to the main weakness of the tool identified above which is the tool development limitations (as the results are contextualized within in an ongoing evaluation during the co-creation process, instead of an evaluation of a final version). Moreover, they can also be due to the main difficulty found by the teachers regarding the slow edition (which could be perceived as a frustration and it can be conditioned these results). The low rate of teachers who documented more than the 80% of their designs, as well as the limited time on the workshops for the sharing part, could also affect the percentages obtained by the sentence *d* (only 30% of agreement with it) as teachers could not reflect on the others' implementations in the best conditions.

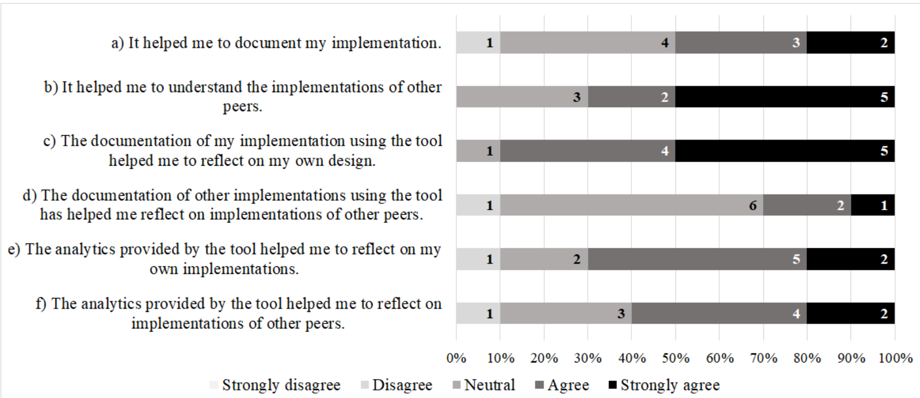

Fig. 4. Documentation and analytics evaluation (tool's versions 0.3 and 0.4). Results from the questionnaire delivered during the development workshops 2.

Interestingly, and regarding the question Q2-4 of the questionnaire, a common view amongst participants was that the design tool allows to document and visualize a complete learning design (positively supporting the RQ2) – as a teacher said, 'I think it is very useful for documenting and for giving you a more global idea of what you want to design' (U2-4). This result aligned with the findings from the paper-based model [13]. Despite all participants answered positively, some of them also pointed out to some of the limitations already discussed above. For instance, one of them (U2-1) highlighted that the agility to introduce the data on to the system needs to be improved. Also, two of them mentioned that it requires time: 'Yes, it can help, but it takes time. Once done, it can be very useful' (U1-4) or 'Yes, but the first time you do it you need a lot of time' (U1-5). Moreover, a last participant mentioned 'Yes, but I lack a lot of practice. I find it a bit repetitive and long work, and I get lost often' (U1-1). In the final part of the questionnaire, participants were asked to report missing functionalities in the tool which would help them to better document their designs and which functionalities were missing in order to better understand the designs of other colleagues (Q2-5 and 6). One participant (U2-3) answered the Q2-6 reporting the need of knowing the overall work students must do out of class (according to the teacher's design) and grouping this information from the different subjects (several teachers' designs) which are running in parallel to better plan the out of class work for the students and not overload them. This result was already reported during the focus group of the school #2 which has resulted in the improvement 24 implemented in the version 1.0 of the tool (see appendix, table 6).

The next section of the survey was concerned with offering them an open space for comments. Participant U2-3 said 'I really like to control what part of the work is done at home and what part is done in class' (reinforcing the in-class/out-of-class dimensions of the model.) and U2-4 thinks that is a great tool. The first result is in line with some of the interview answers, which indicated that being able to control the time of workload planned to be done out-of-class allows teacher to be prepared and informed to deal with student complaints about homework. Whereas U2-1 offered an interesting reflection about the potentialities of the tool in facilitating the reflection process but also arguing that it is still not 'practical' enough to be used during the day-to-day teachers' practices:

> 'I see it impractical, since it is about documenting and planning a lot, which takes a long time, but perhaps has little impact in practice. If you do it or do not do it, it does not show in the classroom. It has long-term advantages, the next course, by another teacher... but it requires a lot of time to implement and later, so you can do your service, you also have to dedicate time. It has helped me to reflect and improve, but I doubt that in the future I will use it for day to day.' (U2-1)

It can therefore be assumed that further work needs to be done to reduce the time to plan or document a design using the tool (in line of several proposed improvements about making the tool more agile and connect it with the existing systems users already used, to easily migrate their work from one side to another automatically – especially for those teachers who have been teaching a subject during long time and do not have the need of designing the course for the first time). In the case of the experienced teachers, most of the times they redesign the course based on the last course results, thus they need more flexibility in the timeline to change the initial design (result obtained from the interviews, asking e.g. to be able to eliminate an activity and automatically reorder the others on the classes times, see *Imp27* of table 6 in the appendix). However, at the end, it is a matter of reducing drawbacks and trying to increase the benefits, and future studies will show whether some advantages that the tool can bring to the teachers, which may solve some of their day-to-day challenges (e.g. the community analytics feature discussion) will be enough to 'seduce' them to use and adopt the LD approach that the tool offers whereas we try to reduce the drawbacks.

5.3 Revision of the blended learning visual model

During the co-creation process, we identified that users had a challenge for representing the activities out of class using the tool due to the out-of-class activities often are flexible in time: teachers can estimate their duration as well as define the period when students can do the activity (usually, from the day that the teachers publish the instructions till the delivery date). But, at the end, students are who decide in which moment of this period they do the activity. Thus, the model has been updated with the possibility of representing flexible activities over the time (see figure 5 and *Imp28* in table 6 of the appendix).

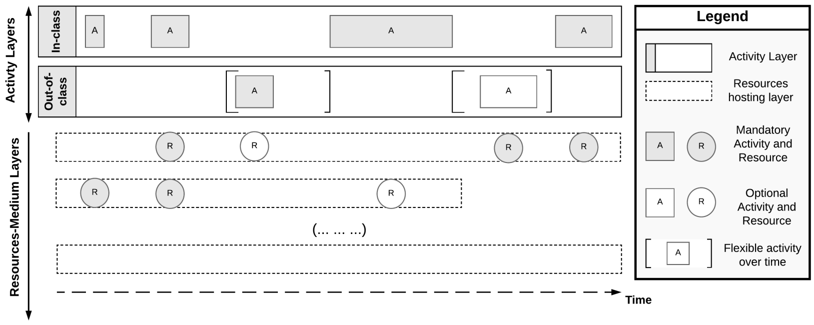

Fig. 5. Revised Blended learning visual model.

This new element add complexity in exploring how to visualize synchronicity within the model, discussion which already raised during the conceptualization phase of the model [13]. As Norberg, Dziuban, & Moskal (2011) argue, the synchronicity can be determined by type of resource used in the activity (e.g. a book, a forum… are asynchronous; whereas a webinar, a classroom… are synchronous). But we argue that, in some cases, the same resource (e.g. a book), can be used synchronously (e.g. at class, when teacher gives 20 minutes to students for reading a chapter of a book individually, and the whole class is doing the same activity at the same time) or asynchronously (when teacher ask students to read a chapter of a book as a homework for the next week). Hence, synchronicity also depends on the type of collaborative work related with the activity and also whether this activity have been defined to be done exactly on a specific date/time or, on the contrary, students can decide within a period when they want to do the activity, etc. Thus, we think that the model provides, together with the type of resource and its medium, all the contextual elements necessary from which synchronicity can be deducted.

Finally, from the results of the evaluation, it has been decided to update the categories of one tasks' descriptor: the students' type of work. Apart from the current descriptor's options 'individual', 'in groups' or 'the whole class' (as it is used on the orchestration graphs by Dillenbourg, 2015), results indicate that it is necessary to add a new category, which we named 'dynamic groups', in line with the research done by [36]. This new category (see appendix, *Imp10* in table 6) would allow users to represent group activities where the number of members per group can change dynamically (e.g. when groups are grouped, instead of individuals, in several steps of the activity).

5.4 Reflections on the implemented co-creation process

Participatory design workshops provided effective scenarios to develop the tool together with the final users which allowed us to advance in cycles of improvements depending on the users' insights and needs. Results from the continue evaluation trough the different co-creation workshops gave rise to a series of design principles collected in [30] and facilitated the development of the tool through different prototype versions reported in this case study. Despite that co-creation had a positive impact in the decision-making process of our research, it also presented two important challenges: (1) the prioritization of feedback diversity; and (2) the management of workshops' time and participants' expectations.

First, researchers analyzed the results after each workshop to be able to identify the software improvements arose from the participatory design activities. Then, they prioritized those improvements to be developed for the next workshop and let the rest as future work. This prioritizing process (following cycles of improvements) has been the most challenging part of the development phase. The prioritization process was always a balance between considering the feasible points to be developed in the time we had until the next workshop, and that a direct proposal from the participants would always be included to motivate them to continue in the process (since during the use of the first versions it was quite frustrating for them to use a system that was not yet very mature and, thus, usable). Having new versions of the prototype in each workshop allowed us to advance considering participants' insights and engaging them in the co-creation process. Table 6 in the appendix shows the list of the improvements (each of them with its corresponding ID), their short descriptions, the source (the instrument/s from which the need for this improvement has been identified), the development state (implemented or still not implemented) as well as in which version the improvement has been published (in case it has been developed). Out of the 28 improvements listed in the previous table, 15 have been implemented (54%) within the cycles of improvements trough the several tool's versions of the development process. However, there are still 13 (46%) pending implementations to be considered and developed in future versions.

Second, due to our context, the workshops had to offer some benefit to the participants beyond participating in a co-creation process: we taught them how to design applying FC and PBL methodologies. This was good for motivating participants, but it was challenging in terms of managing the limited time and expectations. While we were training the participants, we had to collect data and fit the corresponding co-creation activity using the tool. The hardest point was managing participants' expectations, finding a balance between their collaboration in our research and our contribution to them in terms of learning about educational design through the activities.

Apart from the difficulties detected in using the tool, participants also mentioned other challenges concerning the workshop structure and organization. Firstly, two participants mentioned the difficulties for finding the ideas for the design itself beyond the use of the tool. U1-6 expressed that the main difficulty was ‘Have the overall vision of the design that I am developing’, whereas U1-1 stated that ‘It's harder to think what you need to do than to use the tool itself. The tool is pretty intuitive’. Secondly, the lack of time for using the tool for the first time in the workshops also introduced some challenges, as U1-10 stated ‘The lack of time to place the activity (also the lack of familiarity with the tool) slows down the entire process’. Thirdly, the short duration of the workshops and the language spoken by the researchers (part of the workshop was in a different mother language of those from the teachers) had a negative impact on the participants as it introduced somehow stress and frustrations, as one participant commented such difficulties as ‘Follow-up of the explanations in English, having to make decisions quickly' (U1-5). And lastly, having access to multiple features and authoring tools in the ILDE platform [32] as well as the use of other platforms during the workshop (e.g. a *Moodle* virtual learning environment, for explaining the PBL and FC theory) introduced more difficulties and frustrations to participants: ‘...insecurity in the use of the ILDE’ (U1-5); or difficulties expressed by the same user related with ‘the access to the tool, I just did not locate the resources well: in *Moodle* of PBL, ILDE, to my designs…’. To minimize the usability issues which might come from having access to other editors and design types within the same platform, researchers proposed to develop in a future a separate instance of the LdShake platform [33] which only would contain the edCrumble’s editor (see *Imp15* in table 6 of the appendix) to carry out a more focused usability analysis in further evaluations.

6 Conclusions

Researchers have developed the learning design authoring tool edCrumble following a co-creation process. The tool provides an innovative visual representation of the designs that facilitates the planning, visualization, understanding and reuse of complex designs. The results show that the tool can not only be used within the hybrid MOOCs blended learning cases, but also for representing other complex blended learning designs as FC or PBL. This study has shown that the main strengths of the first versions of the tool are in line with those from the paper-prototype version of the blended learning model in which the tool is based, which are: its visual representation, that facilitates the organization and planning, promotes reflection and awareness; as well as that it provides support and guidance during the design process. However, the tool has presented some limitations which include: the tool’s missing features due to that the evaluation has been done during the development process; the high time investment needed for documenting a design; the need of support and some issues related with educational polices.

The co-creation process carried out has had a positive impact during the development of the tool allowing to identify the cycles of improvements needed as well as to revise the initial blended learning model. However, co-creation also has presented challenges related with the prioritization of feedback diversity and the management of workshops’ time and participants’ expectations. Despite half of the improvements identified with the teachers have been already implemented during the co-creation process, further work is required for continuing developing the tool and minimizing its limitations considering the research results. Specially, authoring strategies need to be ideated to reduce the time needed for documenting designs using the tool. Moreover, an evaluation of a final version of the tool as well as more research exploring the potentialities of the design analytics embedded in the tool is needed.

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Appendix

Table 1
Participants' demographics: gender, age, teaching experience and teaching subjects.

		School #1 (N=11)		School #2 (N=13)		Both (N =24)	
		N	%	N	%	N	%
Gender	Female	7	64	9	69	16	67
	Male	4	36	4	31	8	33
Age	20-34	3	27	2	22	5	25
	35-44	4	36	1	11	5	25
	45-54	4	36	6	67	10	50
Teaching experience	5 or fewer	2	18	0	0	2	9
	6-10	4	36	2	18	6	27
	11-15	2	18	1	9	3	14
	16-20	1	9	2	18	3	14
	21-25	0	0	4	36	4	18
	> 25	2	18	2	18	4	18
Teaching subjects	Arts/Music	0	0	1	14	1	5
	Language	0	0	1	14	1	5
	Foreign Language	0	0	1	14	1	5
	Social stud. /History	1	9	2	29	3	15
	Maths	0	0	1	14	1	5
	Science	5	45	2	29	7	35
	Other	5	45	1	14	6	30

Table 2
Difficulties found during the design process in the development workshops 1 as well as their related improvements to consider. Results extracted from the questionnaire responses (n=14).

#	Topics	Frequency Sch.#1	Sch.#2	Excerpts from the research questionnaire	Improvement ID
1	Slow edition (activities & tasks)	4	1	"I have progressed very little since I have to constantly repeat aspects that in my case are constant…" (U1-7) "…when creating an activity on a specific day, the duration of the activity by default is 1 day, so you always have to change the day and the end time of the activity" (U1-8) "Lack of flexibility in some aspects, to copy tasks, add links to tasks, etc." (U1-8) "The tasks could not be copied, dragged or changed." (U1-3) "be able to repeat the activities of the classes" (U2-3)	Imp1, Imp2, Imp3
2	Timeline management	1	1	"It's a bit difficult to move around the timeline. You have to invest too much time in deciding which day, and at what times, each task must be done." (U1-9) "mark the calendar and the days of school holidays for control the work sessions" (U2-3)	Imp4, Imp5
3	Tool inputs & outputs	2	0	"You cannot download a summary document of the design." (U1-3) "You cannot upload already prepared documents to associate them with a task." (U1-3)	Imp6, Imp7
4	Activities' types visualization awareness	0	2	"I find it difficult to visualize when I am working with the work in the classroom and at home…" (U2-2) "…know where you are in the line of work (school / house)" (U2-3)	Imp8, Imp 9
5	Designs representation	1	0	"It does not give the possibility to indicate that an activity is done with a group of groups" (U1-9)	Imp10
6	Goals edition	0	1	"I found that the goals could not be edited…" (U2-4)	Imp11
7	Web navigator	0	1	"… did not go well with the safari browser." (U2-4)	Imp12
8	Saving work	0	1	"go back without erasing" (U2-3)	Imp13, Imp14

Table 3

Main strengths of the web-based prototype (versions 0 and 0.1). Indicating the main topics extracted from the qualitative analysis (VR: visual representation; O/P: organization and planning; R/A: reflection and awareness; S/G: support and guidance).

#	Excerpts from the Q1-2 question's answers	VR	O/P	R/A	S/G
1	The sequencing of all phases of the learning process. (U1-5)	x			
2	Easy to collect any idea and reflect it in a design material. (U1-2)	x		x	
3	It allows you to have a lot of information about each designed activity. Give a complete and accurate view of the activities. Help and guide in the design. (UD1)	x			x
4	Make the teachers aware of the objectives of the activities and also the way in which they will carry them out in class. (U1-10)		x	x	
5	The degree of specification of the different activities throughout the design and the incorporation of tools to support this design. (U1-6)	x			
6	Leave a pretty complete record, with the most important points of PBL. It is easily registered the grouping of students, the tasks to be performed, etc. (U1-8)	x			
7	It allows you to structure the sessions very well and design them by carrying out a very necessary reflective process. (U1-3)		x	x	
8	It is all collected in one place only and helps you plan all sessions without forgetting any information. (U1-9)	x	x		
9	The possibility of planning in a very visual way. (U2-1)	x	x		
10	The possibility of systematically guiding and organizing teaching-learning activities. (U2-2)		x		x
11	the general view at a glance, the control of time and activities inside and outside the classroom, the possibility of having the tools / activities resources, the teacher's performance, … (U2-3)	x			x
12	It is an application that facilitates the organization of activities inside and outside the classroom to make FC. (U2-4)		x		
13	The previous organization and the obligatory organization. (U2-5)		x		
14	It allows to order and clarify the whole process avoiding improvisations. (U2-6)		x	x	
	Total frequencies	**8**	**8**	**4**	**3**
	Total percentages	**35**	**35**	**17**	**13**

Table 4

Main weaknesses of the web-based prototype (versions 0 and 0.1). Indicating the main topics extracted from the qualitative analysis (TdL: tool's development limitations; HtI: High time investment; NoS: Need of support; Ep: Educational polices).

#	Excerpts from the Q1-3 question's answers	TdL	HtI	NoS	Ep
1	The calendar of the tasks. (U1-1)	x			
2	A bit difficult do it without receiving support, I think it will cost me to do it alone. (U1-10)			x	
3	Apart from the difficulties mentioned above, perhaps a very high investment of planning time. (U1-8)	x	x		
4	If the PBL is long, you have to devote much time to designing all the sessions. However, and as always, it is work that we can take advantage of for other courses. (U1-3)		x		
5	Those mentioned in question 1. (U1-9)	x			
6	It is not connected to other tools that may be of more everyday use, such as Google Calendar or other types of notices that can reach students more directly. It also gives a lot of work and it will be necessary to see if it compensates in practice. (U2-1)	x	x		
7	I do not know yet, but what is an advantage (systematization) can be an inconvenience (bureaucratization). (U2-2)				x
8	I think it's a tool that can be very powerful if you fix the little details. (U2-4)	x			
9	I think that the options already set have to be better configured. For example, when defining a session, it would be good to define them by default of 60 or 55 minutes. (U2-5)	x			
	Total frequencies	**6**	**3**	**1**	**1**
	Total percentages	**55**	**27**	**9**	**9**

Table 5

Direct suggestions from the participants to improve the tool collected from the research questionnaire.

#	Topics	Excerpts from the research questionnaire	Improvement ID
1	Platform config.	Maybe add direct links to ILDE to go from one place to another. (U1-1)	Out of scope
		Do not have to remember more of a user and a password. (U1-5)	
2	Tool inputs and outputs	It would be positive that the tool itself could be used in class. ... there was a "class mode" that allowed displaying links, extracting explanations that could be projected, integrating applications and centralizing the results. (U1-8)	Imp16
		Be able to download a summary document of the design. (U1-3)	Imp 6
		Generate a document with all the information presented. (U1-2)	
		Upload documents already elaborated to associate them with a task. (U1-3)	Imp 7
3	Timeline manage-ment	Improve viewing of activities in the timeline to better understand in which point I am in the design, activities done, and activities I have pending. (U1-6)	Imp17
		It would be nice to see all PBL sessions on a single screen (such as PBL's planning for sessions at a glance only). (U1-9)	Imp18
4	Tool inter-operability	Be able to connect the design with our Google account or ClickEdu, to the forms of organization that we already have integrated. (U2-1)	Imp19
		Security copy to a compatible document with other formats. (U1-2)	
5	Slow edition (activities)	Be able to copy the tasks and / or sessions. (U1-3)	Imp 1, Imp3
		Would like to copy the activities (U1-2)	
		That you can copy / paste session designs. (U1-7)	
		Be able to drag or change tasks in order. (U1-3)	Imp20
		The possibility of changing if an activity is done at home or in the classroom once edited. (U2-5)	Imp21

Table 6

Improvements to consider. Indicating their source (Q: questionnaires 1 and 2; FG: focus groups; I: interviews, O: observations), the state (i: implemented; ni: not implemented) and the version readiness (tool's version in which the improvement has been implemented).

ID	Description of the improvement to consider	Source	State	Version readiness
Imp1	Repetitive activities creation need to be optimized.	*Q, FG, I, O*	*i*	*0.3 (duplicate activities)*
Imp2	Allow to configure pre-setting of the activities (i.e. time duration) and tasks.	*Q, FG*	*i*	*0.4*
Imp3	Allow to duplicate tasks (within an activity and between activities).	*Q*	*ni*	-
Imp4	Timeline improvements Import/export calendar (VLE, online calendar…).	*Q, FG, I*	*ni*	-
Imp5	Import holidays from an external calendar.	*Q*	*ni*	-
Imp6	Allow to generate and download a summary document about the design (syllabus).	*Q, FG*	*i*	*1.0*
Imp7	Allow to upload documents attached to a certain task within an activity.	*Q*	*i*	*0.3*
Imp8	Indicate better the type of activity when they are editing (icons).	*Q, O*	*i*	*0.2*
Imp 9	Highlight in a more effective way the activity selected on the timeline (which the user is editing it on a specific moment).	*Q*	*i*	*0.2*
Imp10	'Dynamic groups' category in the students' type of task descriptor.	*Q*	*ni*	-
Imp11	Add the possibility of editing the objectives once they have created.	*Q, O*	*i*	*0.3*
Imp12	Only works in Chrome. Extend for other browsers.	*Q, O*	*ni*	-
Imp13	Automatically save the changes user has done in the editor.	*Q, O*	*i*	*1.0*
Imp14	Undo (Ctrl + Z) and Redo editing commands.	*Q, O*	*ni*	-
Imp15	Instantiate an LDshake platform only for the authoring tool.	*Q*	*i*	*1.0*
Imp16	Class mode interactive visualization	*Q, FG*	*ni*	-
Imp17	Allow users to mark/visualize on the timeline which sessions have been already done.	*Q*	*ni*	-
Imp18	Provide a 'all-sessions' view on the timeline (hiding the time between the sessions).	*Q, FG*	*i*	*0.2*
Imp19	Connect with the VLE/platforms being used by the institution.	*Q*	*ni*	-
Imp20	Be able to change the order of the tasks within an activity, once they have created.	*Q, FG*	*ni*	-

Imp21	The possibility of changing if an activity is done at home or in the classroom once edited.	*Q*	*ni*	-
Imp22	Automatic tab selection in visualizing the graphs whereas users are editing.	*Q*	*i*	*0.2*
Imp23	Video tutorials as well as pop-up tips and messages embedded in the editor for providing help during the edition.	*Q*	*i*	*1.0*
Imp24	Community analytics.	*Q, FG, I*	*i*	*1.0*
Imp25	Add titles of the activities in the timeline/or visualization.	*FG*	*i*	*0.4*
Imp26	Editor's sections flexible display (hide-show buttons).	*FG*	*i*	*0.3*
Imp 27	Improve the flexibility of the activities changes on the timeline.	*I*	*ni*	-
Imp 28	To be able to add a flexible time range for the out-of-class activities.	*O*	*ni*	-

4.2 edCrumble: designing for learning with data analytics

The content of this section was published in the following demonstration conference article (which won the BEST DEMO AWARD):

Albó, L., & Hernández-Leo, D. (2018). edCrumble: designing for learning with data analytics. In V. Pammer-Schindler, M. Pérez-Sanagustín, H. Drachsler, R. Elferink, & M. Scheffel (Eds.), *Lifelong Technology-Enhanced Learning. EC-TEL 2018. Lecture Notes in Computer Science, vol 11082.* (pp. 605–608). Leeds, UK: Springer, Cham.

edCrumble: Designing for Learning with Data Analytics

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Abstract. This demonstration introduces ILDE2/edCrumble, an online learning design platform that allows teachers the creation of learning designs (LDs) with the support of data analytics. ILDE2/edCrumble is built on top of the LdShake platform, which provides social features enabling the sharing and co-edition of LDs. The tool provides an innovative visual representation of LDs combining face-to-face and online learning in different places (in-class and out-of-class) and times (synchronous and asynchronous). Decision making during the LD process is supported by two types of analytics: resulting from the design of the activities sequenced in a timeline (LD analytics); and aggregated meta-data extracted from several grouped LDs (community analytics). Preliminary results conducted as part of an iterative design-based research process, show that the tool is being perceived as easy to use and useful. During the demo we will show the use case of how LD and community analytics can help balancing the workload and design between different courses which are part of a whole curriculum.

Keywords: Authoring tool · Learning design · Data analytics
Communities of educators · Visualization · Pedagogical planner · edCrumble
ILDE2 · LdShake

1 Introduction

For some time now, Learning Design (LD) tools have been conceived to support teachers in the process of documenting their teaching practices, making their learning design ideas explicit and sharable [1–4]. The LD process often implies taking decisions about the selection of the most appropriate pedagogical model, the definition of the flow of tasks, the specification of roles as well as the choice of the most suitable resources and educational tools that can support the tasks defined, all to lead to potentially effective learning considering the needs of the educational context. However, despite existing proposed representations of pedagogical practice are varied, some are too specific for particular pedagogies and general approaches are not sufficiently accessible for teachers that do not have the required technical skills [5]. More intuitive visual representations of LD are needed [1, 2]. Moreover, with the spread of ICTs more complex educational scenarios are arising –combining face-to-face and online teaching in different places (in-class and out-of-class) and times (synchronous and asynchronous) [6]. [7] distinguishes two types of LD tools: “tools for visualizing designs” (which can be used to visualize

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and represent LDs) and the "pedagogical planners" (which can guide and support practitioners in making informed learning design decisions). In this paper, we present a LD tool that aims fitting in both categories bringing together the advantages of both types of tools. ILDE2/edCrumble can be considered a pedagogical planner which provides an innovative visual representation of the LDs characterized by data analytics with the aim of facilitating the planning, visualization, understanding and reuse of complex LDs. Specifically, the decision-making during the LD process is supported by two types of analytics [8]: resulting from the design of the activities sequenced in a timeline (LD analytics); and aggregated meta-data extracted from several grouped LDs created by multiple teachers within a community, e.g. a school (community analytics).

2 Technological Background

edCrumble is a web-based running LD editor prototype developed in JavaScript and HTML5. It is mainly composed of five zones (see Fig. 1), described as follows.

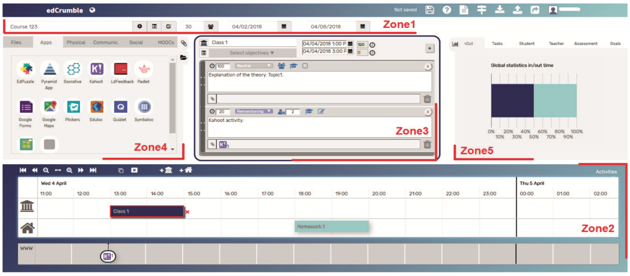

Fig. 1. edCrumble screenshot with the zones indicated in red (https://ilde2.upf.edu/edcrumble/) (Color figure online)

Zone1: It allows users to provide general information about the LD. The title, number of students and the start and end dates of the LD. It has three buttons to specify: (a) the LD description, the educational level and topic; (2) the list of learning objectives; and (3) the evaluation. **Zone2:** It allows users to create in-class and out-of-class activities and place them in a timeline limited by the dates introduced in zone1. The timeline has two main layers by default (in and out-of-class), where the activities are visualized sequentially depending on their schedule and type. **Zone3:** It allows users to edit the activities. Once an activity is selected, the user can set up the corresponding learning objectives and add the tasks that compose it. Indicating and editing for each task: the time allocated, the cognitive process level associated (according to the Blooms' taxonomy [9]), the students type of work (individual, in groups or the whole class), the teacher's presence (teacher available face-to-face, online or not present), and the evaluation mode (graded task, not graded or task for auto-evaluation). The user can also write a description of the task to be done by the students with indicators for teachers and add the associated learning resources. **Zone4:** It allows users to select the resources for the activities. Resources are divided on different categories (placed in different tabs):

Files, Apps, Physical, Communication, Social and *MOOCs*. The user can drag and drop a resource to the task of an activity and edit its characteristics: title, description, target (teacher or student resource), host-medium type (miscellanea, LMS, local storage, MOOC platform, web, physical artifact, cloud storage) and host-medium name. Moreover, it is possible to specify an URL for the resource and/or upload a file. After adding a resource in an activity, a visualization of an icon associated to this resource appears automatically in the timeline, placed in a new layer depending on the host-medium type (see Fig. 1 where a resource added in the second activity's task in zone3 appears in a host-medium layer -in grey- into the timeline in zone2, aligned with the corresponding activity). **Zone5:** It allows users to consult LD analytics extracted from the meta-data of the produced LD itself. Design analytics are divided on different categories (placed in different tabs): in-class/out-of-class time analytics, tasks 'cognitive process, student type of work, teacher presence, tasks' evaluation mode. In each category it is possible to have 3 different visualizations: global time statistics, statistics depending on the activities 'type (in or out-of-class) and depending on the learning objectives. Last, a button on the **Zone2** allows users to have another view of the timeline hiding the time intervals between the activities and activating the analytics per activity (controlled by a legend composed by buttons corresponding to the different LD analytics' categories). Resulting in a completed interactive visual representation of the LD (see Fig. 2).

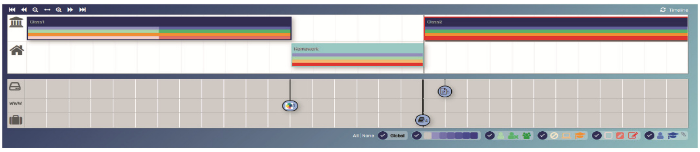

Fig. 2. Visual representation of a LD composed by 2 in-class and 1 out-of-class activities and 3 resources placed on 3 host-medium layers. Screenshot from the activities' analytics view.

edCrumble has been integrated as an authoring tool within the Integrated LD Environment (ILDE2) [4]. The integration of edCrumble into ILDE2 allows practitioners to co-edit, share, remix and comment their designs and others' designs within a community of teaching -ILDE2 is built on top of the LdShake platform that provides social network features [10]. Moreover, it facilitates teacher's access their designs for future design improvements during the iterative processes of the LD and teacher inquiry cycles (as LdShake acts as a repository of LDs). Once teachers have implemented their LDs, they can upload their evaluations to the edCrumble editor, helping others understand their impact and facilitating the adaptation and reusability of their LDs (for instance, describing the main challenges found or uploading links to the resulting learning analytics). The tool allows generating LD analytics aggregated from all the LDs placed in a folder, named as community analytics –supporting teachers' decision making during the LD process not only at their individual level but also allowing the possibility of considering the colleagues' LDs analytics in their community. The tool also offers the possibility of activating pedagogical guidelines (e.g. flipped classroom) during the design process as well as generating a LD summary including: (1) a printable syllabus with all the analytics generated; and (2) an interactive visualization to be embedded or shared with the colleagues but also with the students to help them organize their courses.

3 Use Case, Preliminary Results and Future Work

In the demo we will show the use case of how LD and community analytics extracted from ILDE2/edCrumble can help balancing the out-of-class workload between different courses which are part of a whole curriculum and support the necessary reflection process for specifically improving the LD quality of the activities within a community of educators. Despite the final evaluations of ILDE2/edCrumble are part of an ongoing cycle of a design-based research process, preliminary results from initial evaluation workshops with stakeholders indicate that the tool is being perceived as easy to use and useful. But also, the need for further work has been identified in the line of providing more flexibility during the activities' creation process (e.g. allowing users to import their activities from existing calendars or creating grouped activities which follow a certain time pattern).

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4.3 Identifying design principles for learning design tools: the case of edCrumble

The content of this section was published in the following conference article:

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Identifying Design Principles for Learning Design Tools: The Case of edCrumble

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Abstract. Despite the existing variety of learning design tools, there is a gap in their understanding and adoption by the educators in their everyday practices. Sharing is one of the main pillars of learning design but sometimes it is not a sufficient reason to convince teachers to adopt the habit of documenting their practices so they can be shared. This study presents the design principles of edCrumble, an online learning design platform that allow teachers the creation and sharing of blended learning designs with the support of data analytics. The design principles have been learned and extracted from a participatory design process with teachers during the conceptualization and ongoing development of the tool. Several workshops including interviews were carried out as part of a design-based research iteration process. Later analysis has been done to extract and highlight those design principles aiming informing the development of learning design tools towards better learning design adoption.

Keywords: Design principles · edCrumble · Learning Design · Authoring tool
Learning design adoption

1 Introduction

Learning Design (LD) tools have been conceived to support teachers in the process of documenting their teaching practices, making their learning design ideas explicit and sharable [1–3]. Despite the existing variety of learning design (LD) tools, there is a gap in their understanding and adoption by the educators in their everyday practices [4, 5]. Sharing is one of the main pillars of LD [6] but sometimes it is not a sufficient reason to convince teachers to adopt the habit of documenting their practices so they can be shared. Thus, one of the near-future LD challenge is reducing this gap and providing LD tools that can facilitate their adoption [5]. Moreover, despite existing proposed representations of pedagogical practice are varied, some are too specific for particular pedagogies and general approaches are not sufficiently accessible for teachers that do not have the required technical skills [7]. More intuitive visual representations of LD are needed [2]. [1] distinguishes two types of LD tools: "tools for visualizing designs" (which can be used to visualize and represent LDs) and "pedagogical planners" (which can guide and support educators in making informed LD decisions).

In this line, we have conceptualized and developed a generic LD tool that aims fitting in both categories bringing together the advantages of both types of tools. ILDE2/

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edCrumble can be considered a pedagogical planner which provides an innovative visual representation of the LDs characterized by data analytics with the aim of facilitating the planning, visualization, understanding and reuse of complex LDs (available online at https://ilde2.upf.edu/edcrumble/). This study presents the design principles of edCrumble, extracted from a participatory design process with high school teachers during the conceptualization and ongoing development of the tool (Fig. 1).

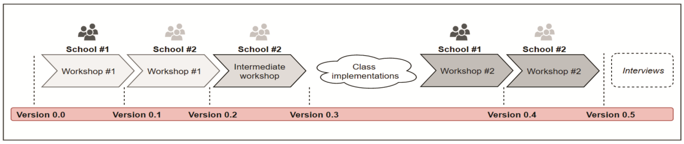

Fig. 1. edCrumble development versions regarding the participatory design workshops outputs.

2 Methodology

The development of edCrumble is part of a design-based research project which integrates several iteration cycles [8]. In this paper, we will present the design principles extracted from a complete cycle of this process which has the aim of prototyping and assessing the preliminary versions of the authoring tool. Within this cycle, 24 high school teachers from two different school communities have been involved in several participatory design workshops [9] between October 2017 and February 2018. Those teachers were participating in the context of a Teacher Professional Development program which had the aim of training teachers as designers of TEL and facilitate their inquiry practice with the collection of student data. For this reason, workshops were structured based on the following pattern: (1) **Workshop#1(2 h):** teachers had to design a LD using edCrumble, with the help of the researchers (participants were asked to come to the workshop with a concrete LD idea); (2) **Class implementations (9 and 4 weeks respectively):** teachers had to implement their LDs in class and collect students‘data; (3) **Workshop#2 (2 h and 1 h respectively):** joint reflection about the implementation phase and possible redesign (using edCrumble) of their original LDs. In the case of the second school, they had an intermediate 2 h workshop because they needed more time for designing the interventions.

At the end of the workshops phase, we carried out seven semi-structured face-to-face interviews of about 45 min each (three teachers from School#1 and four from School#2 -due time and resources constraints we could not interview all 24). The interviews consisted of a series of open-ended questions that invited participants to share their perspectives regarding (1) how they used to design and document their educational practices before knowing our tool and (2) how was the design process they followed during the workshops using the edCrumble (see the demographics of participants and interviews questions in [10]). The resulting qualitative data were coded, analyzed and triangulated by two researchers familiarized with the data. An open coding was used for identifying the main topics, extracting design principles and highlighting those aiming at informing the development of learning design tools towards better learning design adoption. Specifically, in this paper we will focus on describing the design principles learned and extracted from the steps' outputs from the first version of the LD tool – conceived from the existing theory of the research field and our previous studies [11, 12] – to the current version (v.0.5) –developed based on the workshops'outputs during this cycle (Fig. 1).

3 Design Principles Regarding edCrumble Development Process

3.1 Content and Activity Centered Planning

When we asked teachers "How do you usually design or prepare your courses?" they did not answer from a pedagogical point of view, instead they answered first from the content perspective – i.e. they explained how they structured the content without mentioning any pedagogical details (e.g. how the activities were designed: if they used collaborative learning or any pedagogical model…etc.). On one hand, five out of seven teachers said that they start preparing their courses examining the content that they must deliver and then filtering this content depending on the learning objectives. On the other hand, one participant said that she first starts looking on the objectives and then she plans the content. Last, one said that her preparation consists on a revision of the last year course and the re-adaptation of the content to the current objectives, as she has been teaching the same course for some years. This result is aligned with findings from related research. First, [13] state that the starting point of the design process depends on the nature of the design problem, identifying also three distinct starting points: from the learning outcomes, from a content-area focus and from a direct re-adaptation of previous LDs. Second, there is a need of describing teaching and learning activities as the "content" dimension of education is already captured in books, websites, etc. [14] for the later sharing and reuse of LDs. From our results we have observed that teachers need support to adopt and switch between these two approaches. **Implications for LD adoption:** From the above discussion we argue that it is important to foster the use of activity-centered model for capturing pedagogy beyond the content-based approach. But, at the same time, it is necessary to allow teachers to connect with their content-based approach whereas they adopting the LD aims (e.g. allow them to upload content related with their activities).

3.2 Planning Tool Based on a Timeline

All teachers stated that they design their courses based on time using different tools: paper-based calendars or notes with dates, online calendar applications, LMS which organize the content based on time…etc. The time-based design approach used by teachers is aligned with Laurillard research insights in [6], who points out that the learning sequence is essentially time-based and that a LD does demand a plan. Other research findings also highlight the importance of the time and activity-sequence in course planning [3, 15]. **Implications for LD adoption:** we argue that LD tools which act as pedagogical planners can serve users in connecting their current planning practices with LD as they can foster the LD approach adoption by offering pedagogy support and helping in taking design-informed decisions during the design process.

3.3 Facilitate the Design in a Community of Educators

Most of teachers stated that they plan their activities alone, showing a high level of autonomy in deciding what and how to teach –results in line with [13]. The main reason is that usually there is only one teacher per topic and educational level in the school and there is no chance for co-design between teachers of the same educational context. Moreover, from the participatory workshops they highlighted the sharing and reflection phase they had during the second workshop as they really appreciated having found a space to talk with and learn from others' practices –despite they were LDs from other topics. It is known that the sharing is one of the most important aspects of LD field [15], but still there are few learning design tools that offer a social platform for exchange LDs. **Implications for LD adoption:** we argue that is necessary to have LD tools that facilitate the sharing of the created LDs between educators –creating spaces for sharing LDs and support the seeking of similar topic LDs cross education-communities (open community instead of institutions-based closed communities).

3.4 Usability Matters: The Google Apps Effect

When we asked teachers about the weaknesses of the edCrumble, we detected what we name as the "Google Apps effect": they were continuously referring to Google apps (calendar, drive, etc.) features for suggesting usability improvements to our tool. This result suggests, as other research findings pointed out, that usability is one of the two most important things (together with the usefulness) for users adopting a new technology [1]. Teachers are used to commercial applications, and existing LD applications are far from them in terms of design appeal and usability. **Implications for LD adoption:** Aesthetics and usability are an important factor to consider in the design of LD tools to facilitate their adoption.

3.5 Increasing the Utility Perception Solving Teachers' Real Problems

General opinion of teachers regarding edCrumble was positive despite most of them recognized that it will be difficult for them because of lack of time (as they put LD approach at the bottom of their list of day-to-day priorities). **Implications for LD adoption:** We argue that offering LD tools that can solve some of their day-to-day problems can be a way of adopting the LD approach –as it can increase their utility perception of the tools.

4 Decisions and Implications for the edCrumble Development

Content and Activity centered planning: (1) The LD is based on defining a sequence of activities which are composed by tasks. User can indicate for each task: the cognitive process level associated, the students type of work, the teacher's presence and the evaluation mode; (2) Users can provide the detailed list of learning objectives and relate them with the activities; (3) Users can upload all the content necessary to carry on their courses. **Planning tool based on a timeline:** The main element of the LD tool is a timeline where users can place their activities sequenced depending on their schedule and type (in-class/out-of-class activities). **Facilitate the design in a community of educators:** edCrumble has been integrated as an authoring tool within the Integrated Learning Design Environment (ILDE2) [16] allowing practitioners to co-edit, share, remix and comment their designs and others' designs within a community of educators. Once teachers have implemented their LDs, they can upload their evaluation, helping others understand their impact and facilitating the adaptation and reusability of their LDs (e.g. describing the challenges found or uploading links to the resulting learning analytics). **Usability matters: the Google apps effect:** edCrumble must be improved in terms of design aesthetics and usability (i.e. allowing users creating grouped activities which follow a certain time pattern as Google Calendar automatically does when you want to create the same event at the same day every week). **Increasing the utility perception solving teachers' real problems:** During the interviews we have detected some teachers' needs arising during the LD process which edCrumble can solve: (1) the need of having a syllabus of the course for sharing it with students and institution (online and printed version) *–edCrumble can generate a LD summary including a printable syllabus with the activities description, the resources' plan and a report with all the analytics generated. Also, it provides an interactive visualization of the LD to be embedded or shared with the colleagues but also with the students to help them organize their courses.* (2) the interest of sharing the plan of the out-of-class activities between the different colleagues of the same educational level to leverage the "homework" of their students in a certain period *–the tool enables users to generate aggregated LD analytics from all the LDs placed in a folder (named as community analytics), supporting teachers' decision making during the LD process not only at their individual level but also allowing the possibility of considering the colleagues' LDs analytics in their community;* (3) the need of decreasing the time needed to document their practices in edCrumble as it is an entry barrier for those teachers that do not plan but only need re-adapting LDs *–further work has to be done to improve the flexibility and connection with existing tools (LMS, calendars…).*

5 Discussion and Conclusions

In this paper, we have extracted some design principles from interviews with high school teachers involved in participatory design workshops with the aim of informing the design and development of the edCrumble learning design tool. Of those design principles, we can highlight two rules which we think they can facilitate the adoption of the LD tools by educators in their daily practices: LD tools which seek to connect with teachers' existing practices and LD tools which seek for solving teachers' day-to-day problems [13]. From the first one, the following design principles are derived: *Content and Activity centered planning*, *Planning tools based on time*, *Usability matters: the Google apps effect*. And from the second one: *Facilitate the learning design in a community of educators* and *Increasing the utility perception solving teachers' day-to-day problems*. The final evaluations of ILDE2/edCrumble are part of an ongoing cycle of a design-based research process. Further research is needed to evaluate the edCrumble adoption by educators and inform the redesign of the existing identified design principles for supporting the development of future learning design tools.

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CHAPTER 5

DESIGN ANALYTICS SUPPORT FOR DESIGNING BLENDED LEARNING

This chapter addresses the evaluation of the product as well as the design analytics as part of the second objective of the thesis (Figure 5.1). It contains two articles which address the fifth phase of the DBR process, the Assessment of Preliminary products and theories (Figure 5.2):

- the first paper (J3, see Section 1.4.3) offers a more in-depth description of the authoring tool (and design analytics) as well as it provides a general evaluation of the final product—which is made upon several workshops using different participants: teachers, students and EdTech related stakeholders (Section 5.1).
- the second paper (C7) is specifically focused on exploring the value of concept-level design analytics integrated into the authoring tool and evaluating its potentialities (Section 5.2).

Part of the J3 research paper was also reported in an additional study specifically exploring how educators value design analytics for blended learning, which can be found in Appendix B. Moreover, an extension of the tool that considers the integration of MOOCs can be found on the Appendix C. However, the new feature needs to be evaluated in further iterations of the tool as a future research line.

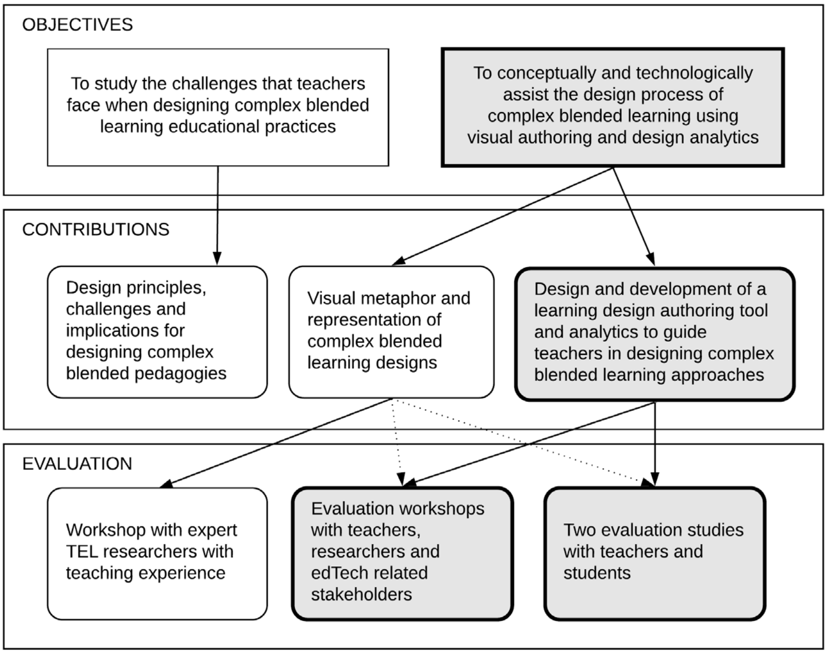

Figure 5.1. Objectives, contributions and evaluation works covered by Chapter 5.

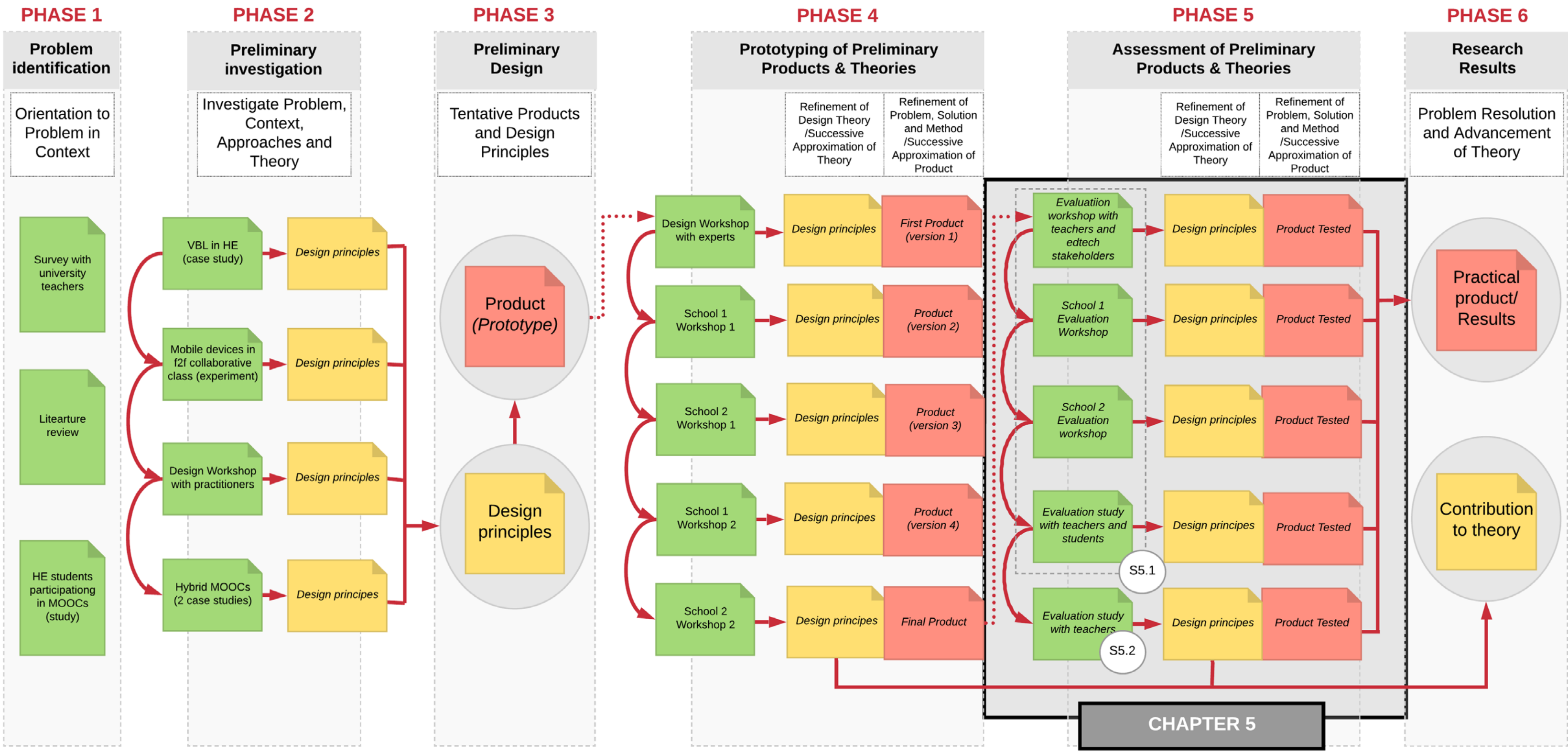

Figure 5.2. Part of the research process covered by Chapter 5.

5.1 edCrumble, a data-enriched visual authoring tool to design for blended learning

The content of this section was submitted to a JCR-indexed international peer-reviewed journal and is under review:

Albó, L., Hernández-Leo, D. edCrumble, a data-enriched visual authoring design tool for blended learning (Submitted to Journal).

edCrumble, a data-enriched visual authoring design tool for blended learning

Laia Albó and Davinia Hernández-Leo

Abstract—**This paper presents the data-enriched visual learning design authoring tool edCrumble, which aims to support teachers in designing blended learning scenarios. The tool is evaluated within the context of the existing learning design tools adoption gap, which lies beyond the usability perspective, and provides teachers' insights on the advantages and disadvantages of using the tool as compared to their traditional methods. Moreover, it presents an analysis of factors that could facilitate or hinder its later adoption by teachers. Three evaluation workshops were held with 69 participants, including teachers of different backgrounds, educational stakeholders, and students. Data-gathering instruments included interviews and questionnaires to collect qualitative and quantitative data, as well as analysis of the design artifacts resulting from the workshops. The evaluation shows that the tool possesses specific features that facilitate the representation of and support for designing blended learning, uncovers the factors that may promote or inhibit its adoption, demonstrates its connection with solving actual educational challenges, and reveals the strengths and weaknesses in the tool's usability.**

Index Terms—**Authoring tools, blended learning, data-driven support, instructor interfaces, learning design.**

I. Introduction

THE learning design (LD) field aims to support teachers in becoming learning designers to improve their teaching practices through evidence-based design decisions and by supporting the sharing and co-creation of learning designs among communities of teachers [1], [2]. Research and practice in LD seek to provide suitable textual, visual, and computational means to represent teaching practices, as well as the tools to manage and share them [2], [3]. Currently, the need to achieve LD goals has received considerable attention since, with the spread of the use of technology in education, the complexity of educational designs has increased significantly, which presents both challenges and opportunities.

On the one hand, the use of internet-connected technology has allowed teachers to go beyond the use of traditional face-to-face (f2f) instruction and adopt more complex scenarios that combine multiple teaching and learning modalities (mixing learning contexts and spaces, physical and digital tools, time settings as well as formal and informal structures) [4], [5]. These new blended scenarios present several design challenges since their design complexity often hampers the reporting of well-documented case studies, which frequently lack evidence on how pedagogy and/or technology influence learning outcomes, making the study of their effectiveness difficult [6], [7].

On the other hand, these new complex educational contexts provide opportunities for educators and researchers because they usually integrate technology that simplifies the automated collection of educational data during teaching and learning processes [8]. These contexts can then provide data-based evidence to improve the overall quality of the learning experience. Although learning analytics (LA) is the most familiar type of data collected from specific technological environments that allow educators to evaluate how students are learning within a learning context [9], there are more types of data available that may contribute to better design educational practices that are least explored, such as community analytics, the metrics and patterns of design activity within a community of teachers and related stakeholders [8], [10]; and design analytics, the metrics of design decisions and related aspects that inform learning designs [8].

Despite the variety of existing proposed LD tools and representations of pedagogical practice [11]–[16], new approaches addressing the complexity as well as the new challenges and opportunities of blended learning educational practices are needed. Accordingly, this paper presents and evaluates a learning design authoring tool, edCrumble [17], which aims to support teachers in designing blended learning scenarios. The tool enables the representation of hybrid educational practices through a visual representation of a layered-timeline that is informed and supported by design analytics [8], [17], [18]. edCrumble is also integrated into a social platform [13], [19] that allows teachers to share their designs among a community of educators both within and beyond their own institutions. This paper is divided into five sections, including the introduction. After a description of the authoring tool (section 2), we introduce the research questions for the tool's evaluation (section 3). The fourth section covers the methodology used and the fifth presents the findings of the research. Finally, we close with the conclusions and

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possibilities for future research.

II. The edCrumble Authoring Tool

A. The Learning Design Approach Adoption Gap

Despite the potential affordances of the Learning Design (LD) approach [1], [3], several researchers have identified a gap in the use of LD tools and methods by teachers [20]–[25]. Specifically, from their literature review in this field, [20] identified five first-order barriers to teacher adoption of LD aims, including: lack of institutional support, lack of adequate teacher training, time/workload factors, conceptual complexity of methods and tools, and adoption by their peers. Moreover, the authors also posited two second-order barriers: the use of information and communication technologies (ICTs) in teaching practice and teacher motivation. To address these obstacles, the same researchers outlined what teachers need from LD tools, including:

1. Flexibility
2. Support for reuse and adaptation of designs
3. Support for cooperation among teachers
4. Support for reflection
5. Ease of use
6. Saving time
7. Textual vs. graphical representation
8. Activating design thinking processes teachers are familiar with

Thus, in the design of edCrumble, it has been necessary to keep teachers' needs in mind, particularly entry barriers as well as their current practices. As Bennett, Agostinho, and Lockyer (2015) point out, "support tools have most potential to improve design decisions by engaging with the key influences that shape existing design practice".

In order to meet this challenge, we have involved different education-related stakeholders, including teachers, in the whole co-creation process of the new LD authoring tool through participatory design workshops [26]. Furthermore, design decisions during the development process were made while taking into account the main entry barriers and maximizing support for the teacher needs mentioned above. With all this in mind, edCrumble was built on top of the LdShake platform [13], [19] to address two of the teacher needs identified (support for reuse and adaptation of designs and support for cooperation among teachers). This integration allows teachers to co-edit, share, remix, and comment on their and others' designs within a community of teaching since the LdShake platform provides social network features [13], [19]. Moreover, as the literature reveals [27], sharing designs can have pedagogical benefits – through improved student learning outcomes – as well as productivity benefits – through a decrease in educator preparation time arising from the re-use of other educators' effective ideas – which also allows us to address another of the teacher needs above: saving time. As Laurillard [28] argues, "we make progress faster if we can learn from each other, and especially if we can transfer proven pedagogical practice through cross-disciplinary collaboration." On the other hand, Kurvits, Laanpere, and Väljataga [29] evaluated several existing LD tools and proposed the following design guidelines when developing this type of tool to increase teacher acceptance:

1. It should use a simple visual language for representing the structure and components (artefacts, tasks, roles, workflows, activity types).
2. It should be easy to use and allow lightweight integration with common web tools used by teachers (e.g. Google Docs).
3. It should also allow teachers to create sub-versions and remixes of validated "template scenarios."
4. It should semantically link generic pedagogical scenarios with contextualized learning scenarios and ex-post-facto teaching and learning stories, together with learning analytics data gathered during the lesson that was implemented in accordance with the scenario.

edCrumble has also been developed considering these design guidelines, and the following sections will provide a more detailed description of how it works.

B. Visual Representation for Blended Learning Designs

The visual representation of blended learning designs that edCrumble offers originates from the visual blended learning representation shown in Fig. 1 [30] – since the tool's ultimate goal is to support the design of blended learning educational practices. The main element of the visual representation is a timeline that comprises two activity layers (in-class and out-of-class). The granularity of the representation is variable, and it is defined by the start and end dates of the module, course, activity, etc. set by the teacher (as well as the possible time indicators, which may be weeks, days, etc.).

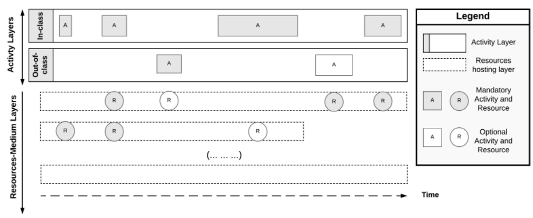

Fig. 1. Visual representation for blended learning designs.

Below these two main layers are the resource layers, which are extensible and can be defined by the designer according to her needs. We can distinguish between the resource and the resource-medium layers, which indicate the medium in which the resource is provided to the student. For example, a book (resource) would be placed in a physical resource-medium layer, like other physical resources such as photocopies or laboratory material; or a Massive Open Online Course (MOOC) medium layer could contain a video, an online test or a web-text resource, among others. Thus, the activities are sequenced on the timeline and located in the place where they occur (in or outside of class), whereas the resources are aligned with the activities in which they are used and placed in the corresponding resource-medium layer, affecting if and when they are available (physical resource, online resource, virtual learning environment, web, cloud, etc.). Moreover, it is possible to indicate whether the blended activities and resources will be mandatory or optional. The blended learning visual model also defines how to represent the activities, mainly using the following four descriptors:

1. Teacher presence (available face-to-face, online, or not present).
2. Type of student work (individual, in groups, or whole class).
3. Type of task, following Blooms' taxonomy [31] (remembering, understanding, applying, analyzing, evaluating, and creating).
4. Grading mode (graded, not graded, or self-evaluation).

C. *edCrumble Editor Analogy*

To date, several authors have employed different analogies to describe the underlying ideas of the LD approach. The theatre play comparison proposed by [32] in the IMS LD specification was used by Littlejohn and Pegler [7], where the screenplay would be equivalent to a lesson plan and the director's working document – a schematic of the technical performance with stage directions (choreography) and parallel processes (lighting, stage, directions, etc.) – would be the activity sequence map [7]. Alternatively, Dalziel et al. [33] suggest similarities with a musical notation system to represent the abstract concept of music:

> The purpose of creating musical notation was not simply the abstract concept of music representation; rather, it was a vehicle for conveying great musical ideas to others. (p.2) [33]
>
> The ultimate goal of Learning Design is to convey great teaching ideas among educators in order to improve student learning. (p.1) [33]

Whatever the trope, an effective way of representing these teaching ideas is clearly lacking, which is also what LD aims to solve.

Inspired by the imagery above, we proposed a visual analog corresponding to the characteristics of the visual representation in which edCrumble is based (explained in the previous section, 2.2), with the objective of finding an existing interface that was already intuitive and easy to use, in accordance with one of the teacher needs discussed in section 2.1. Observing the visual representation for blended learning designs [30], which are composed of different layers in time (Fig. 1), we believed that it could be compared to the process of working in layers that occurs when editing video. In video editing, similar to what happens in the blended visual representation, several layers (containing mainly video and audio tracks) are placed within a timeline (sequentially or in parallel) and interconnected with resources (video transitions, effects, etc.) to generate the final video output. In this analogy, the output video (composed of a sequence of frames) would be equivalent to an educational practice (composed of a sequence of learning activities).

Furthermore, video editing is a clear example of how a complex process, which was until recently the exclusive domain of specialized professionals – as we might consider LD to be presently – has become available to anyone due to advances in technology and access (e.g., apps and tools that facilitate video editing by non-experts, including on smartphones). Video editing is becoming widespread and some online video repositories like Youtube even incorporate editing tools. This is especially relevant in education, where video lectures have been growing in popularity, mostly thanks to the proliferation of MOOCs, and their use is increasing both inside and outside classrooms [34]. Thus, recently, several tools have emerged to simplify video management and editing for educational purposes (e.g., edPuzzle [35], Camtasia Studio [36], [37] or Doceri [38]).

Fig. 2 is a comparison of three video editors: Vegas Pro [39], which is used mainly by professionals; Moovly [40]; and Windows Movie Maker [41], the latter two of which are more accessible for non-professional users, with WMM being the easiest to use. When analyzing the interfaces, we may observe that all three have similar layouts, with the work areas structured similarly, showing the main output at the center of the screen. It may be noticed, though, that in the one most intended for general consumers, Windows Movie Maker, the background color is white and there is no area for advanced features on the right side, whereas the more professional the editor is, the more complex and technical the elements of the timeline are.

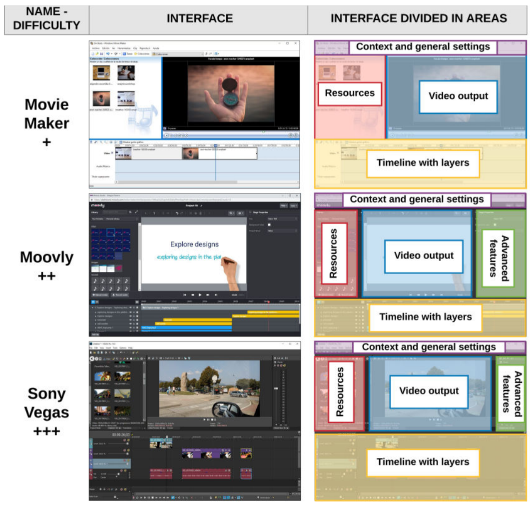

Fig. 2. Interfaces comparison of three video editor software tools.

Analogous to these layouts, we have adopted the same structure as the video editors described (Fig. 2) to build the edCrumble editing interface (Fig. 3). We have decided to use a white background similar to that in the Movie Maker interface; the elements in the timeline are similar to those in the Moovly software as well as the area on the right of the screen for the tool's design analytics visualizations, which is equivalent to the advanced features area in the video editors.

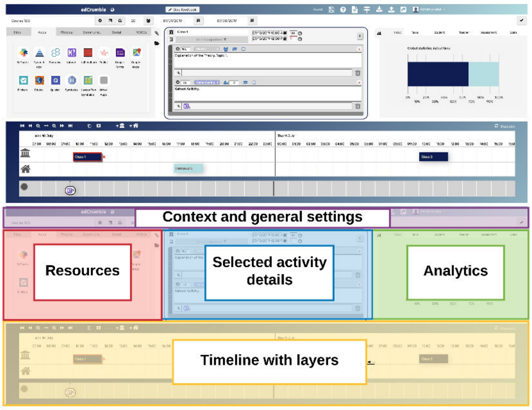

Fig. 3. edCrumble editing interface areas.

D. *edCrumble Description*

Having now covered the context and origins of the authoring tool, in this section we describe the functionalities of the main areas of the edCrumble editing interface (Fig. 3) [17]:

Context and general settings area: this allows users to provide general information about the LD such as the title, number of students, and start and end dates of the LD. It has three buttons to define: (1) the LD description, and the educational level and subject; (2) the list of learning objectives; and (3) the evaluation.

Timeline with layers area: this allows users to create in-class and out-of-class activities and place them in a timeline bounded by the dates entered in the context and general settings area. The timeline has two main layers by default (in- and out-of-class), where the activities are visualized sequentially depending on their schedule and type, as shown in section 2.2, "Visual representation for blended learning designs" [30] (see Fig. 1).

Selected activity details area: this allows users to edit the activities. Once an activity is selected, the user can define its learning objectives and add the tasks it includes. For each task, the following may be defined and edited: the time allocated; the cognitive process level associated, according to Blooms' taxonomy [31]; the type of student work (individual, in groups, or whole class); the teacher presence (teacher available face-to-face, online, or not present); and the evaluation mode (graded, not graded, or self-evaluation). The user can also write a description of the task to be done by the students with indicators for teachers and add the associated learning resources.

Resources area: this allows users to select the resources for the activities. Resources are divided into different categories, which appear as different tabs: Files, Apps, Physical, Communication, Social, and MOOCs. The user can drag and drop a resource to the task of an activity and edit its characteristics: title, description, target (teacher or student resource), host-medium type (miscellanea, LMS, local storage, MOOC platform, web, physical artifact, cloud storage), and host-medium name. Additionally, it is possible to specify a URL for the resource and/or upload a file. After adding a resource to an activity, a visualization of an icon associated with this resource automatically appears in the timeline, placed in a new layer depending on the host-medium type (see Fig. 3 where a resource added in the second activity's task in the selected activity area appears in grey in a host-medium layer in the timeline area and aligned with the corresponding activity).

Analytics area: this allows users to consult design analytics, which are extracted from the meta-data of the produced LD itself. Design analytics are divided into different categories and appear as different tabs, Fig. 4 right upper corner): in-class/out-of-class time analytics (DA1), task cognitive process (DA2), type of student work (DA3), teacher presence (DA4), and task evaluation mode (DA5). One may observe that the categories are the same as those in the task descriptors in the blended visualization described in section 2.2, as well as those in the selected activity area (each analytics category is identified by a different color).

Furthermore, in each category there are 3 different visualizations possible: global time statistics, statistics depending on the activity type (in- or out-of-class), and those depending on the learning objectives (Fig. 4). The global visualizations show the time dedicated for each item in relation to the whole learning design (Fig. 4, lower left corner visualization), whereas the in/out class visualizations show the time for each category item separated into in- and out-of-class activity time (Fig. 4, upper right corner visualization).

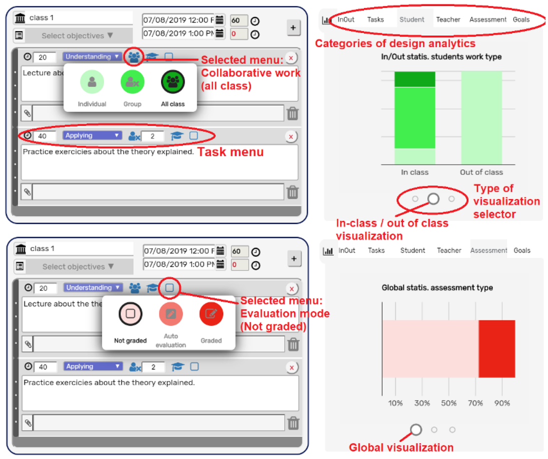

Fig. 4. Two screen captures of the *Selected activity details* and *Analytics* areas. Top: type of student work analytics with in/out class visualization. Bottom: evaluation mode analytics with the global visualization.

Lastly, a button within the timeline with layers area (Fig. 5, A and B), allows users to have another view of the timeline that hides the time intervals between the activities and shows the analytics per activity, which is controlled by a legend composed of buttons corresponding to the different LD analytics categories (Fig. 5, C to G). This results in a complete interactive visual representation of the LD.

The tool allows users to generate design analytics aggregated from all the LDs placed in a folder, called community analytics [8], that supports teachers' decision making during the LD

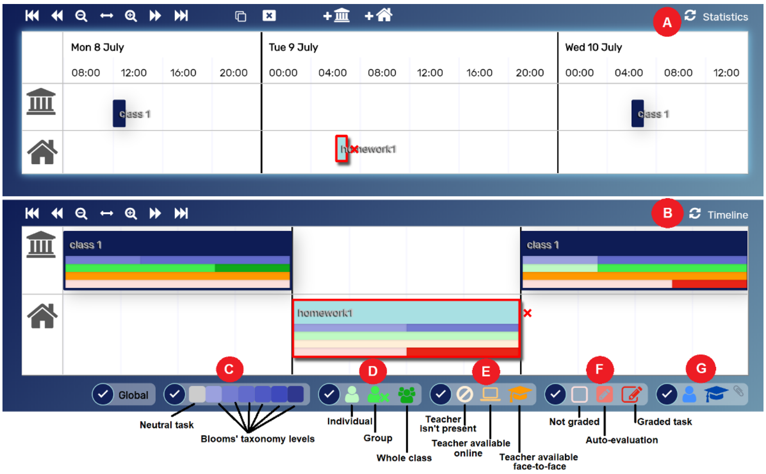

Fig. 5. Design analytics at the activity level. Top: timeline without the analytics. Bottom: timeline with the analytics (enabled using button A; disabled using button B). On the bottom, analytics menu C- F (design analytics categories), G (resource types: students vs. teachers).

process not only at the individual but also the community level by offering the possibility of considering their colleagues' LD analytics.

E. *edCrumble Outputs*

At the end, edCrumble follows the approach of the LD_lite planning tool [7], which integrates three types of frameworks in one, and affords teachers the opportunity to generate four different output artifacts from the same design (Table I).

When a group of tutors was asked about which framework from LD_lite was the most useful for describing and documenting practice and could be reused most easily, their response was that since all three types of descriptions serve different purposes and would be useful to different people at different times, they were all useful aids for thinking through potential issues and designing blended learning [7]. Along these lines, Laurillard et al. [14] suggest that "to represent fully the pedagogical properties of a learning design, it is important for the user to have access to multiple representations of the underlying properties of the domain model (given that a learning design plays out over time, we need to include a time-based representation as well)".

III. Research Goals Of The Evaluation

Considering the context above in respect to LD tools, the objective of this study is to evaluate edCrumble based on the following topics stemming from the discussions within the previous section, which led us to formulate the corresponding evaluation research questions:

1. Design process support: to study the extent to which the design tool can support and bring new perspectives to current teacher practices in designing their blended courses. Specifically, to evaluate the general features – which can also be found in other LD tools – as well as the unique features that characterize edCrumble and blended learning representation and support, including the timeline, the design layers, and the design analytics. RQ1: *To what extent does the tool (and their features) support the specific design process of creating blended learning designs?*
2. Factors influencing tool adoption: to explore what factors could promote or inhibit the adoption of the edCrumble authoring tool in actual practice. RQ2: *What factors might be potential facilitators or disruptors of subsequent actual adoption of the tool?*

TABLE I
EDCRUMBLE 4-IN-1 AUTHORING TOOL VERSUS LD_LITE 3-IN-1 FRAMEWORK FOR BLENDED LEARNING

edCrumble		LD_lite	
Artifact output	**Description**	**Framework**	**Description**
Printable syllabus or lesson plan	Text document describing the context, activities, resources, and analytics of a design.	The lesson plan	Matrix description of the time, mode (online or offline), activities (tutor and student roles), and resources.
Online design summary (with a shareable URL)	Comprises an interactive visualization of the learning sequence and information about the context and the results of applying the design with students.	The pattern	Sets out general ideas and perspectives, giving information on the learning goals and offering solutions to specific problems in learning and teaching.
Interactive visualization (embeddable)	Outlines how activities, resources, and support services might be integrated in time in an interactive web-based visualization.	The sequence map	Outlines how activities, resources, and support services might be integrated in time.
Json file	Technical document with the whole elements of the design to facilitate interoperability with other systems.		

3. Connection with the challenges of actual practice: to study the tool's potential for solving existing challenges in current teaching communities, since maximizing these connections and relevance could increase the probability of the tool's adoption. RQ3: *How important are the challenges faced by teaching communities that could potentially be addressed/solved by the authoring tool?*
4. System usability: to determine the extent to which the interface provided by the tool meets its usability objectives, in terms of maximizing its ease of use, effectiveness, satisfaction, and efficiency. RQ4: *To what extent does the tool's user interface affect the perceived value of the tool?*
5. Learning design representation: to evaluate the expressivity of the tool in representing blended learning designs. RQ5: *To what extent is the tool able to represent/document blended learning designs?*

IV. Methodology

A. Participants and Sample

The study involved 69 participants for the evaluation of the authoring tool. Three different groups of participants could be distinguished based on their prior experience using the tool and the evaluation context.

High school teachers: there were 14 high school teachers from two different school communities who attended several participatory design workshops prior to this evaluation. They actually participated in the co-design process of the authoring tool. Finally, they were invited to participate in the last workshop (reported in this study) to evaluate the last version of the tool.

Random teachers and edtech stakeholders: these participated in a workshop held as part of a teaching innovation conference. There were 23 participants from different backgrounds, including random teachers and edtech-related stakeholders. They did not have any prior experience using edCrumble.

Undergraduate students: there were 32 undergraduate students participating in a local research study on blended learning at the authors' home university. They did not have any prior experience using edCrumble.

The use of undergraduate students responds to the need to collect data on actual longer course designs – in this case, a three-month course – using the tool in order to evaluate its capability for representing blended learning designs (expressivity). While students could not contribute to evaluating the tool's pedagogical support, they could offer their insights on its usability and expressivity. Students volunteered for the study and indicated 3-5 subjects from their bachelor's degrees on which they would be able to report. Researchers assigned one course per student depending on their preferences. They were complementary compensated financially for working with the system and participating in the study.

B. Procedure

Two types of workshops served as chances to practice to give participants the opportunity to interact with the system for later evaluation. The high school teachers, random teachers, and edtech stakeholders had to document a given example of a short design (a module composed of two or three in-class sessions, and one or two out-of-class sessions). The 90-minute workshop consisted of a role-play game where participants were placed in groups of 2-4 people. Each group of participants represented an imaginary school and each participant in each group represented a teacher of a different subject (simulating different educational communities). The role-play game had two main parts (individual and in group), each of which involved three steps. The individual activity (at "imaginary" teacher-role level) consisted of:

1. Designing a short teaching unit with the edCrumble online version – a prepared printed design was provided by the researchers for each teacher role.
2. Analyzing the data resulting from the design produced.
3. Sharing the design created within the edCrumble community.

The subsequent group activity (at "imaginary" school-role level) involved:

1. Grouping several designs to generate community analytics.
2. Solving an educational challenge.
3. Discussing results with all participants.

The educational challenge proposed was to use community analytics to balance the out-of-class workload between the different designs they created, which were part of a complete curriculum to be worked on by the same cohort of students (within the simulated school community). The objective was first to analyze how many hours of homework they had given to the students in total by adding together all the designs generated by the school; and second, to reduce the total hours of work outside the classroom, if there were many, to a certain number that they would consider appropriate by debating what criteria to apply. At the end of the workshop, the researchers asked the participants to fill in a research questionnaire to evaluate edCrumble. Lastly, participants were asked to discuss in groups the educational problems the tool can or could solve as well as the factors that would facilitate or hinder their acquiring the habit of documenting with edCrumble.

By contrast, in the undergraduate student workshop, the participants had to document their own design of a trimester-long course, having on average two/three in-class sessions per week over three months and all the out-of-class activities and homework as well. The two-hour workshop consisted of the following phases:

1. 10 minutes: students signed the consent form and a document with their bank details (they received €15 as complementary compensation).
2. 15 minutes: researchers explained the aim and procedure of the study and made a short demonstration of how to document a course plan in edCrumble.

3. 80 minutes: students worked with edCrumble to enter the course plan into the system. Students were asked in advance to come sufficiently prepared to be able to document the design of the course that had been assigned to them by the researchers.
4. 15 minutes: students filled out the questionnaire on the evaluation of edCrumble.

C. Instruments, Data Collection, and Analysis

Data were collected using two main instruments: semi-structured interviews and a questionnaire. In addition, we used and analyzed the design artifacts resulting from the three workshops. Fig. 6 shows the instruments used in collecting data for each of the five evaluation topics (described in section 3): design process support, factors influencing tool adoption, connection with the challenges of actual practice, usability of the system, and learning design representation.

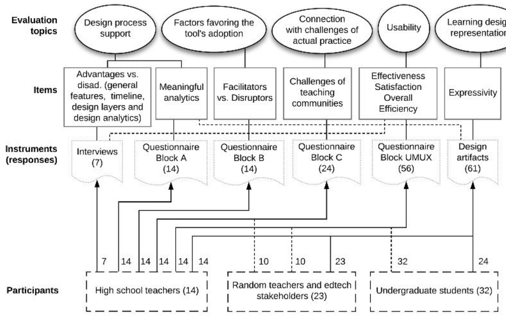

Fig. 6. Instruments used by evaluation topic and workshop participant.

The interviews were face to face and comprised a series of open-ended questions that invited participants to share their perspectives regarding: their reflections on the possible advantages and disadvantages of using the tool as a new methodology; and teachers' views of visualizing and planning their lessons using a timeline with layers (separating in- and out-of-class activities). The interviews were conducted before the evaluation workshop and included only those participants who had already had experience with the tool (the high school teacher group). Due to teacher time constraints, the researchers were able to interview seven schoolteachers in the end. The corresponding qualitative analysis of the responses focused mainly on identifying the advantages and disadvantages of using edCrumble to evaluate the general features of the tool, as well as those designed specifically to support the blended learning design process (timeline, design layers, and design analytics). After the classification into advantages and disadvantages, we further grouped the final items by related emerging topics, which led to the identification of the general features in the advantages analysis and six emergent topics in the disadvantages analysis. We believe that the interview results offer a deeper perspective from those end users who had been collaborating on the tool's conceptualization and development from an early stage. Thus, this qualitative data, which complements the quantitative data analysis performed on the questionnaire responses, enriches our evaluation.

The research questionnaire consisted of four blocks of questions: A, B, C, and UMUX. Block A complemented the design interviews regarding the design process support evaluation, specifically focusing on the evaluation of design analytics. First, it had three main statements and, for each, participants indicated their level of agreement on a five-point Likert scale. They were invited to provide optional additional comments or open responses for each statement. Second, participants were asked to evaluate design analytics based on several factors, again on a five-point Likert scale.

Block B was designed to discover what factors would promote the habit of documenting with edCrumble and what factors would impede it. Researchers prepared (from the literature and previous work) 12 four-point Likert scale items that could facilitate tool adoption and 3 four-point Likert scale items that could discourage it. After rating all the proposed items, participants had extra space to add new items for both types of factors at the end of the questionnaire.

Block C used a five-point Likert scale for participants to evaluate the level of importance of 5 educational challenges – from items selected by the researchers based on the literature and previous work – which could be addressed with the authoring tool. At the end of this block, participants were provided extra space for any other challenges they considered relevant that the tool should/could resolve.

The fourth block focused on measuring the user experience with the system. Due to the limited workshop time, the Usability Metric for User Experience (UMUX) questionnaire, a compact usability questionnaire with a high degree of reliability, was used. The UMUX instrument is a four-item Likert scale used for the subjective assessment of an application's perceived usability. It is designed to provide results similar to those obtained with the ten-item System Usability Scale, and is organized around the ISO 9241-11 definition of usability [42].

Finally, the design artifacts resulting from the role-play game workshop were analyzed, to check whether participants were able to generate the community analytics correctly and whether they successfully solved the educational challenge proposed, which contributed to the evaluation of the pertinence of design analytics. The design artifacts generated by the undergraduate students, on the other hand, were studied to assess its expressivity and evaluate the tool in terms of blended learning design representation potential.

D. Limitations and Ethics

One of the main limitations of this study is that the high school teachers and the random teachers and edtech stakeholders were volunteers who were motivated to continually improve their teaching practice and probably reflect a sub-set of "motivated" professionals who may not be representative of the wider population. Another limitation is that the UMUX questionnaire provides a subjective evaluation of system usability. In future research, its scoring should be compared to objective metrics, such as error rates and task timings, in a full experiment [42] to perform a more comprehensive usability assessment.

The researchers affirm that the data collection and analysis took ethical considerations into account by avoiding harm to participants, respecting their privacy by anonymizing the data collected, and ensuring that their participation was voluntary; for instance, they could withdraw at any time without needing to provide a reason, as well as had the right to decline to answer any question. At the beginning of the project, the researchers explained the context of the study and obtained informed consent from the participants who were willing to participate.

V. Results and Discussion

A. Support During the Design Process

1) Advantages and disadvantages: general features, timeline, design layers, and design analytics

In this section, we present the main findings from the interviews, which will contribute to determining whether the design tool can support and bring new perspectives to the current teacher practices in designing their blended courses. Table II shows the advantages and disadvantages identified in teacher responses, divided into several categories. From the general perspective of tool use, teachers considered raising awareness, promoting reflection, and possibilities for sharing their ideas as three key advantages. Additionally, they believe that it makes organizing the course easier and day-to-day use more systematic. The majority of participants agreed with the advantage of having everything that was planned with the tool automatically documented for the future, to be revised for later course redesign and/or for sharing with other teachers. One teacher said that it would be a great advantage to share the visualization plan generated with the students in class, including access to the course resources.

However, interestingly, the advantages most frequently mentioned related to the specific features of the tool for supporting the design of blended learning, which answers RQ1 positively. First and foremost is the timeline-based planning that the tool offers, which is especially important the first time one is designing a course, when everything must be planned from the beginning. The second most highlighted advantage is the separation of in-class and out-of-class activity planning. One teacher said that it makes you remember that the learning process occurs not only in class, but also continues after it. Still others believe that the tool helps you to remain aware of the time you are asking students to devote to work after class, which is sometimes ignored or simply not taken into account when designing with other tools. Interestingly, they think that the possibility of having this information aggregated from different courses that are running in parallel could offer new insights for teacher coordination, through sharing what type of work they have assigned students in a certain week to avoid repetition of similar tasks or educational strategies, which underlines the idea of community analytics in edCrumble. Finally, educators also identified the design analytics that the tool provides as an advantage compared to their traditional working habits, as well as the ability to print the course syllabus from the planning generated with the tool, since some teachers prefer having their lesson plans on paper (e.g., for administrative purposes).

Conversely, a recurrent theme in the interviews was a sense among interviewees that the main disadvantage is the extra effort that using the tool demands. Documenting their practices using the tool means extra work that they often cannot afford. Sometimes it is a prioritization issue, where they feel that assessment work or other urgent day-to-day duties are more important than planning using the tool, which some teachers argue takes more time than traditional planning methods. Furthermore, some teachers have been teaching a course for years and they already have their own organization, with everything already planned and what resources to use and for what already decided. Thus, despite the positives, using edCrumble as a new method means considerable extra effort for them that involves transferring their plans from the system/s they are using into our system. It is most likely in these cases that they do not perceive the cost/benefit balance as falling in their favor.

Some teachers also found the need for a high degree of time specificity when planning with edCrumble as a disadvantage. In addition, another disadvantage for them is the lack of system flexibility, e.g. they would like to change their set plans easily and smoothly, even from a different device than a computer, such as through a smartphone app. Finally, the most experienced teachers commented that despite the tool providing good guidance and planning support for those teachers just starting the profession, they would like it to offer more functionality for re-adapting their already planned courses rather than to have all of the current support on planning them for the first time.

Answering the first research question, the results presented above demonstrate that edCrumble supports teachers in the design of blended learning practices, especially with its timeline, design layers, and design analytics, as the other sections have already discussed. The use of the tool can raise awareness, support reflection, as well as facilitate planning by providing the opportunity to share plans within a teaching community. Moreover, specific characteristics of the tool – such as the timeline, the distinction between in-class/out-of-class layers, and the design analytics – have been identified as features that offer advantages over current teaching methods.

2) Meaningful analytics

Six out of seven respondents agreed strongly (with the seventh agreeing) with the statement, "I think that the real-time visualizations while designing help me to better understand the design that I am creating" (first statement in questionnaire block A). In the open responses, one participant indicated that the visualizations would help him to better time the distribution of activities. Another participant highlighted the value of seeing how any activity is balanced at the pedagogical level, whereas others mentioned that analytics helped them to better organize themselves mentally, that it was very intuitive and helped them to be aware of the design and the workload that it entails. It also allowed them to spot design errors to fix. One participant added that design analytics is the outstanding feature of the learning design tool.

TABLE II
ADVANTAGES AND DISADVANTAGES OF USING OUR TOOL COMPARED TO TRADITIONAL TEACHER METHODS
(EXCERPTS TRANSLATED FROM THEIR ORIGINAL LANGUAGE)

	Advantages	
	Category	**Excerpts.**
General	Awareness	"The potential of the tool is that it allows you to be much more aware of the design you are creating."
	Reflection	"The advantage is that in the process of doing something like this [...] you are thinking more about what you will do and how you will do it."
	Sharing	"The advantage is sharing. I think it's a fantastic advantage."
	Planning /Organization	"It makes organizing things easier." "The advantage is that, if you have time to do it, it is a fantastic systematization."
	Documentation	"Another advantage is that everything is recorded. If you can save it, you have it for another year." "That this is recorded [...] if the feedback is also documented, if the design has worked or not, [means] it can be used by another person in the community ... this, as an idea, is very good" "It will help me next year to remember what I did: how many sessions I dedicated to a specific topic, etc."
	In-class use	"If we could use it in class, for example if you can save resources there, opening only the visualization in class, you could have all the resources and access it..., etc. So, I think that all of this is an advantage."
Specific features	Printed Syllabus	"With the printed document of the timing my course would improve a lot because I would have spent a lot of time writing many elements and being aware of what I am doing and why I am doing it [...]. I would like to have everything on sheets of paper to collect the different schedules year after year."
	Timeline	"For me, everything is advantageous (timeline). Although it serves then to break it, but for me the timing is basic because it presupposes organization." "I think it is useful. It is useful when you start. What happens to me, is that [...] I have taught these subjects for many years and I have everything more or less organized, and now I work more by emotional inputs from the students." "When you work on a timeline you realize what margins you are giving students to do their homework (how many days), e.g. in my case, the difference between one group of students and another is quite large because in the first I have classes on Mondays and Fridays, and in the second on Tuesdays and Wednesdays."
	In/out class layers	"It is very interesting because it makes visible something that maybe I had not considered, which is how much time they will spend on out-of-class activities. And taking this into account allows you to pace the subject very well." "This I found, perhaps, [to be] one of the most interesting things [having the global out-of-class workload per grade level, which is shared between teachers]. The organization by inside/outside the classroom would allow me to be clearer about what I am asking them to do outside of class and maybe ask for more things, since sometimes they complain that they have many assignments, but I do not know if they are deceiving me...." "This seems interesting to me on two levels. […] Thinking that the learning process goes beyond the classroom [...] and, being aware that sometimes they spend more time at home than we think [...]. If all teachers ask students to watch videos at home, they will be quickly bored. Sometimes, when we ask for so much time outside of class, certain strategies may end up losing effectiveness. […] It helps to visualize if there is coordination between all the teachers."
	Design analytics	"Having the planning would allow me to collect data to see it graphically, what part they dedicated to autonomous learning, etc. or see cross-disciplinary skills such as teamwork and make sure you are promoting it." "The advantage I see is that it gives you some possibilities and some items – for example, Bloom's taxonomy, or also if the work is individual/collaborative, that's interesting – that the LMS does not."
	Disadvantages	
	Category	**Excerpts.**
User experience limitations	Extra effort (time)	"It entailed a significant amount of extra work for me. [...] Doing it alone made me pause a lot, because I did not remember how it worked. Maybe they were little things [...], but each of them meant a little more time." "The time I need to fill this out, I need for other kinds of things." "It takes even more time to do this planning. And it is time you do not always have." "The problem is in cost-benefit, what benefit will all this cost generate for me, and with the pressure we are under...." "I had to transfer a lot of information that I had already had in another environment. [...] If the school said we work with this application [...] I would do it there directly. But having to do this transfer, I could not find the time."
	Time Specificity	"It did not work so much for me to have to use specific dates for session1 or session2, etc." "It demands very detailed planning, very exhaustive, almost minute by minute [...]. There is no room in our everyday routine for it."
	Lack of flexibility	"Sometimes, I would need it to be more flexible, to make the changes easier for me, because reality is changing." "I take my notepad everywhere and it allows me to do things anywhere (e.g., in the car) [...]. For me it is much more flexible, it is much easier, I do not have to be sitting in a chair with a computer [...]. Lately I have gone from the notepad, which is what suits me, to the smartphone. Because it's what I always have with me everywhere."
	Usability	"The interface lies somewhere between Moodle (I don't like at all) and Google (I love it). In Google Calendar I use the display for three weeks and it's fine. [...] In a single line it is difficult to see everything." "It does not seem particularly efficient to me."
	Not ready for in-class use	"It is complicated because you cannot use it in class because you need to do everything well and fast so as not to lose the attention of the students. You need an application that is very streamlined."
	Adaptation/not planning	"I have been planning for a long time and there are certain things that I already have planned. From there, it's more about adaptation, because every year you have to adapt it to the students you have."

When we asked participants whether they believe that their teaching practice will benefit from having information in the form of design analytics showing what is being designed by other teachers in their teaching community (second statement in questionnaire block A), five participants strongly agreed, one agreed, while one was neutral. Most participants highlighted the value of sharing analytics as a positive aspect for improving, reflecting, and making objective design decisions, but there were discrepancies in whether analytics of designs from different educational backgrounds and topics than their own designs would also be useful. One participant suggested that it would be necessary to complement the design analytics with learning analytics to be able to discern the actual effect of edCrumble planning on student experience and outcomes. The last question asked participants whether they thought that their teaching practices would benefit from having design analytics of other teachers' designs from other teaching communities (third statement in questionnaire block A). The responses were also positive, with four participants agreeing strongly, two agreeing, and one remaining neutral. One participant stated that it would be a good opportunity to learn from brilliant teachers in other communities who have very interesting ideas that may be shared and applied.

In the second part of questionnaire block A, the first factor under evaluation was the *ease of interpretation*, first for the global visualization and then for the in/out visualization. Most of the 14 participants strongly agreed that the global visualization was easy to interpret (13 in the case of DA1, 8 in DA2, 12 in DA3 and DA4, and 11 in DA5). The others simply agreed and only two participants were neutral (one in the case of DA2 and another in DA4). Only one person disagreed on the ease of interpretation of the "type of knowledge" global visualization (DA2). Results for the in/out visualization were similar, with the conclusion that teachers found both visualizations, global and in/out, easy to interpret. The second factor studied was reflection support, the third was improvement support, and the fourth the potential of the design analytics categories to help in maintaining design continuity between in- and out-of-class activities. All the factors above received similar positive evaluations from most participants in all the design analytics categories. The last factor evaluated, which applied only in category D1, asked participants about the balance of out-of-class workload. Results were also positive, with 11 participants agreeing strongly with the statement that "edCrumble is very useful for helping teachers to ensure that the out-of-class workload is not excessive," with a further two agreeing, and only one remaining neutral.

Lastly, regarding the artifacts collected after the role-play game workshops, all groups of participants were able to generate the community analytics without difficulty. Moreover, all groups successfully completed the challenge proposed, being able to reduce the global out-of-class workload to within certain limits in each community. Interestingly, participants used different strategies to meet this challenge. Whereas some groups agreed to reduce the same amount of out-of-class time for each individual design in the community, others only reduced the time of specific designs by, for instance, considering the nature of their subject, pedagogical strategy used, or simply focusing on the design or designs that had assigned more out-of-class hours. On the usefulness of having the aggregated design analytics for each course, participants argued that it has the potential to raise awareness of the work of the other teachers in the same community. Above all, it allows teachers to coordinate different design strategies in order to offer students a better-balanced workload.

In answer to the first research question, results show that the design analytics provided by the tool support teachers greatly in the design of blended learning, by fostering awareness during the design process, teacher coordination and collaboration, and workload balance between in- and out-of-class sessions, among others.

B. *Factors Favoring LD Tool Adoption*

Table III shows the results for factors that would promote the habit of documenting teaching practices with edCrumble. All 14 high school teachers responded to block A of the research questionnaire in groups of 2-3 teachers. Thus, the total number of responses per item was 6, corresponding to the number of groups formed.

Interestingly, the item considered by the teachers to be potentially the most useful in fostering the documentation habit using the tool was f, global analytics for each course. One possible use of this community analytics functionality might be the ability to monitor the number of out-of-class hours per course for doing extra activities, with this often being a critical

TABLE III
FACTORS PROMOTING THE HABIT OF DOCUMENTING WITH EDCRUMBLE (RESULTS IN FREQUENCIES)

Likert Scales (1: not at all; 2: a bit, 3: quite a lot, 4: a lot)	1	2	3	4
a. Pedagogical support integrated within the authoring tool.	0	0	2	4
b. Resources support integrated within the authoring tool.	0	1	2	3
c. That the authoring tool would facilitate the sharing of learning designs with teachers at other institutions.	0	1	1	4
d. That the tool would facilitate the sharing of learning designs with teachers at the same institution.	0	0	1	5
e. Mandatory use by the institution.	3	1	1	1
f. Global analytics per grade level (community analytics) - e.g. homework balance control.	0	0	0	6
g. Connection of the tool with existing tools used by the teachers in the institution (Clickedu, Moodle, etc.).	0	0	2	4
h. Connection of the authoring tool with existing tools used for planning (Google Calendar, etc.).	1	0	0	5
i. That the authoring tool would serve for planning.	0	0	1	5
j. That the authoring tool would allow teachers to share the planning with students.	0	1	1	4
k. That the tool would help me to generate the syllabus of the course (digitally or printed) automatically.	0	0	1	5
l. That the authoring tool would allow me to document the changes I would make to the design easily after knowing what happened in each class (e.g., using a mobile app that asks me how the class was and allows me to enter my feedback by voice or text, for changes next year).	0	0	1	5

N= 6 groups of participants (14 participants divided into groups of 2 or 3 people).

area of contention between high school students and their teachers. When documenting several courses that are running in parallel, the tool allows users to generate the aggregated time allocated for out-of-class activities, making visible the hours required both per course and in total. Thus, this allows teachers to balance the total time and adjust it depending on the students' and teachers' needs, thereby avoiding overloading students with out-of-class work.

The next items by ranking were those related to: the opportunity to share designs between teachers in the same community (item d); the use of the tool for planning (i); the automatic generation of course syllabi from the planning (k); and the flexibility of making modifications to the planning on the fly (l). Teachers also stated that having pedagogical support integrated into the tool as well as its connection with other tools they usually use in their institution (e.g., their Learning Management System) could promote the habit of using edCrumble quite a lot (2 groups of teachers) or a lot (4 groups of teachers). These results are in line with the design guidelines proposed by [29]. Additionally, the tool's connection with other tools specifically focused on planning (item h) was considered by 5 of the groups to be a potential facilitator, despite one group not considering it to be a facilitator at all.

The sharing of designs beyond their institutions with teachers at other schools as well as the sharing of the planning with students ranked lower as facilitators compared to the above-mentioned items. Although the results obtained were still positive – as most of the groups (4) thought that the tool would promote design sharing with other teachers from other institutions and with students "a lot" – one group indicated that it would do so "quite a lot" while another only "a bit". Similar results were obtained for the item on the resource support integrated into the authoring tool (see item b). The only factor that was considered to be definitely not a facilitator by the teachers was item e, which suggests that their institutions mandating use of the tool would not aid in its adoption by faculty.

Overall, these results indicate that aside from item e all the items identified by the researchers were correctly identified as facilitators, since most of the teachers thought that the factors selected for study would promote the habit of documenting with the tool quite a lot or a lot. These results match some of the teacher needs identified by [20], which are directly related to some of the factors identified. Further, it is worth highlighting again that the results indicate that, from a teacher's standpoint, the institution should not consider forcing them to use the tool if the long-term goal is to encourage its adoption. None of the teachers added any other factors to the list provided by the researchers in the space provided for this purpose after block A.

Moving on to inhibiting factors, Table IV presents the results for those that would make forming the habit of using the tool for documenting teaching practices more difficult. Consistent with the literature [20], [22] and our interview results, teachers' general lack of sufficient time and the delicate balance between the time necessary to "invest" in the tool versus the benefits obtained were identified by the participants as clearly disruptive factors, but there were different opinions on the lack of

TABLE IV
FACTORS IMPEDING THE HABIT OF DOCUMENTING WITH EDCRUMBLE
(RESULTS IN FREQUENCIES)

Likert Scales (1: not at all; 2: a bit, 3: quite a lot, 4: a lot)	**1**	**2**	**3**	**4**
a. Lack of time.	0	0	0	6
b. Lack of institutional recognition.	3	1	1	1
c. Work where in the end the time that must be invested vastly outweighs the benefits obtained.	0	2	2	2

N= 6 groups of participants (14 participants divided into groups of 2 or 3 people).

institutional recognition. Half of the teachers responded that this factor would not hinder acquiring the habit of using the tool for documenting their teaching practices at all, but the other half considered (at different levels) that not having institutional recognition for doing the task of documenting would definitely be a disruptive factor. So, recognizing the time spent using design tools for documenting and sharing teaching practices could actually encourage some teachers to adopt these types of tools.

Finally, teachers also added their ideas about other disruptive factors. They mentioned the lack of systematics and the feeling of repeating already-completed tasks, as when entering their existing lesson plans into the tool, as two factors that would make acquiring the habit of documenting their teaching practices using edCrumble more difficult. On the one hand, we believe that the lack of systematics could be addressed at the institutional level by providing more support and reaching agreements with teachers on how to introduce new ways of working. On the other hand, the use of edCrumble as a planning tool from the beginning of the design process as well as improving its connection with tools that teachers are already using in their institutions could lower the perceived cost/benefit barrier in terms of time investment required.

With respect to RQ2, the results presented above highlight several factors that may facilitate or disrupt subsequent adoption of the tool. Knowing which factors facilitate adoption may lead to improving the development process of future versions to yield a more essential design tool. The prioritization of future features will be based on selecting those which maximize facilitating factors while minimizing disruptors, which will allow the researchers to upgrade the tool with a view to wider adoption by teachers.

C. *Connecting with Actual Practice Challenges*

This section evaluates the potential of the tool for solving existing challenges in current teaching communities. As mentioned in section 2, some of the challenges at the community level noted by several authors are the need to support reuse and adaptation of designs, as well as to foster cooperation among teachers [13], [19], [20]. Another challenge that we detected in previous studies during the co-creation of edCrumble with high school teachers was the need to monitor the workload of out-of-class activities, an issue that is related to the community analytics feature we discussed in section 5.3.

Table V shows the perception results of the degree of importance of five items related to the challenges above. More than 60% of the participants assigned all five problems a level

TABLE V
TEACHERS' PERCEPTION OF DEGREE OF IMPORTANCE (1: MIN, 5:MAX) OF THE FOLLOWING PROBLEMS TO SOLVE (RESULTS IN PERCENTAGES)

Workshop types	High school teachers					Random teachers & edtech stakeholders					All participants				
Likert Scales (1: min, 5: max)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
a. Balance between in-class and out-of-class workloads.	7	0	29	14	50	0	20	20	30	30	4	8	25	21	42
b. Fostering the exchange of teaching practices among members of the same school.	0	7	0	36	57	0	0	10	30	60	0	4	4	33	58
c. Fostering the exchange of teaching resources among members of the same school.	0	0	14	36	50	10	0	0	50	40	4	0	8	42	46
d. Fostering the exchange of teaching practices beyond the same school.	0	0	36	29	36	0	0	40	40	20	0	0	38	33	29
e. Fostering the exchange of teaching resources beyond the same school.	0	7	21	29	43	0	0	40	30	30	0	4	29	29	38
	N=10					N=14					N=24				

4 or 5, i.e. high or extremely high, degree of importance. The results from both groups of participants (high school teachers and other conference participants) were similar and no significant differences were found. Items b and c, regarding the exchange of teaching practices and resources among members of the same school, were the problems ranked highest (92% and 88% respectively, marked as level 4 or 5 in degree of importance).

Thus, to answer RQ3, teachers' highest priority would be to address the lack of exchange practices and resources in their own community among teachers at the same institution. The second highest area of need would be in extending cooperation to other teaching communities beyond their own institutions. Lastly, they would address the balance between in-class and out-of-class workloads. These results allow us to confirm that the integration of edCrumble with LdShake community features is well justified. Moreover, it provides guidance for future work to prioritize the improvement of edCrumble's features related to solving the highest ranked problems, which could contribute to increasing the probability of the tool's adoption. As our previous research suggests [43], offering design tools that can resolve some of teachers' day-to-day challenges may be a way of promoting the adoption of the LD approach since it can enhance the perception of the tool's utility.

D. Usability Evaluation

Table VI provides the overall results obtained from the UMUX questionnaire (N=56). In answer to RQ4, 83.9% of the respondents were positive about the effectiveness of the system, agreeing that edCrumble's capabilities met their requirements. In terms of satisfaction, 76.8% disagreed that using the tool was a frustrating experience.

TABLE VI
RESULTS (IN PERCENTAGES) OF THE UMUX QUESTIONNAIRE MEASURING USER EXPERIENCE. LIKERT SCALE FROM 1 (STRONGLY DISAGREE) TO 7 (STRONGLY AGREE)

	Strongly disagree						Strongly agree
	1	2	3	4	5	6	7
Effectiveness. The capabilities of edCrumble meet my requirements.	0	0	3.6	12.5	32.1	41.1	10.7
Satisfaction. Using edCrumble is a frustrating experience.	28.6	30.4	17.9	14.3	7.1	1.8	0
Overall. edCrumble is easy to use.	0	3.6	5.4	5.4	25.0	42.9	17.9
Efficiency. I had to spend too much time correcting things with edCrumble.	3.6	25.0	16.1	25.0	19.6	8.9	1.8

N= 56.

As for overall impressions, 85.7% said that edCrumble was easy to use. The last research question in this study sought to determine the extent to which the tool's user interface affected its perceived value. Despite the positive perceptions of the effectiveness, satisfaction, and overall ease of use, it appears that the system's efficiency needs to be improved (30% of users think that they must spend too much time correcting things with the tool whereas 25% remained neutral). Given that all participants of this study answered the UMUX questionnaire, it would be interesting to explore the results of the three participant groups defined at the beginning of this paper. Comparing the groups and studying their similarities or differences will allow us to interpret the results more accurately. Accordingly, Fig. 7 presents the UMUX questionnaire results by participant group. As we suspected, there are differences in the three groups' usability experience.

The results show that the group of random teachers and edtech stakeholders had the best user experience in terms of satisfaction, efficiency, and easy of use. The group of high school teachers, in contrast, was the one that deemed the system to be most effective. One possible explanation for this might be that the second group had had more time than the other groups to work with, understand, and appreciate the final aim of the system beyond the prototype evaluated, as they had already interacted with it several times before the evaluation workshop. Thus, they knew what they could expect from the tool and adjusted their expectations accordingly, which led to better results in the perception of effectiveness.

Conversely, the undergraduate students' responses were the most negative for all four UMUX items. This result may be explained by the fact that they had the most difficult task to do during the evaluation workshop. First, they had to enter a complete trimester course, whereas the other two groups had a shorter learning design case. Second, they had to author a course they had experienced, while the other two groups were asked to work with predefined examples. The fact that they were students, with little to no experience or motivation to do the activity, might be another factor adversely influencing the results. They should therefore be interpreted cautiously. However, the overall findings do suggest that the system needs to be improved to be more efficient, especially when users are designing long courses.

E. Learning Design Representation

In total, 24 design artifacts representing 24 real courses were collected from the undergraduate students. The other 37 designs collected from the other workshops were not used to evaluate expressivity as we had pre-prepared those designs for the participants. To answer RQ5, the students could represent the

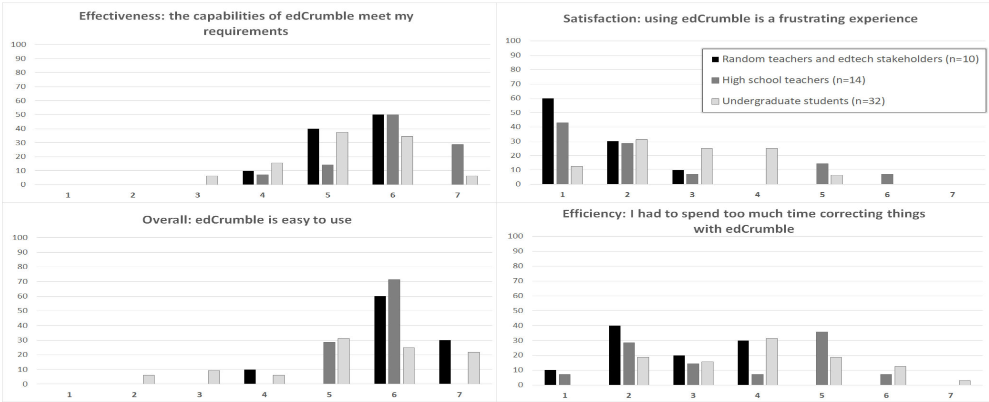

Fig. 7. UMUX questionnaire results depending on the participants' groups.

blended courses successfully, with the tool allowing them to represent the in- and out-of-class sessions without problems. They entered the courses' learning objectives and linked them with both the sessions and the corresponding resources. The main limitation identified in the analysis was in the representation of the out-of-class sessions: they should be represented "flexibly" in terms of time, i.e. without fixed start and end dates and times, as in many scenarios students are the ones deciding when they will do the homework, as shown in the visual representation in Table. 1. edCrumble must be improved in this area and offer more flexibility in representing out-of-class sessions.

VI. Conclusion

This article has described and evaluated edCrumble, a data-enriched visual learning design authoring tool for educators. The aim of edCrumble is to support the design and sharing of blended learning educational practices within a virtual community of educators. The evaluation has proved that the tool has specific features that facilitate the support of designing blended learning, and has examined the factors that may facilitate or impede its adoption, as well as its relevance to solving actual educational challenges. The evaluation has also provided a detailed analysis of its usability and explored the extent to which the tool can represent blended learning designs. The tool is freely available online at https://ilde2.upf.edu/edcrumble/ and all interested researchers and users are invited to use it as well as to provide feedback to help shape the future of the system.

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5.2 Concept-level design analytics for blended courses

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Concept-Level Design Analytics for Blended Courses

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Abstract. Although many efforts are being made to provide educators with dashboards and tools to understand student behaviors within specific technological environments (learning analytics), there is a lack of work in supporting educators in making data-informed design decisions when designing a blended course and planning learning activities. In this paper, we introduce concept-level design analytics, a knowledge-based visualization, which uncovers facets of the learning activities that are being authored. The visualization is integrated into a (blended) learning design authoring tool, edCrumble. This new approach is explored in the context of a higher education programming course, where teaching assistants design labs and home practice sessions with online smart learning content on a weekly basis. We performed a within-subjects user study to compare the use of the design tool both with and without the visualization. We studied the differences in terms of cognitive load, design outcomes and user actions within the system to compare both conditions to the objective of evaluating the impact of using design analytics during the decision-making phase of course design.

Keywords: Design analytics · Blended learning · Concept-level visualization · Authoring tool · Learning design · Smart learning content

1 Introduction

Learning analytics (LA) has attracted a lot of attention of e-learning researchers and practitioners over the last 10 years. Learning analytics allows instructors to evaluate how students are learning within a learning context, providing them with data-based evidence to improve the overall quality of the learning experience [1]. As the field broadened, it has become customary to recognize different categories of learning analytics and to distinguish each category by its targeted group of users or tasks. This paper focuses on *design analytics*, one of the least explored areas within this broad research field.

We adopt the definition of the term “design analytics” as the “metrics of design decisions and related aspects that characterize learning designs” [2]. A learning design (LD) is an explicit representation of a lesson plan created by a teacher [3]. Authoring

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tools can assist teachers in the creation of learning designs, which can lead to computational representations of the elements within a learning design that can be automatically analyzed. Some representations are generic or neutral, which enable only some options for structural analysis of a course (e.g. the number of tasks, time planned for a set of tasks, etc.). Other representations are specific to pedagogical approaches or subject matter concepts and enables a more detailed level of analysis. Analytics of these representations can support teachers' awareness and reflection about the accumulated decisions taken along the learning process to inform pending decisions toward completion of the course designs [2].

This paper explores some approaches for fine-grained design analytics focused on visualizing critical metadata associated with learning content. Our proposed visualization covers various metadata aspects, such as the type of learning content, the nature of knowledge supported, and a list of specific knowledge concepts that a specific fragment of learning content seeks to reinforce. After a brief review of related work (Sect. 2), we explain what we mean by concept-level design analytics (Sect. 3) and introduce its implementation in a design tool that supports teachers in selecting the learning content. The design and results of an experimental study as a first exploration of the value of concept-level design analytics are reported in Sects. 4 and 5.

2 Related Work

2.1 Design Analytics in Learning Design Environments

The term design analytics, in the cross-road of LD and LA, was coined and defined in the framework proposed by [2]. The framework is built on existing learning design tooling that included features that align with the concept of design analytics. An example of design analytics is provided by Web Collage, which analyzes the accumulated design aspects specified by the teacher when completing a template that is based on a collaborative learning flow pattern [4]. With this analysis, the tool computes and visualizes alerts that point teachers to pending actions needed to complete the design, as required by the design guidelines underpinning the pattern [4].

The idea of learning design analytics can be also observed in the *Activity or Pedagogy Profile* tool, which enables the creation of a bar chart representation to help teachers describe the distribution of tutorials and directed study modules [5]. The profile represents tasks across six activity types of a detailed unit-by-unit or week-by-week analysis. The tool was created to be helpful at different times in the design process, from first ideas to evaluation and review. Moreover, the analytics bar charts can be shared with learners and other stakeholders to express how learners are expected to spend their time, in terms of balance and shape of the expected learning activity.

Another example is the *Learning Design Support Environment* (LDSE or the Learning Designer). The LDSE provides an analysis of the properties of the designs being created by the teacher with the environment as a learning design tool [6]. In particular, it generates charts that visualize the proportion of time that students are expected to spend on the diverse types of tasks that are planned in the design, from "acquisition" to more active forms of "inquiry, discussion, production and practice".

This information serves as feedback to teachers about the nature of the learning experience that the learning design proposes.

The *Educational Design Studio* [7] is a physical environment for multiple designers working in teams that is equipped with wall projectors, whiteboards, a digital tabletop, and other tools. The various displays allow for several representations of the designs being created. The environment collects data from the designs and generates various charts; for example, the proportion of learning tasks distributed in the learning spaces (e.g. tasks occurring at the lecture room, at the lab, or online). This information enhances awareness of the broad view and the progress of their designs while building and editing individual tasks, as well as facilitating comparison between designs.

The concept of design analytics has been more extensively exploited in the edCrumble learning design tool. edCrumble is a pedagogical planner that provides a visual representation of the learning designs, strongly characterized by data analytics, that can facilitate the planning, visualization, understanding and reuse of complex blended learning designs [8]. Specifically, the decision-making that occurs during the design process is supported by design analytics that result from the design of the activities sequenced in a timeline. The design analytics provided include several categories: in-class/out-of-class time analytics, tasks' cognitive process, type of student work, teacher presence, and task evaluation mode. In each category, it is possible to have different visualizations: global time analytics, analytics that depend on the activities' type (in or out-of-class), and analytics that depend on the learning objectives.

In this paper, we present our attempt to further expand the design analytics component of edCrumble in order to support teachers at an extremely fine-grained design level. The new design analytics proposals will account for the metadata from the new integration of smart learning content into the resources' panel.

2.2 Open Learner Modelling and Navigation Support for Smart Learning Content

Blended learning approaches usually attempt to focus each of their different learning contexts on the activities that could be performed most efficiently in this context. For example, lecture classroom time could focus on the explanation of complicated topics and discussions and a lab session could focus on solving sample problems where the help of a human teaching assistant might be necessary, while online learning might be devoted to self-study, self-assessment, and practice. As the complexity of learning tools increases, the online component of blended learning is increasingly focused on practicing with so-called *smart learning content* [9]. Each element of this smart content is a relatively complex interactive activity, which engages students in exploration and provides real-time performance feedback. For example, in the area of computer science education, some previously explored types of smart content included interactive animations, worked examples, parameterized semantics questions, Parson's puzzles, and programming problems. As each smart learning content item is relatively complex and advanced, it usually allows a student to practice a number of different course concepts or skills, which could be introduced in different lectures or course units. This complex nature of smart learning content makes it hard for the student to accurately track progress and to select the most relevant learning content item for further practice.

To improve student knowledge-tracking ability in their work with smart learning content, several researchers suggested concept-level *open learner models (OLM)* [10]. A concept-level OLM recognizes the presence of multiple domain knowledge components (KC), such as concepts and skills, and visualizes student knowledge progress separately for each of these skills. Made popular by the field of intelligent tutoring systems as *skillometers* [11], concept-level OLM has become popular in other types of e-learning systems. A brief review of different concept-level OLM visualizations can be found in [12].

In our own work, we have explored visual interfaces, which combine topic-level open learner modeling with navigation support in order to help learners in selecting most relevant learning content [13]. Most recently, we explored student-focused concept-level knowledge visualization to help students in tracking their knowledge and selecting relevant smart content [14]. In this paper, we attempt to further expand the application area of concept-level knowledge visualization by exploring its value in a different context—helping instructors select learning content in a blended learning context.

3 Concept-Level Design Analytics for Blended Learning

The key idea of concept-level design analytics is to visualize the concept coverage of individual learning activities as well as learning sessions (such as a lecture, a lab, or a home practice) to help instructors in creating balanced learning designs. A learning activity is usually associated with metadata, which describes its type, engaged concepts or learning objectives, expected time to complete, and other aspects. This metadata is critical to create balanced learning designs. For example, learning practice prepared for a specific lecture should offer a balance of examples and problems, rather than over-focus on just one of these types of activities, and should cover all critical concepts introduced during the lecture, rather than over-focusing on some of them. Such a balance is usually hard to achieve without supporting the instructors with appropriate design analytics.

In this section, we present the design of a concept-level *design visualization* component, which extends the design analytics offered to the users of edCrumble. To demonstrate the power of the concept-based approach, we apply it to a relatively challenging design context: developing lab and practice sessions for an introductory programming course that uses several kinds of smart learning content. This context is challenging, since these kinds of smart content are of a different nature (examples vs. problems) and cover different kinds of programming knowledge (program comprehension vs. program construction). Moreover, each content item engages students in practicing a number of different programming concepts.

To support teachers in adapting this complex context, our designed visualization offered a concept-level visualization of a learning session being constructed and allowed teachers to compare different aspects of the constructed session on the concept-level by using a mirrored bar chart visualization (i.e., balance of concepts between problems and examples). Firstly, the bar chart approach for showing the distribution of concepts in a programming domain was defined after a series of user studies described in [14]. Secondly, the mirrored layout was grounded by findings in information visualization research, which show that correlation tasks (i.e. easily detecting if two data distributions were similar or not) are better supported when presented through graphs with a mirrored layout [15], and that the visual system's capability for detecting differences between two regions is more efficient when they are shown as mirror images of each other, as compared to repeated translations of each other [16].

We explain the behavior of this visualization with the following scenario. The process of adding a new activity to a learning session starts with selecting a type of learning activity to add. To support the programming context, six types of smart learning content for introductory programming (Table 1) have been integrated into the resources panel of the design tool (Fig. 1A).

Table 1. Smart learning content integrated into the learning design tool, distinguishing between examples and problems and construction and comprehension types.

ID	Title	Type	Description
WebEx	Annotated examples	Example Compr.	Annotated program examples. Students can click each line of code to see the related explanation for that line [17]
AnimEx	Animated examples	Example Compr.	Animated program execution examples, which visualize line-by-line execution of a piece of code [18]
PCEX	Program construction examples	Example Constr.	Interactive program construction examples. Each example provides a goal that specifies the given example's functionality. User can click on each line of code for getting explanations [19]
PCEXch	Program construction challenges	Problem Constr.	Small problems to help students developing program construction skills. Each challenge is a code example with 1–3 removed lines. Students need to drag-drop candidate lines to complete a program to achieve the provided goal [19]
Quizjet	Parameterized problems	Problem Compr.	Parameterized problems for self-assessment of student knowledge of programming semantics. Students are asked to predict the final value of a program output [20]
PCRS	Programming exercises	Problem Constr.	Coding exercises with automatic assessment. The system asks user to complete a partial code skeleton and then, it checks the submitted answer using a set of tests [21]

By clicking on each resource tab, the system shows a list of the corresponding activities available for this content type. Users can select the preview button to open and try each activity and make an informed decision when selecting the activities for a new session. When an activity is judged as suitable to be used in the design, users can drag and drop the activity's icon to the open session (lecture, lab or practice) in the

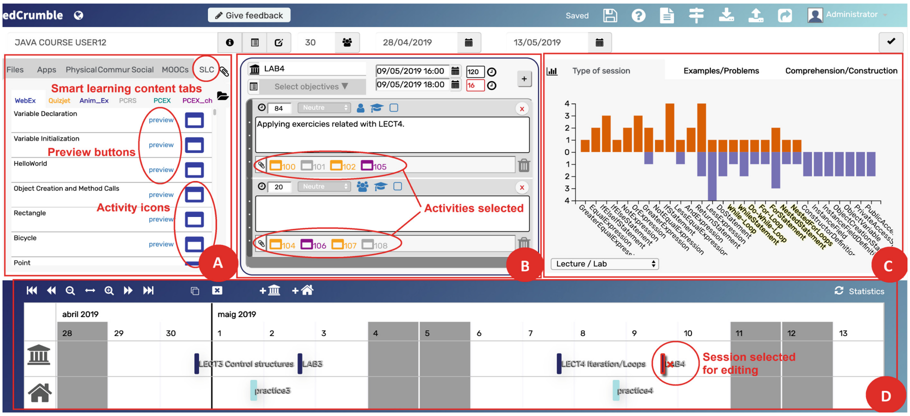

Fig. 1. Screenshot of the learning design tool's editor. (A) Resources panel with the 6 categories of smart learning content; (B) Editor for the selected session in the timeline; (C) Design analytics' visualizations; (D) Timeline with the in-class and out-of-class sessions.

editor (Fig. 1B). Once an activity has been aggregated into the design, the design analytics panel (Fig. 1C) offers a short animation that allows the user to visualize the activity's contribution in terms of concept-level knowledge coverage (knowledge gained upon its completion).

Each bar on the concept-level knowledge visualization chart (Fig. 1C) represents a domain concept, and its length represents how frequently the concept will be practiced by the learner when working with the selected session content (which could be also considered to be an estimation of knowledge gained after completing the session). The name of concepts that the instructor should target when designing for a specific lecture (e.g. lecture 4, with its subsequent lab-4 and practice-4 sessions) are highlighted in yellow for facilitating their coverage (see the seven concepts highlighted in Figs. 1 and 2). The concepts shown to the left of the highlighted ones are those targeted by the previous lecture, whereas those placed to the right are the ones which has not yet been introduced past lectures. The system also offers the possibility of previewing the contribution of a candidate activity to the overall design by situating the mouse over it, before dragging and dropping it into the selected session. The system then shows the preview of its contribution to learning different concepts by adding striped-bars to the visualization, as a short animation is shown when bars are added (Fig. 2 left).

In the analytics panel, we can find three tabs that offer different types of concept-level comparisons, depending on the sessions and the activities' types and knowledge. This comparisons help to balance the concept coverage of selected content by content type, session type, or covered knowledge. The first tab 'Type of session' (Fig. 2 left) allows a user to compare the concept-contribution of the activities selected, depending in which type of session they have been placed. It also offers the possibility of switching between three comparisons (Lecture/Lab, Lecture/Practice and Lab/Practice sessions). The second tab 'Examples/Problems' (Fig. 2 right) offers a unique comparison between these two types of activities but gives the option of filtering the results by visualizing only Lab, Practice, or both. The same applies for the third tab 'Comprehension/Construction'.

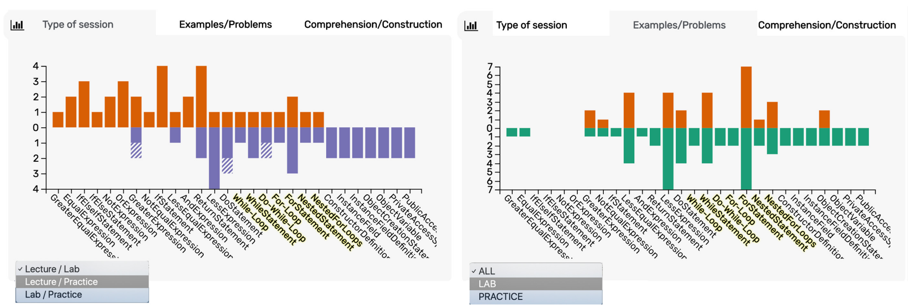

Fig. 2. Design analytics provided in concept-level visualizations. Left: activity contribution split by the type of session (i.e., lecture on top, lab on the bottom). Right: activity contribution split by content type (i.e., examples on top, problems on the bottom. Striped bars (left) indicate the preview of the contribution of a possible addition of a new resource.

4 Exploring the Value of Concept-Level Design Analytics

4.1 Participants and Sample

Evaluating a system focused on instructors as users is a known challenge, due to the limited availability of qualified participants. For our study, we recruited a total of 10 domain experts (six female) who were sufficiently qualified as introductory programming instructors. All of the instructors were computer or information science PhD students in a public university. Eligibility criteria required individuals to have knowledge in programming languages and experience as instructors or teaching assistants. Their ages ranged from 24 to 32 (M = 28, SE = 0.90) and they had between one and 13 years of teaching experience (M = 3.50, SE = 1.15). The scores (on a six-point scale) of how often their teaching tasks had implied selecting what activities and what type of teaching resources would be used during a course were (M = 3.70, SE = 0.42; M = 3.60, SE = 0.48), respectively. The scores (on a five-point scale) related to the instructors' background knowledge of programming in general, in Java, and interpreting graphs were (M = 4.50, SE = 0.17; M = 4.20, SE = 0.20; M = 4.20, SE = 0.20) respectively. In addition to the 10 instructors, two teaching assistants were recruited as pilot users to test and refine the procedure; however, their work has not been considered in the analysis. All 12 subjects were compensated for their participation in the study.

4.2 Design and Procedure

To assess the value of the design analytics that were provided, we compared the interface without the visualizations (baseline interface) to the one with the visualizations (visualizations interface). Due to the size of our sample, we used a within-subjects design. Instructors were asked to perform two different tasks with the system, and all of them experienced both treatments. The order of treatments was randomized to control for the effect of ordering (half of the instructors started the study using the baseline interface) and each participant did each task with just one treatment. The tasks were designed within the context of a higher education programming course (JAVA course) of 15 weeks: each week had a lecture and a lab session in class, and practice time at home. Our study was focused on the third and fourth weeks (the editor was prepared with the sessions of these two weeks to allow instructors to design within this framework) and asked instructors perform realistic design tasks to target concepts explained specifically in Lecture 4, which is described as follows. **Task 1:** Design a Lab session for Lecture 4 using eight (problems) activities in total. (a) Try to ensure that the practice session covers key concepts introduced during the class (as shown by lecture examples). (b) Try to strike a balance between problems that focus on program comprehension and program construction. **Task 2:** Design a Practice session for the Lecture 4 using 20 (examples and problems) activities in total. (a) Try to ensure that the practice covers key concepts introduced at the class (as shown by lecture examples). (b) Try to ensure a balance of examples and problems. (c) Make sure that the student will have a chance to practice both program comprehension and program construction skills. The order of the tasks was not randomized, since we considered the second task to be an extension of the first (albeit with a higher difficulty). Instructors received two training sessions, one about the use of the design tool itself and the other about the use of the visualization. The group that started the study with the baseline interface received the tool training before the first task and the visualization training before the second task, while the group that started with the visualization got both trainings before the first task. During the tasks, instructors had access to help files on the six types of activities with a short description of each one (indicating the categories to which they belonged: examples/problems and construction/comprehension). After each task, we asked instructors to complete a post-task questionnaire. At the end of the study, instructors filled out a final questionnaire.

4.3 Data Collection and Analysis

We collected the action logs of the instructors while they interacted with the system. Above all, we focused on the actions that took place within the resources panel and the visualizations tabs. Moreover, we also gathered the learning design outcomes generated during the study to assess the instructors' performance of the tasks. After each task, we used the NASA_TLX questionnaire [22] which aimed to measure the instructors' cognitive load of the tasks' performances. We used a paper version of the questionnaire that included both known parts (rating and weights). The final questionnaire asked instructors to provide their feedback about the use of visualizations and the design tool. It had two open questions to ask instructors about their preferences between the two treatments, as well as which interface they found to be more efficient in performing the given tasks and why. The third question asked instructors to order the three type of visualizations by their level of usefulness. Next, 14 + 5 items were presented to instructors for gathering their feedback about the visualizations and the design tool (all of them were seven-point Likert scale: strongly disagree: 1, strongly agree: 7). The final open question gave instructors the opportunity to provide general suggestions or comments.

5 Results and Discussion

5.1 Cognitive Load

The first result of the NASA_TLX questionnaire indicates that the second task (TLX index of 56.2) presented more difficulties to the instructors than the first task (TLX index of 37.1). This is an expected result that validates the design of the study, which ordered the tasks by its level of difficulty (not randomized). Global TLX indexes indicate that, in both tasks, the perceived workload was higher when instructors do not use visualizations. The perceived mental demand (MD) is always higher when without visualization, and this difference is significant when comparing all tasks' performances together (using the visualization: $M = 169$, $SE = 36.2$; without visualization: $M = 253$, $SE = 35$; $p < 0.05$). Significant results were also found for the temporal demand (TD) ($p = 0.043$) and frustration (FR) ($p = 0.015$) values when performing the first task. Instructors using the visualization felt that more time was needed to perform the task (time was also slightly higher in the second task when using visualizations), whereas those using the baseline interface felt more frustrated.

5.2 Action Analysis

The click data collected when instructors worked on the tasks provided an objective measure of how the two conditions (with and without the visualization) affect the way subjects use the system. Results of the action analysis (Table 2) reveal significant difference between the number of clicks performed for previewing the activities (the number of clicks being significantly higher in the case of not using the visualizations).

The fact of introducing the visualizations seems to change the behavior of the instructors in selecting the activities. When visual analytics were available, instructors previewed the activities much less frequently (4.2 and 6.2 times on average in tasks 1 and 2, compared with 21.4 and 23.4 in the baseline case). In other words, they decided whether or not to add the activity to the session by previewing the activity's contribution to the concept-level visualization, rather than previewing the activity itself. We can also observe that the time needed to perform the tasks was slightly higher on average in the condition with visualizations; however, this difference was not significant. Thus, the introduction of the visualization did not significantly influence the design time. Actions related to the addition and deletion of activities indicated similar results for both treatments.

5.3 Learning Design Outcomes

The learning designs collected after instructors completed the tasks provide an objective measure of how the two treatments affect the way subjects designed the two sessions (the lab and practice sessions required in the two tasks, respectively). As shown in Table 3, the presence of visualization slightly increased the instructors' ability to focus on the concepts of the target and immediate previous lectures when selecting activities (*onTopicCurrent* and *OnTopicPrevious*). However, the most impressive difference between the conditions was the almost complete disappearance of

Table 2. User actions with the system while performing each task during the two treatments.

Task	Action	With visualization	Without visualization	P
		M (SE)	M (SE)	
T 1	Total actions	119.4 (18.16)	136.6 (23.0)	
	Click preview activity	4.2 (2.8)	21.4 (3.04)	
	Add activity	10.2 (0.73)	11.2 (1.69)	
	Delete activity selected	2.2 (0.73)	3.4 (1.75)	
	Time spent (min)	13.78	11.88	
T 2	Total actions	236.4 (26.28)	211.4 (17.4)	
	Click preview activity	**1.6 (1.03)***	**23.4 (5.3)***	*p = 0.03 T-test between-subjects
	Add activity	26.4 (2.79)	23.4 (1.8)	
	Delete activity selected	6.2 (2.96)	4 (1.9)	
	Time spent (min)	19.14	17.72	

concepts that had not yet been introduced during the lectures (*outTopic*). The presence of these "future" concepts in practice and lab sessions is undesirable, since the students have not yet been introduced to them; yet instructors frequently miss these unwanted concepts when selecting learning content. As our data shows, the concept-level design analytics helped designers to avoid these future concepts in their design. When instructors used the baseline interface, they introduced, on average, a significantly higher number of future concepts (M = 5.6, SE = 2.61 in the first task; M = 8.2, SE = 5.3 in the second task). When using the visualization, the cases of introducing future concepts practically disappeared (0 in task 1; M = 1, SE = .63 in task 2).

Table 3. Learning designs' outcomes. *($p = 0.011$; $p < 0.05$) T-test between subjects.

Task	Selected concepts	With visualization	Without visualization	P
		M (SE)	M (SE)	
T 1	OnTopicCurrent	13 (.84)	10.6 (.60)	
	OnTopicPrevious	10.2 (1.59)	8.2 (1.28)	
	OutTopic (future)	0	5.6 (2.61)	*
T 2	OnTopicCurrent	29.2 (1.39)	28.8 (1.90)	
	OnTopicPrevious	28 (5.06)	21 (2.12)	
	OutTopic (future)	1 (.63)	8.2 (5.3)	

Consider the distribution of the concepts' coverage from the learning design outcomes. Figure 3 shows how many times concepts have been practiced in the designed sessions, on average, depending on the tasks and the treatments. Results show that using the visualization approach may have a positive impact on concept-level balance when it is necessary to select just a few activities (task 1), as the educator needs to be more precise when selecting the best ones for their class. However, when the instructor can select a higher number of activities (task 2), the probability of covering the necessary concepts by chance is higher and the presence of visualizations has a lower impact on improving the concept-level balance. However, the selection of a higher number of activities in the second task without using the visualizations led users to introduce a higher number of future concepts. When using the visualizations, in both cases, the number of future concepts selected was reduced drastically.

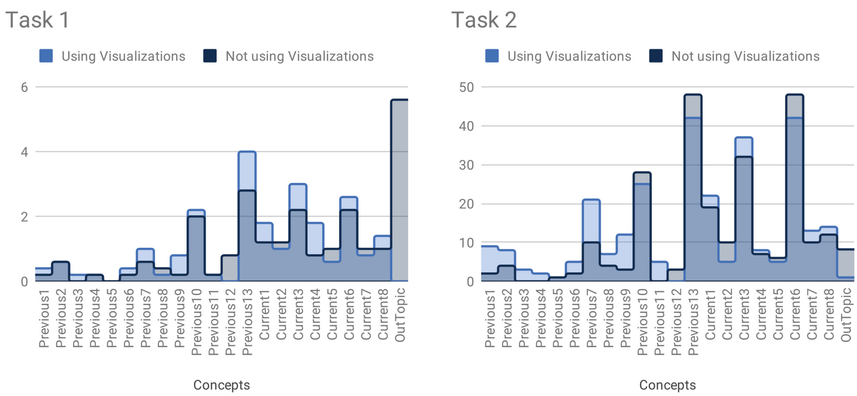

Fig. 3. Mean of the number of times that a concept is practiced during Task 1 (left) and Task 2 (right) (extracted from the learning designs outcomes) depending on the learning designs' conditions (either using or not using the visualizations). Activities can practice a concept more than once, and more than one concept at the same time. Note that there are 13 previous concepts, 8 current concepts, and a counter for future concepts.

Figure 4 presents the balance of concepts from the design outcomes, depending on the characteristics of the smart learning content. Contrary to expectations, the difference for the balance of example versus problem activities between using or not using visualizations is very low; and this balance is also very low in the case of balancing comprehension versus construction activities. We can observe only a moderate improvement of the balance and coverage of the previous concepts in both graphs when using visualizations, as well as a reduction of future concepts, as we discussed above. These results are not entirely surprising. Being domain experts, the instructors were able to understand the type and the most essential concepts of each activity by carefully reviewing its content and were sufficiently successful in balancing the number of activities added to the design (as tasks were requiring). As the log data shows, by previewing the activities, the instructors were able to achieve a reasonably balance, however, for the price of higher load. With the visualization, however, the instructors were able to reach a slightly better balance by using visual previews rather than content previews and with lower load.

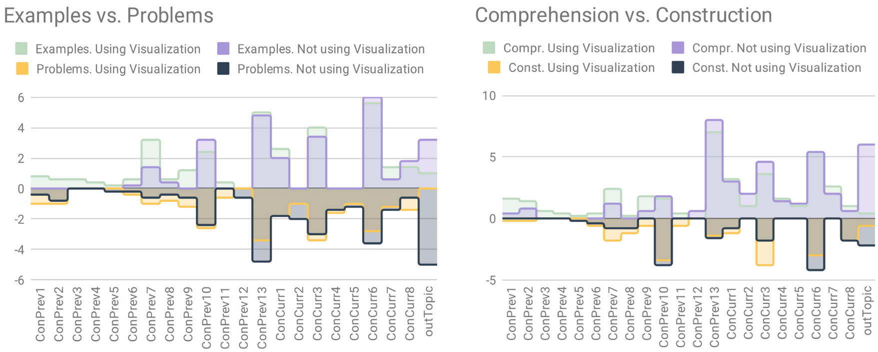

Fig. 4. Mean of the number of times that a concept is practiced during Task 2 (extracted from the learning designs' outcomes), depending on the learning designs' conditions (using or not using the visualizations). Comparison between example activities versus problem activities (left), and comprehension versus construction (right).

5.4 User Feedback Analysis

In the final questionnaire, all 10 instructors stated that they preferred to use the interface with the visualization, and that this condition allowed them to more effectively design their sessions. The visualizations were easy to understand and were useful in deciding which activity to choose; they helped instructors to check whether they were doing well enough in designing the course, as well as thinking about how knowledge was balanced. Regarding their preference about the three visualizations' tabs, six out of ten found the 'Type of session' comparison to be more useful. However, two instructors indicated the 'Examples vs. Problems' comparison as their preferred option, and two other instructors selected the 'Construction vs. Comprehension' comparison as their favorite. We can conclude that all three comparisons were meaningful for the instructors in order to create their course designs.

6 Conclusions

This paper explores some approaches for fine-grained level design analytics focused in visualizing critical metadata associated with smart learning content. Among metadata aspects covered by our visualization are the type of learning content, the nature of knowledge supported by it, and the list of specific knowledge concepts that a specific fragment of learning content allows students to practice. The visualization has been integrated into a (blended) learning design authoring tool. We expected that the concept-level design analytics would help instructors in selecting the most appropriate learning content and would result in designing more balanced learning sessions. We performed a within-subjects user study contrasting conditions both with and without the visualization. Our results indicate that the use of concept-level design analytics may reduce the cognitive load of design tasks, especially in terms of mental demand. We also demonstrated that the use of design analytics has facilitated the selection of the most suitable activities without significantly affecting the overall design time. Interestingly, the presence of the visualizations has changed the behavior of instructors in the process of selecting the activities, by just previewing their contribution to the visualization without looking deeper within their content. When examining the learning outcomes, the most impressive result was an almost complete disappearance of future concepts from sessions designed with the help of visualization. Selecting content that requires future concepts is usually a design error, and the presence of the concept-level design analytics helped users to avoid these errors. Beyond that, the differences in concept balance between the conditions were small. In addition, our results hint that the visualization may have a higher impact on the concept-level balance when it is necessary to select just a few activities, as the instructor needs to be more precise selecting the best ones. On the contrary, when the instructor can select a higher number of activities, the probability of covering the concepts by chance is higher and the visualizations have a smaller impact on improving the overall balance among concept levels.

Although our results indicate that the use of design analytics improves the overall learning design quality, our study has some limitations. Most importantly, the number of subjects was too small to draw a general conclusion, which is, however, typical for studies focused on instructor-level users. Future research will be necessary to explore and evaluate the use of concept-level design analytics with a larger sample in other educational contexts and in comparing different types of visualizations. Moreover, further research may explore the connection of design analytics with learning analytics extracted from the existing smart learning content.

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APPENDIX A

Are higher education students registering and participating in MOOCs? The case of MiríadaX

The content of this section was published in the following conference article:

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Are higher education students registering and participating in MOOCs? The case of MiríadaX

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Abstract

Most MOOCs offer open learning opportunities at Higher Education (HE) level. However, it is still unclear how HE students are taking this type of course. This study focuses on the profile of HE students participating in MOOCs, their registration, preferred topics and completion patterns and how they compare to other types of participants. The paper presents a descriptive analysis of the MiríadaX platform data up to the end of 2014, including an analysis of 144 courses and 191,608 participants. Results indicate that current HE students, who are mostly Latin American and Spainish males interested in technology subjects, register for and complete lower numbers of MOOCs than participants who have already completed their HE studies. HE students older than standard ages have a significant presence in MOOCs and have higher numbers of MOOC registrations and completitions.

Keywords

MOOCs, MiríadaX, higher education, student profile, data-driven analysis

1 Introduction

Many universities have opened up courses to diverse target groups by delivering them in Massive Open Online Course (MOOC) platforms (KOVANOVIC, JOKSIMOVIC, GASEVIC, SIEMENS & HATALA, 2015). This is generating increasing options for the population to organize their learning, which some authors argue can lead to disruption in Higher Education (HE) (JANSEN & SCHUWER 2015; SANCHO, OLIVER & GISBERT, 2015; BOVEN, 2013). This situation poses research questions to better understand the social phenomena behind MOOCs so that data-based consideration may be made on their potential future implications and the elaboration of strategies at the level of HE institutions, MOOC platforms, educational policy makers, and so on (SIEMENS, GASEVIC & DAWSON, 2015; JORDAN, 2014).

In particular, this paper examines the extent to which HE students are taking MOOCs in addition to their formal learning courses at their universities. While only few MOOCs are recognized with credits by particular institutions (JANSEN & SCHUWER 2015) or used in a blended learning approach in residential universities (ALBÓ, HERNÁNDEZ-LEO & OLIVER, 2015; DELGADO KLOOS et AL., 2015; ADONE et AL., 2015), most MOOCs represent informal or non-formal learning actions to the participants (JANSEN & SCHUWER 2015). This line of research can provide society and universities information about the profile of HE students actually interested in additional courses, the subject areas of those courses and their completion rates (YUAN & POWELL, 2013). Moreover, MOOC providers and platforms could benefit from understanding the behaviour of these specific segment of their participants, when compared to other types of participants (e.g., participants not involved in HE and without a degree or participants having completed a degree), to personalize course recommendation or support decisions on the creation of new MOOCs (SIEMENS, GASEVIC & DAWSON, 2015).

The paper aims to answer the following research questions:

R1) What is the profile of the typical higher education student involved in MOOCs?
R2) What is the average number of MOOCs that higher education students register? How this average number compares to other MOOC participants?
R3) What is the average number of MOOCs completed by higher education students?

How this compares with other MOOC participants?
R4) What are the thematic selected/registered by higher education students? How this compares with other MOOC participants?

To answer these questions, the paper uses data from the MiríadaX platform which is the main Spanish MOOC provider, promoted by Telefónica, Universia and Banco Santander (MiríadaX, 2013). MiríadaX offers MOOCs since 2013, most of them in Spanish, and only few are in Portuguese and English. The data used for the analysis has been provided by Telefónica Digital Education to the authors in the context of the Cátedra Telefónica-UPF (Cátedra Telefónica-UPF, 2013).

The remainder of this paper is structured as follows. Section 2 describes the methodology followed to analyse the data. Results presented in Section 3. Finally, Section 4 includes the main conclusions of the study.

2 Methodology

This study is based on a quantitative analysis from MiríadaX data regarding 144 MOOCs which were completed in late 2014. The analysis combines data from two datasets (participants and courses) and applies descriptive statistics to offer results for each research question. Data from participants is provided by two data sources. On the one hand, from the questionnaire which participants respond voluntarily when registering to the MOOC platform. These data include the country of origin, gender, age and education information. On the other hand, data provided automatically by the platform in log files: the number of MOOCs registered and completed for each participant as well as in which courses they have enrolled in. Regarding the data from the courses, the information available refers to the course description, including dates, number of enrollment, and topic.

The global numbers of the two databases offer data from 291.608 participants and 144 courses. Despite this, it has to be taken into account that the final sample changes in the case of the participants data, because part of the information is obtained from a voluntary questionnaire with the following final figures: Country of origin: 94.844 participants have replied (32% of all); Gender: 53.455 participants have replied (18,33% of all); Age: 50.734 participants have replied (17.40% of all); and Education: 87.310 participants have replied (29,94% of all).

3 Results

In this section, the results related to three main themes are discussed: (1) the profile of higher education students involved in MOOCs; (2) the average number of MOOCs that each student registers for and completes, as well as completion rates; and (3) the subject area preferences of higher education students compared to other types of participants.

3.1 Profile of higher education students involved in MOOCs

The majority of the higher education (HE) students taking MOOCs in the MiríadaX platform are male, at 62.06% of the total (Figure 1). This proportion reflects the overall distribution by gender of users of the MiríadaX platform, which is 60.70% male and 39.30% female. This same trend is also observed in the case of the Coursera platform, where females constitute 40% (PIERSON & CHUONG, 2014). Moreover, regarding differences by age, the percentage of males is higher than that of females in all cases (Figure 1).

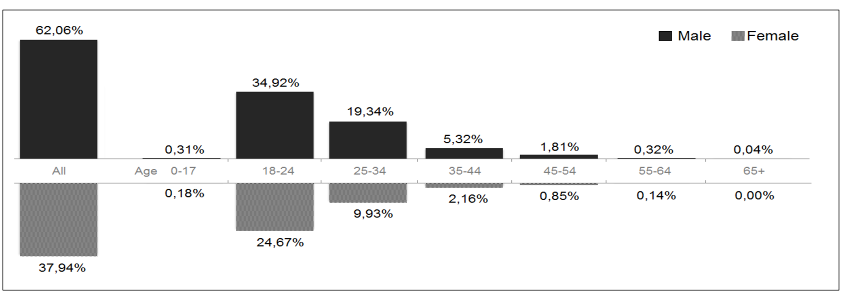

Figure 1: HE students registered in courses by age and gender (N=13.692)

The most common age of higher education students involved in MiríadaX courses is 18-24 years (59.59%). This is an expected result because it is the typical age range for studying at university after completing high school. Despite this, it is worth noting that there are also older higher education students enrolled in MOOCs: 25-34 years (29.27%), 35-44 years (7.48%) and over 45 years (3.16%).

Table 1 shows the number of total higher education students enrolled in MiríadaX courses by their country of origin. The students come from 79 different countries, but mainly from Spain (41.01%) and Latin America (57.5%). The table only shows the specific data of the most common 24 countries since the remaining ones each contributed less than 0.10% of the participants. The Latin American countries with the most students enrolled in MiríadaX are Colombia (16.03%), Mexico (9.87%) and Peru (7.49%). However, Peru has the highest number of MOOC enrollments per student (4.9) while Colombia has the lowest (2.42). The high proportion of Spanish and Latin American HE students in MiríadaX courses is determined by the languages in which the platform offer MOOCs, with Spanish being the principal one.

Table 1: HE students enrolled in MiríadaX MOOCs and registrations per student by country of origin.

	FREQ.	CUMUL. FREQ.	%	CUMUL. %	MOOCs REGIST. /STUDENT	SD
Spain	10.690	10.690	41.01	41.01	3.93	5.46
Colombia	4.178	14.868	16.03	57.04	2.42	3.60
Mexico	2.574	17.442	9.87	66.91	3.59	5.48
Peru	1.952	19.394	7.49	74.40	4.90	6.48
Argentina	1.108	20.502	4.25	78.65	3.11	3.96
Venezuela	912	21.414	3.50	82.15	3.66	6.71
Ecuador	782	22.196	3.00	85.15	3.12	4.46
Chile	697	22.893	2.67	87.82	3.55	5.24
Brazil	635	23.528	2.44	90.26	2.76	4.12
Dominican Repub.	406	23.934	1.56	91.82	3.09	3.58
El Salvador	329	24.263	1.26	93.08	2.88	3.88
Guatemala	276	24.539	1.06	94.14	3.61	4.33
Bolivia	189	24.728	0.73	94.86	4.72	6.23
Uruguay	189	24.917	0.73	95.59	3.59	5.18
Costa Rica	185	25.102	0.71	96.30	3.17	3.80
Paraguay	154	25.256	0.59	96.89	3.97	4.85
Honduras	146	25.402	0.56	97.45	2.61	2.91
Nicaragua	120	25.522	0.46	97.91	3.11	3.86
Portugal	107	25.629	0.41	98.32	3.64	5.61
Puerto Rico	101	25.730	0.39	98.71	2.55	2.77
Panama	55	25.785	0.21	98.92	3.69	5.38
United States	39	25.824	0.15	99.07	3.31	4.46
France	28	25.852	0.11	99.18	2.75	3.13

Germany	27	25.879	0.10	99.28	4.19	4.51
55 countries	<25/country	26.067	<0.10/country	100	---	---
TOTAL	26.067	---	100	---	---	---

3.2 Number of MOOCs

In this section, three indicators are analysed in relation to HE students taking MOOCs on the MiríadaX platform: the average number of courses enrolled per student, the average number of courses completed per student, and finally, the ratio between courses completed and courses registered for per student.

The results show that on average, HE students register of 3.56 courses each and complete on average 0.55 courses (Table 2). The results are similar to other types of participants on the MiríadaX platform, though one can note that participants without university degrees are enrolling in and completing fewer courses per student (2.81 and 0.46, respectively). Participants who already hold university degrees, professors, researchers, and university support and technical staff tend on average to register for similar numbers of MOOCs, but their average completion rate is higher than that of HE students.

The third indicator in Table 2 also supports this finding. Participants without university degrees complete 11.84% of the courses they enroll in, while HE students complete on average 12.87%. Results are higher for the other types of participants: while professors or researchers complete 15.50% and university staff 16.27% of the courses they register for, those participants with university degrees (not including professors, researchers, and university support staff) have the highest completion rate (19.88%).

Table 2: Average number of MOOCs registered for and completed per HE student and completion rates per HE student compared that of other types of participants.

	TYPE OF MIRÍADAX PARTICIPANTS				
(Averages)	HE student	Without university studies	With university studies completed	Professor or Researcher	Uni. support / technical staff
MOOCs registered / HE student	3.56	2.81	3.40	3.69	3.41
MOOCs completed / HE student	0.55	0.46	0.81	0.71	0.70
Completion rate / HE student (%)	1.87	11.84	19.88	15.50	16.27

Table 3 breaks out these three indicators of HE students by gender and age. The results do not revel significant differences by gender: males on average enroll in 3.84 courses and finish 0.58; while females enroll in 3.69 and finish 0.54 courses. Completion rates show similar patterns for both genders.

Table 3: Average number of MOOCs registered for and completed per HE student and completion rates per HE student (by gender and age)

	GENDER		AGE		
(Averages)	Male	Female	0-24	25-44	44+
MOOCs registered / HE student	3.84	3.69	3.55	4.06	4.51
MOOCs completed / HE student	0.58	0.54	0.46	0.70	1.21
Completion rate / HE student (%)	11.39	11.77	10.33	13.31	19.84

In contrast, clear differences can be noticed between different age groups. Older HE students are enrolling in more courses than younger ones, as well as finishing more courses and having higher completion rates. All three indicators show higher values as the age of HE students increases. HE students below the age of 24 enroll in an average of 3.55 courses and have a completion rate of 10.33%. Students from 25-44 register for 4.06 courses per student and have a completion rate of 13.31%. Finally, students older than 44 register for the highest number of MOOCs per student (4.51) as well as have the highest completion rate (19.84%). It is necessary to point out that a limitation of this analysis is that it ignores the registration date of participants on the platform. The omission of this information may be introducing a bias in results; this bias should be considered in the interpretation of data and will be considered in future analyses.

3.3 Course subject preferences of higher education students

Figure 2 shows the number of registered participants by subject area of the courses offered by MiríadaX –the course subjects used in the analysis are those defined by the MOOC platform-. To sort the different subject's areas on the horizontal axis it has taken as a reference the percentages of HE students per subject area - these are ordered from highest to lowest percentage of registrations of this type of participant, therefore, from highest to lowest preferences of this particular group-.

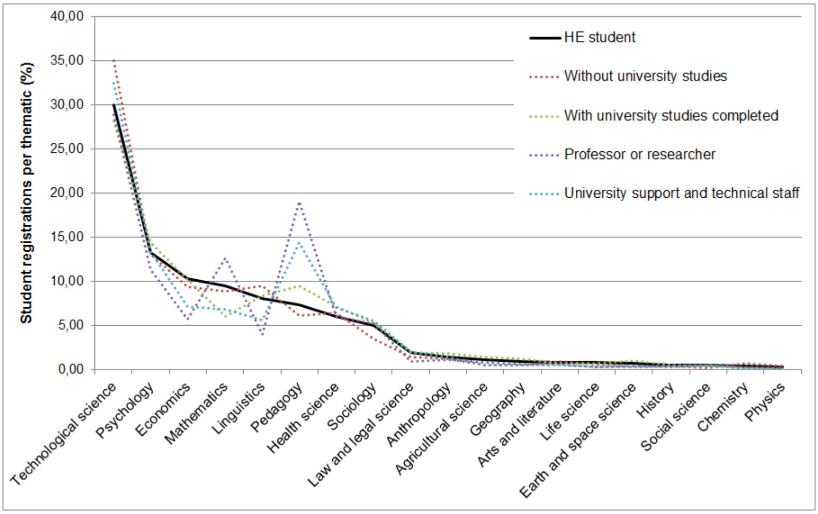

Figure 2: Distribution of registrations per courses' subjects by types of participants.

The subject area preferred by HE students is technological science (30%), while the second is psychology (13.27%) and in the third place economics (10.39%). The following are mathematics (9.52%) and linguistics (8.09%). Participants who have finished university degrees share these first three preferences although with different percentages (28.17%, 14.47% and 10.21% respectively). Technological science is also the subject area with the highest percentage of registrations by the rest of types of participants, and chemistry and Physics the less demanded by all participants' types.

Professors or researchers differ to HE students in showing notable preferences in pedagogy (19.09%) and mathematics (12.69%) areas. They also show lower levels of preferences for economic courses and linguistics. Furthermore, pedagogy is also being remarkably preferred by the university support or technical staff, and by the participants with higher education degrees completed.

After analysing the student preferences and differences with other participants, it is also studied how distributed these groups are within each subject area (Figure 3). One of the first results from this graph is that although being physics the subject area less preferred by the HE students, it presents the highest percentage of this type of participants in its registrations distribution –44.69% of the participants of physics courses are HE students–. In addition, in the others subject areas HE students represents less than 40%, being pedagogy the subject area least represented by this type of participants (21.87%), as previously mentioned.

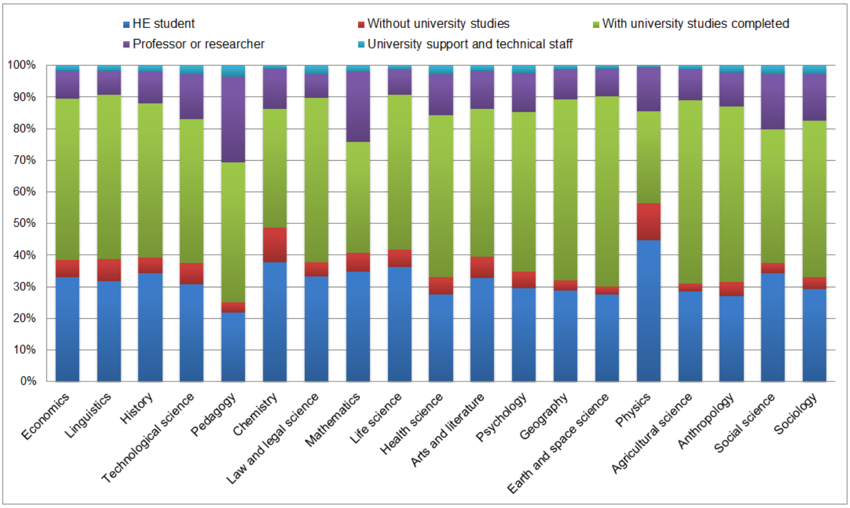

Figure 3: Distribution of the course participants within each subject area.

Finally, in order to contextualize the above results, it is necessary to consider the number of courses offered by the platform in each subject area to understand if the number of registrations has been influenced by it. In this way, figure 4 shows the number of participants' registrations per thematic normalized by the number of MOOCs offered per each subject area. Therefore it is showing a visualization of courses offered against demand depending on the type of participants. Behavior among different groups of participants is quite similar for most categories. Differences are found, in the area of pedagogy where the demand by the group of professors or researchers is higher than in HE students. In this graph it can be also observed if the different subject areas are balanced in relation to the courses offered and the number of participants enrolled in. Aligned with this, linguistics, psychology and earth and space science present a higher "saturation" as they have the highest numbers of participants' registrations per course

(4.273, 2.707 and 2.282 participants/course respectively). At the same time, physics and chemistry present the lowest ratio (320 and 335 participants/course respectively).

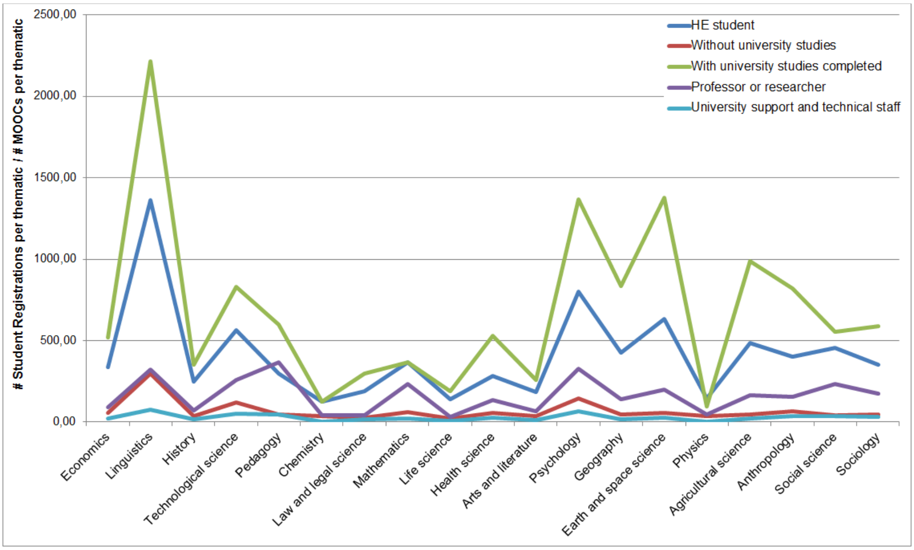

Figure 4: Registrations per topic normalized by the number of MOOCs per subject.

4 Conclusions

The obtained results answer the research questions raised in the introduction. Regarding the profile of HE students involved in MiríadaX MOOCs (RQ1) (data collected since MOOCs started to be published in MiríadaX in 2013 up to the end of 2014), results show that there is a majority of male (60.70%) in a range of 18-24. Interestingly enough, there is an important number of HE students participating in MOOCs with ages as from 24 (40%). Most HE students are from Latin American countries (57.5%) and Spain (41.01%).

Concerning the average number of MOOCs that HE students register for and complete, and how this compares to other types of MOOC participants (RQ2, RQ3), we can say that HE students register for on average of 3.56 courses completing only 0.55 courses (similar pattern when comparing men and women). Though results show a similar trend for the other types of participants, participants without HE degrees register for and complete a slightly lower number of courses, and participants with a HE degree register for and complete a higher number of courses. Interestingly, HE students as from 24 years old register for and complete more MOOCs than standard-age HE students.

Finally, with respect to the topic registered for by HE students and how this compares with other participants in MiríadaX (RQ4), it is interesting to see that MOOCs in the technological science subject area, followed by psychology and economics, show higher percentages of registrations for all types of participants. Professors or researchers differ to HE students in showing notable preferences in pedagogy (19.09%) and mathematics (12.69%). In the physics subject area, HE students represent the highest percentage of types of participants registered.

Overall, we can conclude that HE students are taking MOOCs following a pattern of registration and completion of MOOCs in between participants without HE studies (lower numbers) and with HE studies completed (higher numbers). Within the collective of HE students, those more active are older than 24, representing profiles of stronger intrinsic motivation to learn or to improve their professional competences. One interpretation is that MOOCs are generally perceived as useful lifelong learning opportunities and not that much as a resource (comparable e.g. to books) that can support the HE curriculum. The particular result for the case of physics subject may be explained by a use of these MOOCs as remedial (level O) courses for freshmen at universities (DELGADO KLOOS et AL., 2014). The recent initiatives on the use of MOOCs to support blended educational approaches (ALBÓ, HERNÁNDEZ-LEO & OLIVER, 2015) may influence the future evolution of the trends identified in this paper.

Acknowledgements

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APPENDIX B

How educators value design analytics for blended learning

The content of this section has been accepted to the international workshop on *Hybrid Learning Spaces – Design, Data, Didactics*, (HLS D3 2019) collocated with the *Fourteenth European Conference on Technology Enhanced Learning* (EC-TEL 2019):

Albó, L. & Hernández-Leo, D. How educators value design analytics for blended learning. In *Hybrid Learning Spaces - Design, Data, Didactics*, *ECTEL 2019*. Deft, The Netherlands (accepted).

How Educators Value Design Analytics for Blended Learning

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Abstract. The use of technology in education has opened a range of challenges and opportunities regarding the collection and use of data for improving teaching and learning processes. Among the types of data that can be collected, this paper is focused on the exploration of the value of design analytics, i.e. the metrics of design decisions that characterizes facets of learning designs. These types of analytics can provide awareness and reflection on decisions made during the learning design process as well as inform future design decisions. The learning design authoring tool edCrumble has been used to generate and interact with design analytics and explore their potentialities. Specifically, workshops with teachers and education-related stakeholders have been carried out in order to collect their insights and opinions about the use of different types of design analytics visualizations.

Keywords: Design Analytics, Blended Learning, Authoring tool, Learning Design

1 Introduction

With the increased use of technology in education, educational data science has become more accessible, providing tools and techniques for making sense of educational data [1]–[3]. Nowadays, educators and researchers can extract data from blended educational practices (which combine face to face -f2f- instruction with online activities supported by technology) for analysing and understanding what is happening in the educational settings they have designed [3]. The data collected can serve different purposes, depending on their nature. Whereas data about students' interactions can be used to understand their learning processes and experiences (learning analytics), metrics of design decisions and related aspects characterizing learning designs (design analytics) can provide awareness and reflection on decisions made during the learning design process as well as inform future design decisions [1][4]. Moreover, the metrics and patterns of design activity within a community of teachers and related stakeholders (community analytics) can provide awareness and reflection about individual and collective design activities and trigger orientation and inspiration about how to improve the design practices [1], [5].

In this paper, we explore the opinions of teachers regarding the use of design analytics, probably the least explored type of data in educational technology together with community analytics. Specifically, we analyse the value that design analytics can offer in authoring experiences using the edCrumble learning design tool [6].

2 Design analytics and edCrumble

edCrumble is a pedagogical planner that provides a visual representation of learning designs, strongly characterized by data analytics, that can facilitate the planning, visualization, understanding and reuse of complex blended learning designs [6]. Specifically, the decision-making that occurs during the design process is supported by design analytics that results from the design of the activities sequenced in a timeline composed by two activity layers (in-class activities and out-of-class activities). Design analytics are divided into different categories placed in different tabs within the analytics zone of the edCrumble editor (figure 1).

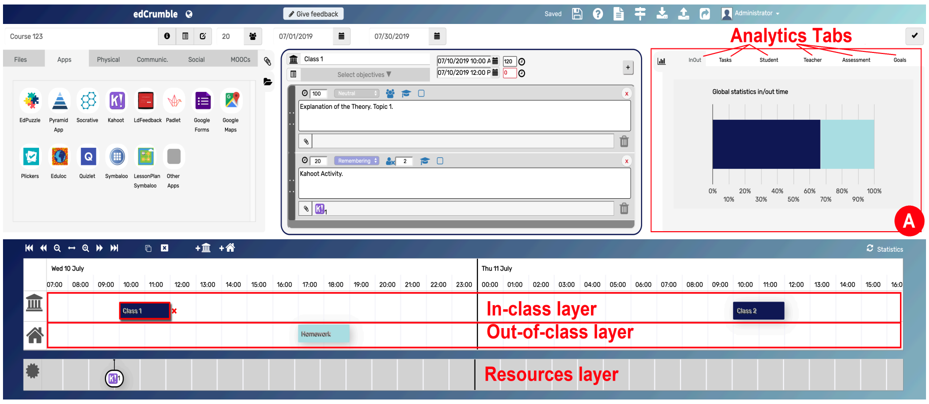

Fig. 1. edCrumble editor with the design analytics zone highlighted in red (A). The design analytics are placed in different tabs depending on their category.

The five categories of edCrumble design analytics analysed in this paper are described in table 1.

Table 1. Categories of design analytics available in edCrumble.

Id	Categories	Description	Items' values
DA1	In-class/ out-of-class	Place where the activity occurs.	In class, Out-of-class.
DA2	Type of knowledge	Type of knowledge to be practised in the activity (based on the Blooms' taxonomy [7])	Remembering, understanding, applying, analysing, evaluating and creating.
DA3	Collaborative learning	Level of collaboration proposed for the activity.	Individual, in groups or the whole class.
DA4	Interaction with the teacher	Expected teacher' presence during the activity performance.	Teacher available f2f, online or not present.
DA5	Assessment	Indicates if the activity will count for the course' assessment or not.	Graded tasks, not graded or tasks for self-assessment.

For each design analytics category (less the category DA1), it is possible to have two different visualizations: *global* or *in/out class* visualizations (figure 2). The global visualizations show the time dedicated for each item with respect to the whole learning design (figure 2 left). Whereas the in/out class visualizations show the time consumption in percentage for each category item separated between time spent on in-class activities and time spent on out-of-class activities (figure 2 right).

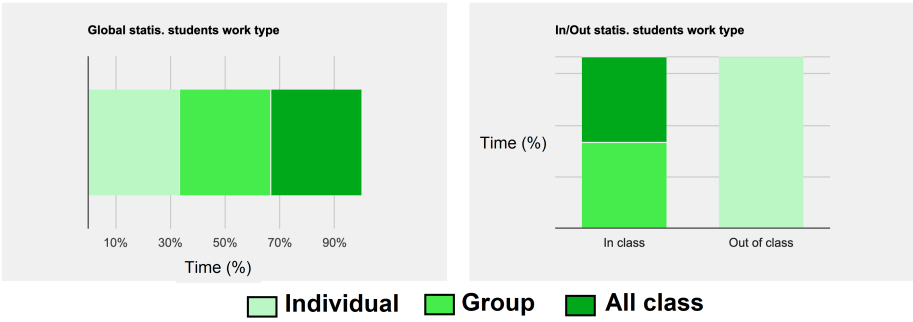

Fig. 2. Collaborative learning design analytics from edCrumble. Left: Global visualization; Right: In/out class visualization.

The tool allows users to generate design analytics aggregated from all the learning designs (LDs) placed in a folder, named as community analytics [1]—supporting teachers' decision making during the LD process not only at their individual level but also allowing the possibility of considering the colleagues' LDs analytics in their community.

3 Methodology

Three workshops were carried out in different contexts to give participants the opportunity of interacting with the tool and evaluate the design analytics provided. The first workshop took place on a teaching innovation conference (April 2018) and participants were 23 teachers, researchers and educational technology-related stakeholders (9 female). Whereas the second and third workshops were placed within a collaboration with two schools in the frame of a research project (May-June 2018). In this case, participants were 14 high school teachers, half of them from each school community. Each workshop (of 90 minutes) consisted of a role-playing game where participants were organized in groups of 2-4 people. Each group of participants represented an imaginary school and each participant of each group represented a teacher in charge of a subject matter (simulating different educational communities). The role-playing game had two main parts (individual and in groups). Each part having three steps. The individual activity (at "imaginary" teacher-role level) consisted of the following tasks: (1) Design of a short teaching unit with the edCrumble online version—a printed LD was provided by the researchers for each teacher role; (2) Analyse the data resulting from the elaborated design, and (3) Share the design created within the edCrumble community. Whereas the group activity (at "imaginary" school-role level) implied: (1) Grouping several designs to generate community analytics; (2) Solving an educational challenge; and (3) Discussing results with all participants.

The education challenge proposed at the group level was asking teachers to use community analytics for balancing the out-of-class workload between the different designs they created which were part of a whole curriculum to be worked with the same cohort of students (within the simulated school community). The objective was first, to analyse how many hours of homework they had given to the students in total, counting all the designs generated by the school (the community analytics allowed the participants to see the aggregated out-of-class hours of all the designs automatically). And second, they were invited to reduce the total hours of work outside the classroom (if there were many) to a certain number that they would consider appropriate, debating what strategy to follow.

At the end of the workshop in one of the schools (n=7), researchers asked participants to fill in a research questionnaire individually (the questionnaire could not be used in the other workshops due to lack of time). The questionnaire (which was anonymous) had three main questions for evaluating the design analytics of edCrumble and, for each of them, participants indicated their level of agreement (using a five-point Likert scale). They were invited to provide an optional comment or open response. Moreover, participants of both schools (n=14) were asked to evaluate design analytics (individually) based on several factors (following a five-point Likert scale of agreement). Finally, the design artefacts resulting from all workshops were analysed, checking whether participants were able to generate the community analytics correctly and whether they successfully solved the educational challenge proposed.

4 Results and Discussion

4.1 Open questions analysis

Regarding the first question, six out of seven individual respondents totally agreed (the seventh agreed) with the statement *I think that the visualizations in real-time while designing help me to better understand the design that I am creating*. In the open responses, one participant indicated that the visualizations would help him to better temporize the distribution of activities. Another participant highlighted the value of seeing how any activity is balanced at the pedagogical level, whereas others mentioned that analytics helped to better structure themselves mentally, that they were very intuitive and helped them to be aware of the design (the workload that it entails). Also, they allowed them to discover design errors to fix. Moreover, one participant stated that design analytics are the strongest point of the learning design tool.

When we asked participants whether they think that their teaching practice will benefit from having information in the form of design analytics of what is being designed by other teachers in their teaching community, five participants totally agreed, one agreed whereas one remained neutral. Most of the participants highlighted the value of sharing analytics as a positive aspect for improving, reflecting and making objective design decisions. But there were discrepancies about whether analytics from different educational backgrounds and topics than their own designs would also be useful. One participant stated that it would be necessary to complement the design analytics with learning analytics for being able to see the alignment with the real impact on the students. The last question asked participants whether they think that their teaching practices will benefit from having design analytics of other teachers 'designs from other teaching communities. Results were also positive, four participants totally agreed, two agreed and one remained neutral. One participant stated that it would be a good opportunity for learning from brilliant teachers of other communities who have very interesting ideas that can be shared and applied.

4.2 Evaluation of the design analytics visualizations

The first factor used for the evaluation was the *ease of interpretation*. Two statements (*The global visualization is easy to interpret* and *The in-class/out-of-class visualization is easy to interpret)* were evaluated by the participants indicating their level of agreement with (for each sentence and category). Most of the 14 participants (only the high school teachers had time on the workshops for doing this evaluation), totally agree with the first statement (13 in the case of DA1, 8 in DA2, 12 in DA3 and DA4 and 11 in DA5). The others just agreed and only two participants remained neutral (one in the case of DA2 and another in DA4). Only one person disagreed on the easiness of interpretation regarding the *Type of knowledge* global visualization (DA2). Results regarding the second statement were similar, concluding that both visualizations (*global* and *in/out)* were found easy to interpret by the teachers.

The second factor used was the *reflection support*, which was evaluated using the following statement …*it is very useful for helping me to reflect on the design of the activities in general* for each design analytics category. The third factor was concerned about the *improvement support* (*…it is very useful for helping me to improve the design of the activities in general*). The fourth factor evaluated the potentialities of design analytics categories for helping in maintaining a design continuity between the activities in-class and out-of-class (…*it is very useful for helping me in maintaining a continued design between the in-class and out-of-class activities*). All the above factors had similar positive evaluations by most of the participants (and in all the design analytics categories). The last factor evaluated only in the category D1, asked participants about the balance of out-of-class workload (…*it is very useful for helping me in controlling that I do not exceed with the out-of-class workload*). Results were also positive, 11 participants totally agreed with the sentence, two agreed and only one remained neutral.

4.3 Aggregated design analytics (community analytics)

All groups of participants were able to generate community analytics without difficulties. Moreover, all groups successfully completed the challenge proposed, being able to reduce the global out-of-class workload to a certain time (within each community). Interestingly, participants used different strategies to solve them. Whereas some groups agreed on reducing the same out-of-class amount of time for each individual design in the community, others only reduced the time of concrete designs (considering their subject nature, the pedagogical strategy used or simply focusing on the design or designs which had assigned more out-of-class hours). Participants commented on the usefulness of having the aggregated design analytics per course arguing that it has the potential of facilitating the awareness of the work of the other teachers in the same community. And above all, teachers valued that aggregated analytics can allow to coordinate the different designs' strategies being able to offer students a better-balanced workload and a fairer curriculum.

5 Conclusions

Design analytics have the potential of supporting teachers during the design process facilitating data-based decision making. The results have shown positive attitudes and opinions of teachers regarding the use of different types of design analytics as they think analytics can help them to improve their designs. Moreover, teachers valued that design analytics could facilitate the reflection during the design process as well as provide them support for achieving a design continuity between the in-class and out-of-class activities. Lastly, aggregated design analytics from multiple designs across educators in a community (community analytics) have also been valued offering design support and awareness at the school community level, with the potential of facilitating the design coordination among teachers of the same students' cohort.

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APPENDIX C

Supporting the planning of hybrid-MOOCs learning designs

The content of this section was published in the following conference proceedings of work-in-progress papers:

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Supporting the planning of hybrid-MOOCs learning designs

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Abstract. This paper presents a work-in-progress solution for planning hybrid Massive Open Online Courses (MOOC). The use of MOOCs in brick and mortar courses presents several design challenges. One of them is to find the most suitable online course regarding the alignment with the face-to-face course structure, timeline and syllabus. Despite there are different lesson planning and design tools which support educators in the design of their courses, there is a lack of solutions allowing to incorporate the use of MOOC or MOOC resources in the planning process of blended courses. In this paper, we present a MOOC design module for being used in design authoring tools which aim to support the planning of blended courses that incorporate MOOCs (or MOOCs resources). We discuss two different solutions for gathering information regarding existing MOOCs in the market: the creation of our own MOOC database versus the parsing of MOOC information from existing search engines on demand. Our exploration leads us to discard the first solution as maintaining the database is highly demanding. Thus, the final system uses existing MOOC search engines to extract the online courses design information to later be used in the overall hybrid-course planning. As it is a work-in-progress article, we present and discuss our future steps for supporting educators in the of design hybrid MOOCs scenarios.

Keywords: Hybrid-MOOCs, Blended Learning, Learning Design, Authoring Tools.

1 Introduction

The use of Massive Open Online Courses (MOOC) or MOOC resources in blended contexts offers the potentiality of influencing higher education in several ways [1]: influencing and shaping students' approaches to learning; assisting in the development and use of online resources by the educators as well as changing their traditional teaching practices; and providing large amount of data to be analysed and used by institutions and researchers to advance in the understanding of learning processes and behaviours. Despite their potentialities [2], the use of MOOCs in face-to-face (f2f) university courses presents several challenges [3]. One of them is to find the most suitable online course regarding the alignment with the f2f course structure and syllabus (including time constraints). Despite there are different lesson planning and design tools which support educators in the design of their courses, there is a lack of solutions allowing the incorporation of MOOC or MOOC resources in the planning process [4]. In this paper, we present a MOOC design module for being used in learning design authoring tools which aim to support the planning of blended courses that incorporate MOOCs (or MOOCs resources). The final system uses existing MOOC search engines to extract the online courses design information to be later used in a design authoring tool for the hybrid-course planning.

2 Planning hybrid MOOCs

The use of MOOCs in regular university courses has led to different types of hybrid combinations [5], with different goals [6]. In some cases, the main aim is increasing variety of the f2f curriculum and provide students more opportunities to learn beyond the university course [7]. In others, the goal is to leverage the work done in developing their own MOOC by providing it to the campus students in an Small Private Open Curse (SPOC) format [8][9]. But, in all cases, the context and learning objectives require to identify the best hybrid model that can take advantage of MOOCs in effective, efficient, and engaging ways [3].

The planning of blended learning can be challenging in general, but the planning process of hybrid MOOCs can be even more, especially when using external MOOC/s or MOOC/s resources (i.e. using MOOCs that are not from our university and have been designed by other instructors). In this context, we have developed a learning design tool [10] which is based on a visual representation of hybrid MOOC designs [4] which aims to support teachers in designing blended learning. Specifically, in the case of blended MOOC cases, the tool aims to facilitate the integration of MOOCs in the design process to be able to better plan the integration of both worlds regarding the curriculum alignment (topic, language, educational level…) and time suitability (dates of both courses, availability constraints…). Our work in progress presented in this paper arises from this need and studies a solution for extracting MOOC design data to be used in the learning design authoring tool. Next section presents the exploration of two possible ways of doing this data extraction in our research context.

3 Exploring solutions for extracting MOOC information from existing platform providers

3.1 First exploration: building our own data base of MOOCs

Our first exploration was centred on building a data base from scratch, which contained the available information about existing MOOCs in the market. The main idea was to extract the MOOCs' information from the existing platforms and update the database periodically (e.g. daily). Our authoring tool would communicate directly with the database when information on MOOCs was required during the blended courses design process (Fig. 1-A). The main method thought for gathering the data was using the existing APIs from the MOOC providers. However, only few platforms offered an API and sometimes they did not provide all the necessary data or documentation. To face this limitation, we decided to implement a web crawler for the MOOC platforms that were not providing a satisfactory API. The diversity of platforms and the unexpected changes that could occur on the web interfaces by the providers hindered the automatic crawling development based on MOOC platforms. On that point, we looked for existing searchers engines (we selected Class Central https://www.classcentral.com/, and MOOC list https://www.mooc-list.com/) and decided to apply the crawler to both MOOC aggregators (as they had no available APIs). The implemented solution was successful but presented several issues regarding ethical and security restrictions. Despite the exploration was in a research context, the application used for the automatic crawler was at certain time automatically blocked due to prevention of Denial of Service (DoS) attacks ensured by security companies. Although, even if working, the fact of maintaining the database of MOOCs would be highly demanding for research purposes (APIs from some MOOC providers, the crawler, etc.) and would not be justified by the use that we seek to (as an integrated feature in our authoring tool). Moreover, the possibility that new platforms may appear in the market, it would also present a new scalability challenge.

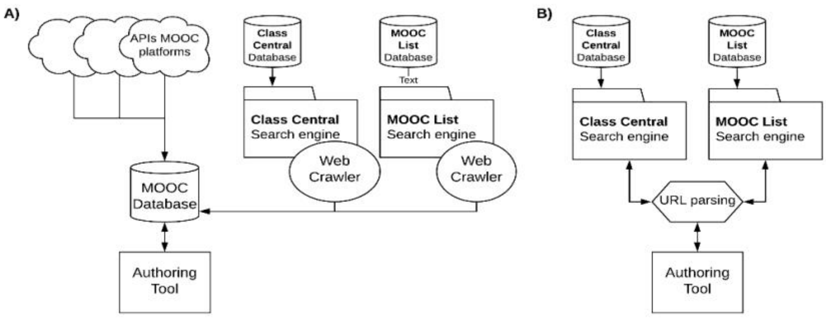

Fig. 1. Diagrams of explored solutions for extracting MOOC information from the existing MOOC providers: A) own Database and B) URL parsing on demand.

3.2 Second exploration: using MOOC data from existing search engines

There are web search engines that allow users find a desired MOOC on the market, allowing them searching courses filtering them by MOOC platform, university, topic, language, etc. Our second exploration had the aim of using the two above mentioned search engines (Class Central and MOOC list) as a source for our design module. But instead of using an automatic crawler of the complete web engines (as we already explored in our first approach) we developed a less intrusive system which use a grammatical parsing of single MOOC pages on demand. The system asks users to add the webpage Uniform Resource Locator (URL) of the online course provided by the selected search engine. Then, it extracts the required information from it to be used in the design authoring tool (Fig. 1-B). The main inconvenient of this approach is that, as well as in the crawler solution, the interfaces of the search engines may change periodically. Thus, the parsing algorithms need to be updated every time the search engine changes their web design configuration. But this would be less demanding and intrusive than our first solution.

4 Planning hybrid MOOC courses: the MOOC integration in-design module

This section describes the implementation of the second solution: an independent MOOC module which is integrated in our design authoring tool. Users can use the module for extracting data from MOOCs and use it for planning the blended learning unit that they are designing in the tool’s editor. The system provides an interface with the links to the two search engines and asks users to add the URL of the online course provided by the selected search engine (see Fig. 2). Then, when the users click on the 'Read Info' button, the system extracts the information from the URL and it shows it in another interface (Fig. 3).

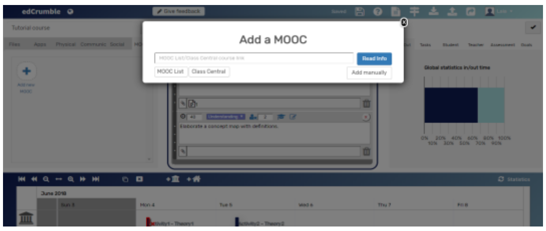

Fig. 2. Screen capture of the interface of the module within the authoring tool edCrumble.

Probably, the best way of implementing this solution would be to directly provide the web of the search engines to the users using an iframe in the authoring tool and extract the information directly (so users would not need to leave the tool's webpage and switch to the search engines sites). But for security reasons, the web browsers do not allow to discover the URL that the user is viewing using code through an embedded iframe. Thus, we decided to use the URL “copy and paste” approach.

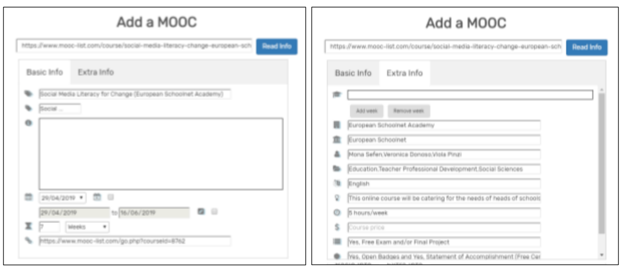

Fig. 3. Screen capture of the interface that shows A) the 'Basic Information' and B) the 'Extra Information' extracted from the MOOC URL from the search engines.

The system also allows users to introduce the information of a MOOC manually. Due to the amount of information extracted is quite large, we needed to prioritize it and we decided to divide it in two groups (showing them in two different tabs): the first tab contains the 'Basic information' (Fig. 3-A) whereas the second tab shows the 'Extra Information' (Fig. 3-B). The system provides all the extracted information in a json file format. Table 1 presents the list of items that the system can extract from the URL provided indicating which ones are in the Basic tab or in the Extra tab. Sometimes, the system cannot extract all the items due to, in some cases, the MOOC URL do not provide them all. To face this issue, the interface allows users to edit all found items as well as introducing new information in the empty ones at any moment.

Table 1. Items extracted from the MOOC URL provided by the search engines.

Item	Description	Tab
Title	Complete name of the MOOC.	Basic Info
Short title	Short version of the name of the MOOC.	Basic Info
Description	Course description.	Basic Info
Start date	Date when the MOOC starts. In case of self-paced courses, there is an option to indicate there is no start/end dates.	Basic Info
Length	Duration of the course in weeks, sessions, days or hours.	Basic Info
Link	Link to the course URL in the origin MOOC platform.	Basic Info
Course syllabus	Syllabus of the course (e.g. content for each week).	Extra Info
Provider	Name of the MOOC platform.	Extra Info
University	Name/s of the university/es providing the MOOC.	Extra Info
Teachers	Name/s of the MOOC instructor/s.	Extra Info
Subject	Subject of the MOOC.	Extra Info
Language	Language/s of the MOOC.	Extra Info
Prerequisites	Recommended prerequisites to take the MOOC.	Extra Info
Effort	Workload of the course (e.g. hours/week).	Extra Info
Course price	Price of the course.	Extra Info
Exam	Indicates if the course requires doing a final exam/project.	Extra Info
Certificate	Indicates if the MOOC provides a certificate.	Extra Info
Certificate price	Price of the certificate (if it applies).	Extra Info

5 Conclusions and Future work

Whereas some of the items extracted from the MOOC design module can serve for reporting general context of the MOOC (title, description, provider, university…), others can have a more relevant role in the design process. In the context of our authoring tool [4][10], the dates of the course, for instance, can facilitate the visualization of the time compatibility between the f2f course and the online one (allowing teachers accept or discard the selected MOOC for the hybridization). Moreover, the workload of the MOOC as well as the syllabus per week, can support educators during the design process allowing them to decide which modules of the MOOC use in their regular courses or if they are aligned with the f2f curriculum. Despite the ideal solution would be using an API of from the search engines (e.g. reaching an agreement in research contexts), our solution allows us to keep forward and studying how to better support educators in the design of hybrid MOOC courses. Our next steps will include an evaluation of the whole integrated system with the authoring tool to study its potentialities as well as its further improvements.

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