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Giuseppe Ritella

Chronotope: an investigation of the spatial and temporal organization in technology-mediated collaborative learning

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Abstract

The present dissertation project investigated the organization of space-time in collaborative learning processes mediated by Information and Communication Technology (ICT). The background of my argumentation is that we live in an historical moment in which the introduction of continuously evolving virtual spaces and the implementation of novel pedagogical approaches entail the transformation of the spatial and temporal relations of pedagogical activities. In order to examine these transforming space-time relations and the role that they may play in the learning process, I propose an adapted socio-cultural perspective based on the dialogical notion of chronotope. A chronotope depicts the emergent configuration of space-time relations during an intentional, collaborative learning activity. In sum, the perspective that I adopt considers cognition and learning as distributed in the environment, and space and time as interdependent social constructions. The dissertation report aimed to account for multiple types of physical, social, virtual, real and imagined spatialities and temporalities as they are perceived, discursively negotiated, and bodily enacted by participants in ICT-mediated learning practices.

I carried out four studies that examine various aspects of space-time relations. In Study I, I explored how participants in collaborative learning activities locate themselves and the others across multiple physical, social and virtual spaces; in Study II I investigated how the space-time frames detected in students' discourse on the task affect the process of task interpretation; Study III was aimed at analysing if and how space-time configurations bodily enacted by participants affect the pace and the quality of the learning process; in Study IV I examined the significance and implications of patterns of organization of space-time during the process of instrumental genesis. All the studies adopt a qualitative ethnographic methodology that involves the triangulation of participant observation, discourse analysis, and video analysis.

The results of my studies suggest that examining the organization of space and time can provide crucial insights into technology-mediated collaborative learning activities, informing both theory and practice. Understanding how participants locate themselves and the others in space and time might help us to design learning space-times that enhance coordination and collaborative processes. Considering the discursive framing of space-time by the students can help teachers and instructional designers to ensure that divergent assumptions concerning space-time frames will not induce students to deviate from the set task. Modelling the space-time configurations bodily enacted by participants may provide cues for scaffolding the learning process, helping students to orchestrate space and manage time, in line with the teachers' pedagogical aims. Finally, detecting patterns of space-

time organization may inform decisions concerning where and when to provide just-in-time information, scaffolds and tools to enhance students' learning without interrupting their experience of flow.

Keywords: chronotope, Bakhtin, space-time, technology-mediated collaborative learning

Tiivistelmä

Tämä väitöskirja käsittelee aika-tilan organisointia yhteistoiminnallisissa oppimisprosesseissa, joissa hyödynnetään tieto- ja viestintäteknologiaa. Väitöskirjan argumentin lähtökohta on, että elämme historiallisella hetkellä, jossa oppimisen suhde tilaan ja aikaan on muutoksessa. Muutokseen vaikuttaa uusien virtuaalisten tilojen ja pedagogisten lähestymistapojen käyttöönotto. Kehittelen väitöskirjassa sosiokulttuurista näkökulmaa, jonka avulla voidaan tutkia muuttuvia aika-tila-suhteita ja niiden roolia oppimisprosessissa. Näkökulma hyödyntää dialogista kronotoopin käsitettä, jonka avulla kuvaan tavoitteellisen, yhteistoiminnallisen oppimistoiminnan aikana syntyviä aika-tila-suhteiden muodostelmia. Kaiken kaikkiaan valitsemani näkökulma tarkastelee kognitiota ja oppimista ympäristöön hajautuneina ilmiöinä. Lisäksi tarkastelen tilaa ja aikaa toisistaan riippuvina sosiaalisina konstruktioina. Väitöskirjan tavoitteena oli selittää monentyyppisiä fyysisiä, sosiaalisia, virtuaalisia, todellisia ja kuviteltuja tilallisuuksia ja ajallisuuksia osana tieto- ja viestintäteknologiaa hyödyntäviä oppimiskäytäntöjä. Tavoitteena oli selittää tilallisuuksia ja ajallisuuksia sellaisina kuin osallistujat havaitsivat ne, neuvottelivat niistä diskursiivisesti tai toteuttivat ne kehollisesti.

Toteutin neljä osatutkimusta, joissa tutkin aika-tila-suhteita eri näkökulmista. Ensimmäisessä osatutkimuksessa tutkin sitä, miten yhteistoiminnallisen oppimisen osallistujat sijoittivat itsensä ja toisensa useiden fyysisten, sosiaalisten ja virtuaalisten tilojen välillä. Toisessa osatutkimuksessa tarkastelin, miten opiskelijoiden tehtävän tekemiseen liittyvistä keskusteluista tunnistamani aika-tila-kehykset vaikuttivat heidän tehtävän tulkitsemisen prosessiin. Kolmannen osatutkimuksen tavoitteena oli analysoida, kuinka osallistujien kehollisesti toteuttamat aika-tila-muodostelmat vaikuttavat oppimisprosessin tahtiin ja laatuun. Neljännessä osatutkimuksessa tutkin, minkälaisia merkityksiä ja seuraamuksia aika-tila-suhteiden säännönmukaisuuksilla oli työvälineen syntyprosessissa. Kaikissa osatutkimuksissa käytin laadullista etnografista metodologiaa ja hyödynsin tutkimusmenetelmällistä triangulaatiota. Tutkimusmenetelminä käytin osallistuvaa havainnointia, diskurssianalyysiä ja videoanalyysiä.

Tutkimukseni tulokset viittaavat siihen, että ajan ja tilan organisoinnin tutkiminen voi tuottaa ratkaisevan tärkeitä oivalluksia teknologiavälitteisestä yhteistoiminnallisesta oppimisesta. Tuloksista on hyötyä sekä käytännössä että teorian kehittämisessä. Sen ymmärtäminen, miten osallistujat sijoittavat itsensä ja toisensa tilassa ja ajassa, voi auttaa suunnittelemaan oppimisympäristöjen aika-tiloja, jotka edistävät osallistujien keskinäistä koordinaatiota ja yhteistoiminnallisia prosesseja. Sen huomioiminen, miten opiskelijat kehystävät aika-tilat diskursiivisesti, voi auttaa opettajia ja oppimisympäristöjen suunnittelijoita varmistamaan, etteivät aika-tila-kehyksiin liittyvät monenlaiset olettamukset saa opiskelijoita poikkeamaan annetusta tehtävästä. Osallistujien kehollisesti toteuttamien aika-tila-asetelmien mallintaminen voi antaa vihjeitä, miten oppimisprosessia voidaan tukea. Opiskelijoita voidaan tukea tilan organisoimisessa ja ajan hallitsemisessa opettajien pedagogisten tavoitteiden suunnassa. Lopuksi aika-tila-suhteiden säännönmukaisuuksien tunnistaminen voi

auttaa tekemään päätöksiä siitä, missä ja milloin kannattaa tarjota opiskelijoille oikea-aikaista tietoa, tukea ja välineitä, jotka edistävät heidän oppimistaan ilman, että heidän virtauksen kokemuksensa häiriintyy.

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telling each other about our lives, or hours watching movies. We have been close when life hit one of us hard and needed our help, and shared happiness when one of us made important moves in his or her private and working life. At times, life took us physically away from each other, or busy lives drew us temporarily apart, but on many occasions I have had confirmation that these distances were just an illusion and you have been closer than I could ever imagine. This thought has been very inspirational for me. Ideas are more easily turned into words when one can count on his friends. So, thank you my old and new friends, wherever you are!

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Helsinki, 4.12.2017
Giuseppe Ritella

List of original articles

This thesis is based on the following articles:

Ritella, G. (2010). Presence, social presence and heterotopia: the self and the others in a multi-space. *Cultural-Historical Psychology*, 2010(4), 39-46.

Ritella, G., Ligorio, M. B., & Hakkarainen, K. (2017). Interconnections between the discursive framing of space-time and the interpretation of a collaborative task. *Learning, Culture and Social Interaction*.

Ligorio, M. B., & Ritella, G. (2010). The collaborative construction of chronotopes during computer-supported collaborative professional tasks. *International Journal of Computer-Supported Collaborative Learning*, 5(4), 433-452.

Ritella, G., Ligorio, M. B., & Hakkarainen, K. (2016). The role of context in a collaborative problem-solving task during professional development. *Technology, Pedagogy and Education*, 25(3), 395-412.

Table of contents

1 Introduction

The present dissertation aims at investigating the organization of space-time in collaborative learning mediated by Information and Communication Technology (ICT). The dissertation contains four studies that examine different aspects of space-time relations. All the studies adopt the Bakhtinian concept of *chronotope* to conceptualize space and time as interdependent social constructions, discursively negotiated, and bodily enacted by the participants in ICT-mediated learning practices. It is important to state, from the beginning, that these studies do not concern space and time per se, but the organization of space and time in learning practices. In other words, the object of this dissertation is not to question the ontology of space and time, addressing what space and time are, but to develop a research program to understand how participants in learning activities organize their practices in space and time, and what kinds of implications the emerging space-time frames can have for pedagogical activities.

In the next section, I will discuss the necessity of a specific focus on space and time in contemporary research in education. I propose three main arguments that research on space-time relations is crucial, especially in the present historical period. In sum, I argue that 1) digital technology, 2) educational theory and 3) educational reforms push toward a radical transformation of space-time of educational practices. I argue that these transformations have profound implications for education, which need to be investigated.

Second, I will discuss some assumptions on which I base my conceptualization and operationalization of space and time, positioning myself in relation to ongoing theoretical debates. Such discussion is not aimed at presenting an extensive literature review of the concepts of space and time as scientific concepts, which would be beyond the scope of this text. Rather, I will discuss four assumptions that clarify my position in relation to some ongoing scholarly debates that I consider relevant for the field of study in which my research takes place. In sum, I maintain that 1) human cognition and learning are *distributed* in space and time by means of artifacts; 2) space and time are socially negotiated constructs; 3) spatial and temporal relations apply simultaneously to social events, thus they should be analysed in a coordinated way; 4) space and time are interdependent, affecting each other in multiple ways.

Third, I will introduce the concept of *chronotope*. To do so, I will briefly describe the historical evolution of the concept, from Bakhtin to contemporary studies in education and learning research. Given that *chronotope* is an emerging concept not yet fully developed, a great part of my work has concerned the theoretical foundations for *chronotopic analysis*. Therefore, many of the articles contained in

this dissertation contain rich theoretical sections, discussing the foundations of chronotopic analysis. I will largely build on these articles to present my understanding of the notion of chronotope, clarifying the theoretical framework from which it is derived.

Fourth, I will move to an operational description of space-time as chronotope. Referring to the literature using the concept, I will describe different layers of space and time that will be further developed throughout the dissertation. These layers – location, extent, space-time organizing and connotation - allow one to summarize the main dimensions of space-time that were examined in my studies.

Fifth, I will present my research questions, and discuss how they relate to the theoretical framework of the dissertation. Generally, the objective of my investigations is to uncover the processes that underlie the social negotiation and bodily enactment of space and time during ICT-mediated learning practices. Starting from this general objective, I have developed four interconnected research questions. For each of these research questions, I have carried out a different study, each presented in a separate article (articles I-IV).

Sixth, I will tackle the methodological challenges and solutions that I have been encountering and developing throughout my investigations. I argue that, given the complexity and ubiquity of the object of investigation, chronotopic analysis involves the triangulation of multiple methods and perspectives. In particular, I will discuss how participant observation, discourse analysis, and video analysis, all contribute to improve our understanding of space-time relations in learning and educational practices mediated by ICT. An integral part of the methodological section is the discussion of the units of analysis adopted.

Seventh, I will briefly summarize each of the studies, describing specific research questions, methods and results. Finally, I will discuss my findings, the limitations and the implications of my doctoral studies, sketching directions for future research.

2 The relevance of space and time for contemporary education

Space and time are ubiquitous in human life. People feel that all events of life are situated in space and time. As noted by Zerubavel (1985, 1989), concerning time, our social environment is structured along temporal patterns (for example, weekly patterns), and our social lives are regulated through schedules and calendars:

> In order to navigate successfully within society, we require a sort of "temporal map" that informs us, for example, that the best day for spending a relaxed morning with our parents is Sunday, that museums are often closed on Mondays, and that there are reduced rates for long-distance telephone calls on weekends. […] Recalling what day today is is one of the first things we usually do upon waking, since it is indispensable for transcending our subjectivity and participating – at least mentally – in a social, rather than merely personal, world. (Zerubavel, 1989, p. 2)

In the same way, spatial patterns play a great role in everyday life:

> In having a body, we are spatially located creatures: we must always be facing some direction, have only certain objects in view, be within reach of certain others. How we manage the space around us, then, is not an afterthought; it is an integral part of the way we think, plan and behave, a central element in the way we shape the very world that constrains and guides our behaviour (Kirsch, 1995, pp. 31-32).

By referring to the work of Zerubavel and Kirsch, I argue that space and time are relevant for educational research because of their significance for the psychic and social processes that these researchers have discussed. In this way, both space and time are fundamental for organizing the human experience of the world and are crucial for psychological and sociological analysis. However, considering space-time relations as an emerging issue research on pedagogical activities requires further discussion concerning also historical aspects. Indeed, we live in an historical moment characterized by deep changes in space-time relations. The change in

> movements or mobilities of people, media, material goods, and other social phenomena, including the reach or extension of such movements,

> connections between "global" and "local" life, the creation of new spaces and places, and new speeds and rhythms of everyday social practice, is arguably the most important contrast between contemporary social life and that of just a decade or two ago. (Leander et al., 2010, p. 329)

To address the point of historical relevance, I propose three main arguments, which illustrate how technological innovation, emergent pedagogical approaches and contemporary trends in educational policy all push toward transformations of the space-time relations that function as premises for learning processes.

The first argument is connected with societal transformations triggered by the spread of digital technology. Twenty-first-century learning practices are characterised by an intensive use of digital technologies, which constitute a significant medium in both private and professional lives (Rückriem et al., 2011), and their use opens up new pedagogical opportunities (and risks) for education. Many technological tools are commonly used in workplaces, and some are widely used in everyday life. The so-called "digital agenda" is being emphasised by the European Commission (2014), which is promoting specific actions for digital literacy: "As ever more daily tasks are carried out online, everyone needs enhanced digital skills to participate fully in society." A specific aspect of the process of digitalization is that the space and time of learning have been radically changing with the advent of multiple types of semiotic spaces employed to develop novel knowledge practices (see Carvalho et al., 2017)

The entire temporally-layered flow of activity can be transformed when different types of technology are used. The operation of an instrument transforms the task for the user and implies temporally-layered procedures and practices that differ significantly according to the instrument (Norman, 1991; Hutchins, 1995). This is apparent considering that many professional tools require large user manuals and/or extensive training to master the procedures essential for the functioning of the tool. Indeed, learning to use a tool is a developmental process, which involves both the development of usage schemes by the user (instrumentation), and the evolution of the artifact in association to its current functions in the activity (Beguin & Rabardel, 2000; Lonchamp, 2012). When mastering a tool, the user faces a different task, which often implies a different organization of space and time. For example, using a software suite, such as SPSS, for complex statistical analysis transforms the task for the user, who does not accomplish all the required mathematical operations, which could be a very long process, but involves bringing the instrument to a place accessible when needed (i.e., install it on the computer in the workspace), taking it up at the right moment, correctly inserting the input and finally reading and interpreting the output delivered by software. In this case, there is an enrichment of the workspace with the addition of a tool and a

transformation of the temporal organization and duration of the action. Indeed, complex operations of statistical analysis carried out without the software might require a long (and for many people boring) time, and most likely would involve a set of alternative tools such as an electronic calculator, paper and pencil, etc. Moreover, it would involve an iterative process of checking and correcting mathematical mistakes. In the case of SPSS, the duration of the activity is defined by the procedures required for inserting the input in the symbolic space of the user interface, the time that the computer requires for elaborating the information, the practices for the interpretation of the results defined by the methodology adopted (Table 1). By comparison, the duration of the activity carried out by using SPSS can be considered significantly lower than the case where mathematical operations are manually performed, thanks to the fact that SPSS returns instantly both mathematical and visual representation of results.

Table 1. Summary of possible space-time relations for statistical analysis

	Spatial arrangement	Sequence of actions (temporal organization)	Duration (temporal extent)
Case 1	Spatial arrangement involving: pencil and paper, electronic calculator, desk, sheets containing raw data, colleagues present in the room, and so on.	Reading of the data Identification of the statistical tests to be applied Performing of mathematical operations Report of the results Interpretation of the findings	Duration of procedures for performing the mathematical operations, including the iterative checking and correcting mistakes Duration of procedures for reporting the results of the operations Duration of procedures for interpreting the results
Case 2	Spatial arrangement involving: computer, statistical software suite, desk, electric plug, excel file containing raw data, online and offline colleagues, and so on.	Reading of the data Identification of the statistical tests to be applied Inserting input in SPSS Reading and interpreting the output of SPSS	Duration of procedures for turning on the computer and opening the software suite Duration of procedures for inserting the input Duration of the processing of information by the computer Duration of procedures for interpreting the results

In Table 1, one notices that the actions performed by the user change with the introduction of the software. This implies both changes in the workspace, where some tools that become irrelevant and might disappear, and changes in the duration of the overall activity. The issue at stake however, does not merely regard the presence or absence of tools from the work space, nor the sole temporal duration of the activity.[1] The way in which their use is coordinated throughout the activity – they are picked up in temporally ordered sequences, and positioned in different places – might change as well. An analysis of this kind was accomplished by Hutchins (1995) who examined how the use of multiple representational tools was coordinated by navigational personnel of a military ship in order to define the exact position and bearing of their ship. He found that "the directional relationships of the ship to landmarks in the world are reproduced in a set of spaces: the alidade, the gyrocompass scale, the hoey scale, the hoey arm, and finally the space of the chart" (p. 126). The coordination of different material and semiotic resources, which also involves spatially organizing the context of the activity and temporally arranging the performing of sequences of sub-tasks, is not neutral with regard to cognitive processes. Indeed, such coordination of instruments makes it possible to transform the task, involving different cognitive processes in the activity. Since learning and working environments are becoming more and more complex, it is important to examine how different kinds of instrumentalities are arranged in space and taken up during learning activities and how the temporal duration and organization of practices changes during this process.

Becoming an expert in a profession, and a citizen of contemporary society, requires becoming familiar with multiple technology-rich environments and with many changing practices of using a diversified set of digital tools: "If we want to educate learners to be prepared for life and work in the twenty-first century, we need to create new forms of educational space–time configurations that resonate with students' learning lives in and outside school" (Kumpulainen et al., 2013, p. 16).[2] The process of appropriation of digital tools is critical in this context (Overdijk & van Diggelen, 2008). A better understanding of how students and teachers familiarize with multiple digital tools, and re-organize the space and time of their learning during this process might reveal new insights on how learning takes place

[1] In section 6 of this chapter I will give a more comprehensive account of the different layers of space-time that I consider relevant for the analysis of learning.

[2] Interestingly, also families re-structure the lived spaces – and the learning spaces – of their homes when introducing new technology. For some examples, see Leander and colleagues (2010)

in contemporary education. One trend in this respect is that new technologies enable faster access to and distribution of knowledge resources. This leads to the emergence of "mobile" practices across different settings and situations where the offline and the online are interconnected. In turn, mobile practices challenge traditional and clear-cut boundaries between conceptions of where and when learning takes place and require an expanded conceptualization of learning sites (Erstad, Gilje & Arnseth, 2013; Erstad, 2014). Indeed, as suggested by Goodyear and colleagues (2017),

> The more portable and pervasive that technology becomes, the more – as designers and analysts – we need to pay attention to relations between the digital and the physical. Digital technologies can change the way we experience physical space, and the physical properties of the spaces in which we find ourselves have implications for how – and even whether – we make use of digital devices. […] We need to be able to work with complex entanglements of physical, digital and hybrid tools and artifacts in physically anchored places. (p. 243)

Some schools have been re-designing the space-time frames of their practices, exploiting the potential of digitalization. For example, Erstad (2014) documented a project involving the use of social media for learning in school. In this project, the students were provided with a social network that enriched the set of resources for learning at their disposal both in the classroom and outside. The authors discussed how the new online space allowed the students to position themselves as learners building on their own interests and orientations through self-initiated online interactions, but also to continue academic discussions at home, creating connections between different learning spaces. The time-space of learning and teaching changes, based on the pedagogical use of technology (for further examples see Yaoman, 2017; de Laat & Dawson, 2017). The challenge for research is to develop analytical categories and perspectives able to grasp the dynamic interrelationships between online and offline accomplished by using digital media (Leander et al. 2010; Erstad, 2014; Säljö, 2015). This does not mean only to trace learning outside of local, learning sites such as classrooms, museums, or laboratories. Rather, there is the necessity to conceptualize these sites not only as containers where learning takes place, but to adopt a "nexus-like" perspective, where each site is permeated by movements of energies, materials, resources, information flows coming from different directions (Leander et al., 2010; Cavalho & Goodyear, 2017). From such a perspective, a place – such as a classroom or a museum - is generated by a certain type of work and the displacement of certain kinds of bodies that usually remain invisible. Latour clarifies this point well

through the example of a traveller visiting the Chatelperron Castle. In his analysis, what makes the traveller encounter a place such as the Chatelperron Castle is

> the connexion of actions taking place in different sites and times by various actants. The hard labor of the feudal villains hewing the huge stones and putting them into place is still present today as much as that of the ancient seas and telluric activities of the geological past, and as much as the more recent work by the courageous owner who fixed the roof and consolidated the walls – not to mention the Neanderthal cavemen who placed Chatelperron on the paleontologists' mental maps (Latour, 2004, p. 180).

In a similar way, learning sites can be considered as the ever-changing result of diverse forms of action, from the work of the engineers designing the buildings, to the efforts of teachers orchestrating the space within or outside the classroom, to the engagement of the students who actively and creatively use and transform that space.

Of course, the transformations mentioned here are not related to technology alone. Digital tools do not automatically improve educational practices, nor affect learning by themselves (Säljö, 2016). The effects of technology on education also depend on how tools are integrated into practices of learning and education. Thus, the transformation of learning is realised when technology is paired with change at the organizational and institutional levels, and with the implementation of pedagogical theories and models, which are the subsequent points in my argumentation.

The second argument about the relevance of space-time for educational research and practice, partially connected to the previous one, is related to the evolution of educational theory and the emergence of new pedagogical models that lead to experimentation with novel learning practices and novel space-time frames. Indeed, the contemporary evolution of educational theory and the emergence of new pedagogical models are driving changes in the space-time of learning (Resnick, 2002). For example, Hinton and colleagues (2017) examine the design of a teaching laboratory that was meant to "embody" a paradigm of interdisciplinary and transdisciplinary learning, which supports "interaction and engagement between staff and students, students and other students, and within teams of staff" (p. 209). Their study shows how the design of physical, virtual and social spaces within educational institutions and the organization of tasks and social practices can be driven by a specific pedagogical paradigm and in turn generate particular kinds of problems and opportunities for the students and staff using them. The authors clearly show how different design decisions for the teaching laboratory, which were informed by a participatory educational paradigm, had an

impact on the emerging learning practices, enhancing the "participation in valued practices" and stimulating specific kinds of interactions between different types of participants (p. 223).

In addition, current directions of pedagogical experimentation, such as that inspired by the literature of "place-based learning" (van Eijck & Roth, 2010), emphasise the importance of re-contextualizing learning by moving away from the classroom and linking educational practices to the culture of local communities, manifested materially in the different places in which communities live (Rajala, 2016). Contemporary education may therefore take place in multiple places (historical sites, museums, natural reserves, public locations, and so on.) and the features of each of these environments may affect the organization of educational practices as well as the learning outcomes. Furthermore, some educational theories emphasise the importance of connecting education with other spheres in the lives of learners. While traditional schooling "encapsulates" (Engeström, 1991) learning, detaching it from other spheres of life by means of a special setting, the current development of some approaches to learning suggest that expertise is best developed by supporting students' self-directed and collaborative learning paths across multiple learning contexts. In this view, students are motivated to learn and to excel in their fields of expertise when they can follow their interests and are supported in the building of "learning ecologies" (Barron, 2007) or "connected learning" experiences (Ito et al., 2013). Particularly interesting for the topic of this dissertation is the perspective of networked learning, which partially overlaps with the connected learning approach, but adds a specific focus on how digital technology contributes to the building of learning networks and connections across space and time (Bilandzic & Foth, 2017).

These evolutions of educational theory call for deep reflection on how the space-time of learning practices is organized both within and across contexts and on the role that these spatial and temporal relations might play in improving education and learning. For example, place-based learning approaches might adopt augmented-reality applications through which it is possible to attach additional information to a physical location, which can be visualized through mobile technology (e.g., Ashe & Dohn, 2017). Navigating a location by means of this technology can radically transform both the experience of the place and the way in which learners focus on different particulars of the visited location.

Furthermore, some widely used pedagogical ideas such as the ones associated with the flipped classroom approach (see Bergmann & Sams, 2012, 2014) reverse the usual temporal order and spatial placement of learning activities and call for a transformation of the organization of space and time within schools. While traditional schooling prototypically involves lecturing in the classroom during the morning and practice through homework in the afternoon; the flipped classroom might involve, for example, the visualization of video-based lectures at home,

shared through internet-based software, and collaborative activity in the classroom. A similar argument is true also for the "trialogical learning" (Paavola et al., 2004) perspective that was adopted for the learning practices that I have analysed in my studies. This approach conceptualizes learning as a collaborative effort directed toward developing mediated artifacts, broadly defined as including knowledge, ideas, practices, and material or conceptual ones. It involves the design of authentic tasks in which the learners are required to collaboratively develop, transform, or create shared objects of activity (such as conceptual artifacts, practices, products, diagrams) in a systematic fashion. These types of complex and open-ended tasks usually require complex instrumental ensembles that need to be orchestrated across multiple sessions of learning, going beyond the typical space-time setting of traditional school lessons. The trialogical approach thus aims at triggering the spatially-distributed and temporally layered creation and development of shared objects of activity, which are expected to lead to the growth of students' knowledge and skills.

Examining how the practices of knowledge creation are organized in space and time by students and teachers, and how such space-time organization affects this type of learning, I argue, is crucial for strengthening the foundations of trialogical learning. Indeed, using such kinds of approaches might trigger the restructuring of the whole space and time of the school. For example, some schools that are at the forefront of pedagogical innovation are introducing chairs with wheels and small desks that can be easily moved around the classroom, which allows a flexible use of the space that is typically optimal for collaborative activities; other schools are abandoning the whole idea of closed classrooms and adopting an architectural structure which leaves more freedom for students to use the different spaces of the building as they engage in collaborative learning, going beyond the rigid temporal organization of time typical of traditional schooling. In these cases, the physical space of the school and the temporal organization of activities is transformed based on an underlying pedagogical framework. Thus, space and time become crucial concepts for understanding how learning is changing and how different spatial and temporal arrangements can provide opportunities for learning. My proposal in this dissertation is that this task can be fruitfully addressed by using the concept of chronotope (Bakhtin, 1981).

The third argument for the relevance of space-time is institutional. In agreement with other authors (e.g., Renshaw, 2014), I argue that the institutional dimension of education is intrinsically tied to the governance of space-time relations. Space-time frames in education are concrete manifestations of "pedagogical regimes" (Matusov, 2009), which are also changing in reaction to the new affordances of socio-digital technologies. Techniques for regulating the organiza-

tion of space and segmenting and allocating time at the institutional level are crucial for the management of educational systems. Foucault (1977) brilliantly discussed how the arrangement of space and time in classrooms allowed the systematic supervision of pupils that is typical of traditional schooling:

> The organization of a serial space was one of the great technical mutations of elementary education. It made it possible to supersede the traditional system (a pupil working for a few minutes with the master, while the rest of the heterogeneous group remained idle and unattended). By assigning individual places it made possible the supervision of each individual and the simultaneous work of all. It organized a new economy of the time of apprenticeship. It made the educational space function like a learning machine, but also as a machine for supervising, hierarchizing, rewarding. (Foucault, 1977, p. 155)

The space-time of schooling described by Foucault is still dominant in many schools. However, educational reforms in many countries contribute to the transformation of these institutionally regulated space-time frames. Particularly interesting in this regard is the transformation of space-time frames involved in distance education courses. Indeed, while often distance learning is advocated as a way to free students "from constraints of time and place", in fact what happens is a "transformation of the system of constraints, particularly time constraints, but there is no question of just doing away with them" (Perret, 2005). This is evident when one observes that many distance courses and MOOCs require precise planning of activities and provide tight schedules that define what students should do to progress in their studies at each stage of the course.

Another interesting trend in contemporary educational policy in some countries consists of the reorganization of educational practices based on an emerging "testing culture" (Renshaw, 2014; see also Madaus & Russell, 2010). This implies, among other things, changes in the allocation of classroom time, an intense focus on the limited aspects of the curriculum that are tested and emphasis on memorization and recall; the teaching of complex skills (e.g., deep understanding, inquiry) is considered time-consuming and therefore not efficient (Renshaw, 2014). These types of patterns of space-time frames characterize any historical period and are intrinsically connected to the policymaking that regulates educational reforms, but also to the dominant discourses, ideas and technologies available in a society. As argued by Renshaw, these historical shifts in the organization of schooling are not based simply on scientific discoveries about the process of learning per se (which was my previous argument), but often serve to adapt the system of schooling to the dominant socio-economic system. Within these histor-

ically developing patterns of organizations of time and space, students and teachers can exert their agency, transform their environments and cultivate their identities in dialogue with others (Brown & Renshaw, 2006). Thus, it is crucial for research on learning to investigate how these institutional space-time frames constitute the ground for learning taking place within and outside schools. In line with this argument, Ryan (2011) investigated how the students of an Australian University perceived the space-time of their university life. Some students depicted the university as a site of mass education with large lecture theatres, no permanent space for student groups and limited time for individual meetings with teachers because of the busy life of the academic staff. Together, time limits and spatial arrangements of the university buildings contributed to generate a conception of the university as a potentially distant service provider, which encouraged students to spend most of their time off-campus. In addition, some research shows that "societal institutions like the organization of the school week and the school day influence quantity and type of 'post-school' activities" (Alsaker et al., 2005, p. 109). Thus, the institutional organization of education seems also to have a deep impact on other spheres of students' life.

In this section, I have discussed the rationale for building a research project around the concepts of space and time in learning practices. In sum, I have argued that contemporary education is undergoing profound transformations of space-time relations associated with the pedagogical use of technology, with evolving pedagogical paradigms and with educational reforms. These transformations are still poorly understood although they are fundamental elements of the socio-cultural context of educational practice and might have a crucial impact on learning processes. Accordingly, in order to understand what current transformations imply for learning, we need conceptual and analytical tools that allow one to examine the space-time relations that emerge at the empirical sites of investigation. In my dissertation, I have included four empirical studies that contribute to addressing some of the issues raised by these transformations. In particular, my studies emphasize the focus on the transformation of space and time within technologically rich environments, but they also allow one to reflect on the institutional and pedagogical aspects involved.

In the next section, I will introduce my understanding of space and time by discussing some assumptions that allow one to characterize them as multi-layered and interdependent concepts. Afterwards, I will use *chronotope* as a notion with the capability to synthesize my conceptual understanding of space and time and to develop an analytical framework for empirical investigation.

3 Basic assumptions for conceptualizing space and time

Defining space and time in a clear and comprehensive way is not a trivial issue, and there are still disagreements concerning their nature. Thus, before I can present my analysis of the organization of space and time in learning practices mediated by technology, a discussion of the theoretical positioning that functions as the ground for my empirical work is in order. In this section, I will summarize the assumptions that have guided my conceptualization and operationalization of space and time in the empirical studies that compose this dissertation. Such discussion is not aimed at presenting an extensive literature review on the concepts of space and time as scientific concepts, which would be beyond the scope of this text. Rather, I will discuss four assumptions that clarify my position in relation to some ongoing scholarly debates that I consider relevant for the field of study in which my research takes place. Although these reflections are partly developed as a result of my engagement in the field, and they are an integral part of the conceptualization of space-time as chronotope presented in a following section, I present an overview at the beginning of this chapter, intended to help the reader to follow my argumentation throughout the dissertation.

The first assumption is that *human cognition and learning are not located within the boundaries of the mind, but are distributed in various resources (often called 'artifacts') available in the environment (Donald, 1991; Vygotsky, 1978).* This assumption of cultural mediation is common in many approaches to learning. In particular, it is central in "object-centred" approaches such as the "knowledge-creation" approach to learning (Paavola et al. 2004) that characterizes the context of my studies. In this approach, a key role is played by epistemic mediation, that is, a deliberate process of deepening inquiry by creating external knowledge artifacts (for example, written notes or visual representations) that crystallize meanings and provide stepping stones for directing and guiding further personal or collective inquiry efforts. In line with this idea, I consider cognition and learning as intrinsically "distributed" in space and time (Hollan, Hutchins & Kirsh, 2000), and artifacts as "psychological tools" that serve as epistemic mediators and play a key role in cognition and learning (Vygotsky, 1978). This approach suggests, among other things, that it is essential to examine how the use of tools is distributed in space and time, and how such distribution changes as users "appropriate" the tool. As Béguin and Rabardel (2000) argued, the process of appropriating and integrating external artifacts as instruments of human beings requires adapting and transforming both the external tools and the cognitive-cultural schemas of usage. Looking at how the spatial and temporal organization of activities changes during

the appropriation of technology might improve our understanding of the "mutual shaping" between people and tools (Overdijk and van Diggelen 2008, p. 3) that occurs when artifacts are iteratively used as instruments.

The context of learning in the 21st century abounds in artifacts, technological tools of different kinds, which can function as resources for learning. As richly discussed by Engeström et al. (2003), contemporary society witnesses a spatial and temporal expansion of the objects of activity, which corresponds – among other things – also to the evolution of instrumentalities:

> innovation and learning do not create isolated products or single tools, but integrated instrumental ensembles – constellations of tools – which offer practitioners multiple, variable and flexible ways to answer different questions and accomplish different kinds of tasks. (Markauskaite & Goodyear, 2016, p. 244)

Computer Supported Collaborative Learning (CSCL) environments are complex instrumental systems that often offer a multiplicity of tools, which can be spatially arranged in different ways and taken up at different times. Thus, space and time can be conceived as categories for understanding how contexts of learning are organized in terms of "instrumental ensembles" (see also Engeström, 1990, 2006). The investigation of how the use of artifacts is connected to the emergence of patterns of organization of space-time is a promising area of research that I have explored in the investigations included in this dissertation.

The second assumption is that *space and time are social constructs, thus they are the outcome of social negotiation, which is contested within, and varied across societies (Bakhtin, 1981; Fairclough, 2004; Harvey, 1996; Holquist, 1981).* Many scholars accept this assumption although there is an ongoing debate in which some authors contest this assumption claiming that space and time are universal, also based on the fact that there seem to be specific neuronal circuits involved in the processing of spatial and temporal information (Moser, 2014; Soares et al., 2016). However, there is clear evidence that some cultures such as the Tupi, in Amazonia, have "no time-based interval systems, no lexicalized concept of time as such and no practices of 'time reckoning' as conventionally understood in the anthropological literature" (Da Silva Sinha et al., 2012). Similar arguments concerning culture specific conceptualizations of space are posed by other authors. Indeed, the concepts of space and place "do not always translate well into other languages and cultural contexts" (Merriman et al., 2012, p. 19). A clear exemplification of the cultural conceptualization of space can be traced in the history of maps. Throughout history, different sorts of maps were devised. Such representations of space have seldom been mere technical endeavours of representing the physical

environment according to uniform standards. Typically, they were tools that contributed to the development of worldviews, helping their users to make sense of the universe in which they were living at different scales. Accordingly, the conceptualization of space that was inscribed in maps was the result of complex sociocultural processes. A map, then, represents a symbolic space that has been shaped by values and by cultural and religious beliefs, as well as by the technical instruments devised in each culture for measuring and representing the physical landscape (Talbert, 2012). Another example of the social construction of space lies in the spatial organization of virtual space in different cultures. On this topic, some authors have compared how some design aspects of web pages were interpreted in low-context and high-context cultures. Low-context cultures rely heavily on explicit statements for communication, while high-context cultures there is a tendency to infer meanings from context. In particular, Wurtz (2005) demonstrated that webpages in low-context cultures are characterized by more consistent layouts and colour schemes, if compared with high-context cultures, where pages are characterized by many sidebars and menus. Thus, the spatial organization of webpages seems to be culturally dense, reflecting different ways of conceptualizing the virtual space in the different cultures. Given these arguments, I defend the (provisional) inference that space and time might have both universal and culture-specific features: Even though there is evidence of some universal underpinnings, it is also clear that they can be conceptualized differently depending on language and culture. In sum, in my studies I adopt a view of space and time that implies an analytical focus on the dialogical processes taking place during the development of educational activities, where the organization of space and time is – implicitly or explicitly - negotiated. In this sense, I adopt a "dialogical epistemology" (Linell, 2009), which always considers "dual (or multiple) properties, each one irreducible to the other but unavoidably interdependent, and this system of relations and its dynamics constitutes the focus of dialogical analysis" (Salgado & Clegg, 2011, p. 430).

The third assumption that functions as a ground for my work is that *spatial and temporal relations apply simultaneously to social events, thus they should be analysed in a coordinated way.* In other words, space and time are equally relevant to analyse any social event. To explain this assumption, I refer to the concept of "presence" which is more extensively discussed in Study I of this dissertation. In brief, a person can perceive himself/herself present in relation to a social event if he or she is positioned in a space/place that allows some kind of participation in the event at the time when the event takes place. If either the person reaches the place at a different time, or goes to a different place at the correct time, he or she cannot be considered present. Thus, when analysing presence to a social event, such as the collaborative learning activities that I analyse in my studies, space and

time are equally relevant. Presence is particularly relevant for technology-mediated learning, where the usually clear-cut boundaries between physical spaces are blurred, and there can a seamless mixture between offline and online presence: "although a young person may be physically located in an apartment in Hong Kong, sitting on the couch with a laptop on her lap, she may be virtually located in other cyberspaces: in a chat session with a friend next door, in an online computer game environment with others from across the city, or watching videos produced by youth from another country" (Leander et al., 2010, p. 362). A further example of this connectedness of space and time emerges from the examination of social accessibility as discussed by Zerubavel (1985). Accessibility can be considered as a prerequisite for presence in social events: a person can be present to a social event on the condition that there is some degree of social accessibility. If one is to study how people become accessible to each other, both space and time are relevant. On the one hand, there are specific connotations of space connected to social accessibility. For example, being on a dancing floor suggests more social accessibility than sitting in a library. However, these connotations of space might vary in time. Indeed, some time slots in a library might be reserved for conferences, meeting with authors, and so on. If this is the case, during some time slots it is more likely that people will talk to each other, thus, there is an increased social accessibility. On the other hand, there are specific connotations of time concerning social accessibility. For example, during the night people tend to be less socially accessible than during daytime. However, going to a dance hall during the night makes the person socially accessible during a usually private time slot. Thus, it is the intersection between space and time that allows one to account for social accessibility, and an isolated analysis of either time or space bears the risk of being biased. Such interconnectedness between space and time relations is crucial for collaborative learning. Indeed, the coordination of collective activity requires harmonization of actions on both the spatial and the temporal side.

The fourth assumption is that *space and time are interdependent. Not only events take place both in space and time, requiring coordinated analysis, but the temporal relations and the spatial relations can influence each other in many ways.* Originally, this idea was devised in physics, where Einstein demonstrated that space and time are not independent and absolute as they had been conceptualized in Newtonian physics. In order to re-conceptualize space and time according to this theoretical claim Einstein used the concept of space-time, initially proposed by Minkowski, where time is considered as a fourth dimension of space. In his work, Bakhtin (1981) mentions that his conceptualization of chronotope was inspired by theorization of space-time in physics by Einstein. Bakhtin proposed that the interdependence between space and time is not valid only with respect to physical reality. Some kind of interdependence between space and time is to be

considered also for the analysis of space-time in cultural and literary studies (see also Holquist, 1981). The example of comparing the performing of statistical analysis with or without a software suite (see section 2 of this chapter), is informative in this respect. Analysing these two cases in terms of space-time relations allows one to recognize that the introduction of a virtual space containing a software suite designed for statistical analysis in the workspace involves a transformation of the temporal structure and duration of the activity. Thus, the organization of the space has an impact on the organization of time. The other way around, temporal limitations can affect the selection of tools and the organization of the spaces of the activity. For example, it is possible to choose a shortcut – that is, a different spatial path – in case of time constraints. The examination of spatial and temporal relations, then, needs to provide accounts of how these two dimensions might have an impact on each other.

In sum, the assumptions that I have briefly discussed reveal an understanding of space and time as complex and interconnected concepts. In the following subsection, I will enrich this discussion by examining the multiplicity and diversity of space and time relations. I will present a conceptualization of the context of learning in terms of multiple physical, symbolic, and social spaces and times that emerge during learning activities, and of multiple spatial and temporal scales that in some cases interact with each other.

4 The multiple spatialities and temporalities of the context of learning

According to the first assumption outlined above, learning is a process distributed in the context. Thus, it is important to clarify how I conceptualize context and how space and time are related to it. The concept of context has been crucial for socio-cultural and ecological approaches to learning and cognition (Cole, 1996; Cole & Engestrom, 1993; Bronfenbrenner, 1994; Hutchins, 2009; Nardi & O'Day, 1999; Perret-Clermont, 2004). Largely building on the ideas developed within these approaches, I consider the context of learning as the outcome of a continuous process of social construction engaged in by the participants, who project meanings on the environment and on the artifacts around them according to the activity of the moment. Bateson (1972) discussed the process of arranging the external context as "punctuation", arguing that people arrange the external physical and socio-cultural environment in "meaningful sequences" that allow one to "orient oneself to certain types of contexts" or to acquire "insights into the context of problem solving" (p. 174). In this way, people shape the structure and the salient features of the context according to the activity of the moment (Duranti & Goodwin, 1992; Kirsh, 1995). In such a culturally punctuated context, defined by Kirsch (2000, 2001) as "activity space" or "action landscape", people find the artifacts that become "mediating instruments" for their activity (Rabardel & Beguin, 2005).

In order to examine the results of such process of punctuating the context it is fruitful to think in terms of the emergence of multiple, heterogeneous and often overlapping spaces. For example, the physical spaces of a school such as classrooms, laboratories and even toilets might overlap with the socially organized spaces involving intimate, social and public zones, and with the multiple symbolic spaces of books, blackboards, computers, and so on. The same classroom, then, can be examined as a physical space involving the measurement of the dimension and shape of the room, as a social space where some zones of the classroom are privileged for some kind of social interactions and not for others, as a semiotic/symbolic space filled with signs and symbols interpreted by the teachers and students. Many of these spaces are "domesticated" (Goody, 1977), that is, they are culturally constructed, labelled and socially organized to accomplish some practical, social or cognitive function within the activities of the community that inhabits them. Bilandzic and Foth (2017), for example, examined meet-up groups, hackerspaces and co-working spaces. They showed that many of these communities continuously design, evaluate, and socially organize the space in order to adapt it to the local needs of the group. In particular, they were found to invest in designing

spaces that could facilitate social learning, carrying out three types of possible interventions: 1) hiring professionals responsible for supporting social interaction (designing social space); 2) providing technological tools for social interaction (designing virtual space); 3) keeping the physical space open; arranging the furniture in ways that do not obstruct sightlines but rather facilitate mutual awareness; arranging different zones for different types of activities and work (designing physical space). All together the "domestication" of social, virtual and physical spaces provides opportunities for community members to engage in connected learning and collaborative activities.

All of these spaces compose what Foucault (1967) called *heterotopia*. Heterotopia is a place in which heterogeneous spaces coexist, as in the space projected on the screen and the physical space in a cinema, or the multiple symbolic spaces of books in a library. In the same way, the context of 21st century learning is a heterotopia containing multiple physical, symbolic, and virtual spaces. Thinking in terms of heterotopia allows one to examine many different dimensions of spatiality, as suggested by Sheppard:

> [C]omplex emerging spatialities, or spatiotemporalities, matter. And they matter because even though they are in part constructed by us through a series of socionatural processes in which humans participate, they nevertheless always already exist, always coming back to shape what happens. This is what Ed Soja (1980) has referred to in another context as a 'socio-spatial dialectic'. They matter in multiple ways. They matter materially. They matter in terms of discourses and representations that are mobilized around various spatial concepts. They matter through the ways in which space is performed. And, critically, they matter in terms of the everyday constructions of space that happen in the real world, as social movements, neighbourhood organizations and other groups make the spaces that we academics try to think. Again, it is not a question of either/or: we have to be thinking about spatialities in all of these dimensions at once." (Sheppard, in Merriman et al., 2012, p. 8)

These spaces are not independent of each other, they overlap and interact with each other, with potentially remarkable implications for cognition and learning. For example, Hutchins (1995) discussed how the activity of navigation might imply a switch between physical and symbolic spaces, between being "on the chart" and being "in the world". This kind of switch is necessary for the accomplishment of the task as it is organized in the western tradition of navigation, but requires a learning process in order to be mastered by novices:

> When a Western navigator takes a bearing of landmark, he has a real point of view on a real space. However, as soon as he leans over his chart, he is no longer conceptually on the boat; he is over the sea surface, looking down on the position of his craft in a representation of the real local space. Novice navigators sometimes find this change of viewpoint disorienting, especially if the orientation of the chart does not happen to correspond to the orientation of objects in the world. (p. 79-80)

In this sense, the orientation between physical and symbolic spaces – such as the one described by Hutchins – might be considered in some situations as a pedagogical aim, allowing students to develop novices' skills in orientating between the different spaces typical of a profession. The more general point I make here is that the way in which the different spatialities (physical, social, symbolic/conceptual) are organized and put in relation with each other is not neutral for cognition and learning, and its examination might provide further insights into learning practices. Following this argument, learning contexts can fruitfully be examined in terms of multiple physical, social and symbolic spaces that are organized in a dynamic way by teachers and learners.

As argued above, digital technology triggers a drastic transformation of the heterotopias, which previously relied on more stable media for the generation of symbolic spaces (initially clay, then papyrus, paper and so on), bringing types of space that are qualitatively different from old ones, especially in terms of workability and shareability of epistemic artifacts (Ritella & Hakkarainen, 2012). Learning environments involving digital technology are often multimedia, so that students and teachers are embedded in a diversified heterotopia filled with semiotic resources of different types. During the activity, participants may explore and use different resources and trace trajectories within and across the spaces of the heterotopias.

Not necessarily are the multiple spaces described above bounded to the local sites where situated learning practices take place. Even if the scale chosen for the investigations presented in this dissertation is precisely the fine-grained organization of space (and time) within situated learning practices taking place in circumscribed sites, in principle spatial analysis can be drawn at different scales, from the movements of the eyes on a written page, to the mobility of students and teachers across multiple countries. These spatial scales might interact with each other (Hinton et al., 2017). For example, a high degree of mobility of students on the larger scale might be related, on the smaller scale, to a transformed organization of the social space in the classroom due to the presence of students with different cultural backgrounds, who might have different assumptions concerning what can be defined as an intimate space. In sum, the space of learning in this dissertation

is conceptualized as a multi-space – as a heterotopia, to use Foucault's term – containing different types of spaces and extending over many spatial scales, even though each investigation focuses on a limited range of spaces and spatial scales, as I will discuss in the methodological section of this extended summary.

A dynamic, processual understanding of context cannot rely only on spatial categories but requires also an account of temporal relations. Punctuating the context, thus, does not involve only the organization of space, it also involves a temporal dimension. As there are multiple types of space (physical, social, symbolic), it is possible to identify multiple types of time. In her analysis of Piaget's work, Perret-Clermont (2005) notes that time can be approached from different perspectives, since the human relationship with time is simultaneously biological, psychological, social, historical and technical. Indeed, time correlates with physical and biological effects on human beings; it is a socio-cultural construct that regulates social interaction; it is a psychological category of thought through which people make sense of their lives. Moreover, temporalities in education can be characterized as personal, didactic and institutional (Schubauer-Leoni et al., 2005); as learning time (Perret, 2005); as measurable time use (Alsaker et al. 2005), just to give a few examples. For the scope of the present discussion I will consider only three categories that I consider relevant for my analysis: physical time, social time and psycho-biological time. With physical time, I mean the uninterrupted flow of time that is measured by means of the atomic clocks by physicists and is related to the physical interaction between objects; with social time I mean the social organization of time that is typical of every society, which is measured using different types of time reckoning devices such as clocks and calendars and is related to social interaction and to the organization of activities and institutions; with psycho-biological time I mean the subjective experience of the flowing of time, which is related to biological rhythms and might be different for each person participating to an event. These types of temporality are not independent of each other. For example, in contemporary society, the social regulation of time relies on an extremely precise measurement of physical time, which is necessary for the correct functioning of fast and frequent means of transportation and for telecommunication. Moreover, the physical-time relations involved in neuronal processes are involved in defining the subjective perception of time (Soares et al., 2016).

As for space, the examination of temporal relations involves also accounting for multiple time-scales. As noted by Lemke (2000), the immediate timescale for human interactions "ranges from the glance and the word, said or done in a second or less, to the complex sentence spoken or heard and the complex action performed over a few tens of seconds" (p. 276). However, learning activities are characterized also by patterns at both longer and shorter timescales, from the scale of

neural processes – taking place in a few milliseconds - to the long-term transformation of school systems – which might require hundreds of years. These different timescales, in complex systems can interact in multiple ways. As extensively discussed by Lemke (2000), each timescale is likely to interact with the immediately longer and shorter timescales, while very different timescales usually are independent of each other. This means that events at the timescale of a lesson are likely to be interdependent with events at the timescale of a school day and with events at the timescale of an episode of a few speech turns. In contrast, changes in educational systems usually are too slow to have a direct effect on phenomena taking place at much shorter timescales, such as the articulation of a sentence during a lesson. However, there are exceptions to this general rule. The most important of them for the human social organization of activities across timescales is "semiotically mediated heterochrony", which involves "longer-term processes and shorter-term events linked by a material object that functions in both cases semiotically as well as materially. The material characteristics of the object also function as signs for an interpreting system of meanings that belong to processes on a very different timescale than that of the event in which the interpreting process is taking place" (Lemke, 2000, p. 281). The studies contained in this dissertation will concern only a subset of these timescales, as I will clarify in the methodological section of this extended summary.

Table 2.- Summary of the main types of spaces and times and of the range of spatial and temporal scales involved in learning activities.

	Types	Scales
Space	Physical spaces, social spaces, symbolic spaces, virtual spaces	From the size of a pixel on the screen to distances of cross-country mobility
Time	Physical time, social/institutional time, psychological inner time	From milliseconds of neuronal processes to long term transformations of educational systems

In sum, I have discussed the space of learning as a multi-space encompassing different types of physical, semiotic and social spaces across multiple spatial scales and the time of learning as interwoven types of temporality across potentially interacting timescales (Table 2). In other words, space and time are not conceived only in terms of physical realities that exist in the external world and are perceived by participants as given, but also as "semiotically performed, made significant and coordinated" (Leander et al., 2010, p. 344). Moreover, in the previous

section I argued that space and time are intrinsically connected and require coordinated analysis. In the next section, I will further develop both these arguments by introducing the concept of chronotope, which lends itself well to a holistic examination of complex spatio-temporalities as an integrated whole, allowing one to detect the potential interdependency between space and time.

5 Space and time as chronotope

Bakhtin first introduced the concept of *chronotope* to analyze the space-time patterns that characterize a literary genre. In particular, he used this concept in order to express the "inseparability of space and time (time as the fourth dimension of space)" (Bakhtin, 1981, p. 84). For Bakhtin, chronotopes define the distinctions between different genres, they are "organising centres for the fundamental narrative events of the novel. The chronotope is the place where the knots of narrative are tied and untied. It can be said without qualification that to them belongs the meaning that shapes narrative" (Bakhtin,1981, p. 250).

In his analysis of narratives, Bakhtin worked at two different, although integrated, levels. On the one hand, he pointed out what are the general schemes of narration for each literary genre, showing how space and time emerge in typical configurations. The macrostructure of plots in some genres has a typical composite schema consisting of a stereotypical sequence of spatial settings and invariant series of time segments. For example, the "adventure novel of ordeal" in ancient Greece is characterized by a prototypical unfolding of time – which Bakhtin calls Adventure Time – and by a very broad and varied geographical background, involving foreign, unknown places, often separated by the sea. On the other hand, he described - at the micro-level - typical scenes characterizing a literary genre (Keunen, 2000). An example of these scenes is the "encounter on the road" which, Bakhtin states, in different variations, plays a key role throughout the whole history of the novel.

In his theorization, Bakhtin pointed out that different chronotopes are also associated with a different characterization of the protagonists of literary works. For example, the Adventure Time described above is associated with young heroes that remain unchanged throughout the development of the plot. In this type of chronotope "people and things have gone through something, something that did not, indeed, change them but that did (in a manner of speaking) affirm what they, and precisely they, were as individuals, something that did verify and establish their identity, their durability and continuity" (Bakhtin, 1981, p. 106). By contrast, the chronotopes characterizing the (so called platonic) biographical works present initially self-confident and ignorant characters who, through self-critical scepticisms, develop their self-knowledge and their identities throughout the progress of the plot (Bakhtin, 1981).

Even though the primary use that Bakhtin made of chronotope concerns the analysis of literary texts, the scope of the concept is much broader in his intentions: according to the theory of chronotope, the spaces and times represented in texts are based on the experiences of real and imagined lives (Vadeboncoeur, 2005). Thus, the chronotopes that Bakhtin finds in literary texts may be considered

as a kind of artistic elaboration of space-time configurations that people experience in their life – either real or imagined. Furthermore, Bakhtin argued, all meanings, even abstract meanings, which are per se decontextualized, can become part of our experience only in a given context, which is always situated in space-time. It is within such space-time contexts that meanings contribute to shaping our understanding (Morson & Emerson, 1990). In other words, for Bakhtin, meaning making is necessarily situated in space and time, and such situatedness (partially) shapes meanings. This, in turn, is reflected in literary texts, where the space-time configurations experienced or imagined in real life are artistically elaborated and represented. Chronotope, then, was meant by Bakhtin not only as a concept for textual analysis, but also as a tool for examining the space-time relations of the contexts of "real life". In this sense, Holquist (1982) argued that the concept of chronotope emerged with a double meaning: it was not just a contribution to historical poetics, but also an attempt to re-think some fundamental categories "broken down" by the Russian revolution:

> The essay on the chronotope is addressed to the basic problem the revolution had raised for those who lived through it: how to model space and time relations under radically differing historical and social conditions. Different culture systems differ from each other precisely in the way they conceive space and time in the different strata composing them: as economic value (time as work and space as property), as cosmologies, and in their aesthetics, particularly in literary representation of space-time. The specific forms into which a culture's ideas about time-space materialize Bakhtin calls chronotopes. (p. 8)

In Holquist's view, the concept of chronotope lends itself well to cultural analysis. Different historical and social conditions lead to different conceptualizations of space and time and the way in which they are conceptualized has a significant impact on cultural processes. Thus, using the concept of chronotope implies treating space and time as social constructions negotiated through dialogue, rather than as given realities external to human activities. With the term dialogue, here, I do not simply refer to situated verbal interactions, but to the "responsivity" and "anticipation" inherent in human action and interaction that is not necessarily bound to the current situation (Linell, 2009). Therefore, it requires one to go beyond the measurement of physical spaces and time intervals according to the consolidated scientific paradigm. If space and time are socially negotiated, then the scientific understanding is just one of the voices involved, and the other voices – for instance the voices of the participants – should not be silenced (van Eijk & Roth, 2010). Dialogue and sensemaking, in this view, are crucial for the analysis of space-time relations. On the one hand, different voices contribute to shaping the forms in which space and time "materialize" within a cultural context. On the other hand,

space-time contexts are crucial elements of meaning making and contribute to shaping the meanings emerging in dialogic processes.

This claim by Bakhtin is similar to Goffman's (1974) discussion of space-time relations included in his presentation of frame analysis. Frame analysis was devised to examine how people define the social situations they experience, identifying the "frameworks of understanding" people use for making sense of social events in which they participate. Among other things, to frame a situation involves defining the space and the time boundaries of a social event. For example, a lesson is framed as such also because it takes place in a particular setting, is scheduled in advance, has a pre-determined duration and so forth. The ways in which the space of the setting and the temporal development of the event are organised contribute to the participants' definition of the situation, and in turn affect how the participants act in the situation. Thus, the meaning of a social situation is intrinsically connected with its space-time organization, and it is intrinsically connected to meaning making processes.

In sum, I argue that the concept of chronotope allows one to treat space and time as interdependent social constructions, negotiated and contested in dialogical interaction. The concept of chronotope invokes the inseparability of space and time allowing one to examine how space and time intersect in learning practices, and at the same time it moves one's analytical attention to the social construction of space and time, rather than to their physical ontology. Thus, analytically chronotope allows one to examine how transformations in space (e.g. participants gathering around a workstation) might be motivated by time constraints and, in turn, might impact the tempo of the activity, as well as its quality and its outcomes. Preceding studies on collaborative processes often focus on time (e.g., Scardamalia and Bereiter, 1994; Baker and Lund, 1997; Ligorio 2001; Sarmiento and Stahl 2008) or on space (e.g., Dillenbourg and Traum 2006; Stahl 2009), not emphasizing enough that spatial and temporal dimensions are strictly interconnected. Chronotope, thus allows to overcome some limitations of studies that treat space and time as independent from each other.

Considering space and time as social constructions, however, does not imply the obliteration of material relations from the analytic focus. Indeed, "symbols always have some physical realization" and "the nature of the physical form of symbols constrains the kinds of operations to which they can be subjected" (Hutchins, 1995, p. 131; see also Norman, 1991). The representational (textual) and the material (embodied) world, according to a dialogical understanding, operate relationally and indexically: "The material place helps to give meaning and significance to the discourse, just as the (material and discursive) sign serves to give meaning and significance to the place." (Leander et al., 2010). Chronotope concerns both the immaterial, semiotic, worlds of discourse and narratives, and "patterns of organization of space and time" (Lemke, 2004) that are enacted through the movement of bodies and material objects within and across places and

spaces. Thus, chronotope is consistent with the notion of space and time that was outlined above, where physical, social and symbolic spatialities and temporalities are dynamically segmented and organized by participants.

Many scholars have used the concept of chronotope to examine space and time at the boundary between material and discursive processes (see, for example, Hirst & Vadeboncouer, 2006; Matusov, 2009; Brown & Renshaw, 2006). In the following section I will briefly summarize the studies on chronotope identifying three main themes addressed in the literature. The aim is not to provide a comprehensive review, but to position my research in relation to the uses of the concept in the literature, in terms of aspects of space-time examined and units of analysis used.

5.1 Summary of the usage of chronotope in research on learning

Following Bakhtin's theorizing, there has been a growing use of the concept of *chronotope* in the social and learning sciences: "This notion of the inseparability of space and time, and the constitutive role the chronotope plays in relation to narrative, can be adapted from literary criticism to social and cultural analyses" (Fraser, 2006). Recently researchers have found the concept of chronotope useful in analyzing diverse aspects of learning. The studies that use the concept generally adhere to the theorization made by Bakhtin, but it is possible to identify a relatively variegated range of units of analysis and analytical foci. Various aspects of the space-time grounding of educational activities are investigated and varied units of analysis are used. According to my analysis, this diversity is due to two interrelated reasons. First, space and time are relevant at multiple levels and for multiple units of analysis of educational activities, as I have mentioned in section 3.1 of this chapter. This means that chronotopic analysis can range from a macro-level level where the analysis focuses on the space-time relations characterizing entire school systems (e.g., Matusov, 2009; Renshaw, 2014) to smaller scales, where it is possible to analyse space and time relations within a classroom over a project lasting a few weeks or months (e.g., Brown & Renshaw, 2006). Second, Bakhtin's definition and use of the term is easily adoptable for multiple analytical foci. In this section, I summarize the main analytical distinctions that I have found in the literature. Although these are often treated as interconnected aspects of space-time, and thus are analysed in a coordinated way, for analytical purposes it is useful to discriminate among them:

1) *The organization and moving of objects, bodies, and technologies in space and time*.

For instance, Matusov (2009) refers to the typical school rhythms defined by sequential assignments and the dispositions of desks and bodies in discussing what he calls the "ontological chronotope". Moreover, some authors argue that digital technology triggers the emergence of new chronotopes, considered as "patterns of organization of activities in space and time" (Lemke, 2004). Ritella and Hakkarainen (2012) discuss chronotope in relation to technological innovation in education, exploring how the virtual space generated by technology qualitatively transforms the whole space-time of educational activities.

2) *The discursive negotiation of space and time during pedagogical practices.*

This aspect concerns the discursive processes through which space and time are socially constructed by participants during educational activities. As stated by Hist and Vadeboncoeur, "while social spaces may be most easily defined by the movement of people, practices, and objects, they may also be defined by conversation, speech, and intention" (2006, p. 206). Some authors consider such chronotopic grounding of activities as an implicit discursive process, which involves taken-for-granted views and assumptions that can be inferred from discourse, but are usually not explicitly stated. Following this line of thought, Bloome and colleagues (2009, p. 324) defined chronotope as "a set of assumptions (an ideology) about how people move through time and space and how that movement is related to changes in the person and in the worlds in which she/he participates...."

3) *The organization of meanings in space and time*.

While the previous aspect concerns the discursive construction of the concepts/assumptions associated to space and time, this third aspect concern the fact that meanings and ideas – not only bodies and objects – are located in space and time. For instance, Matusov (2009) discussed the didactic aspect of chronotope as a "drama of curricular ideas", which unfolds in space and time. The focus in this case is on the unfolding of the academic curriculum and the definition of academic success and failure. A similar conceptualization emerged in Wegerif's metaphorical conceptualization of a "dialogical space", as the space-time of the "dynamic continuous emergence of meaning" (Wegerif, 2007, 2013).

4) *The development of the Self in space and time*.

Following the idea that chronotopes provide the ground for characterization, that is, the possibility of "being somebody" (see section 5 of this chapter), some authors have emphasized the relationship between space-time and identity. Fol-

lowing such argument, Ligorio and colleagues (2013) examined the role that chronotopes play for the development of identity trajectories during a blended university course, by tracing the space-time frames associated with the dialogical positions expressed in the students' discourse. Similarly, Ritella and Ligorio (2016) have discussed how social positions emergent in dialogical interaction are linked to specific space-time coordinates (past events, present interaction, or anticipated events), and that such connectedness between social positions and chronotopes contributes to the emergence of meaning and to the organization of collaborative sensemaking.

This brief summary shows that chronotopic analysis is emerging as a rich and variegated approach for studying space-time relations in education, not (only) as physical realities, but (also) as interdependent social constructions. It is necessary for us to understand 1) how learning sites are materially organized in space and time, 2) how space and time are negotiated as social constructs 3) how ideas and meanings are organized spatially and temporally, and 4) how space-time frames can function as ground for the development of personal identities; these interconnected topics are addressed by chronotopic analysis. Given such diverse analytical foci and levels of analysis, when empirically investigating chronotopes, the specific scales and foci of analysis should be reported and the potential interdependencies with other levels discussed. In the following three sections, I will frame my own investigations on chronotope specifying which aspects of space-time I address, and which units of analysis I have selected for my work. In particular, in the next section I will start building an operationalization of chronotope, defining which layers of space and time I have considered in my studies. Then I will briefly present my research questions and discuss the methodological choices I have made to address these questions.

6 Principal layers of space and time for the analysis of learning

After discussing the theoretical assumptions and foundational notions that guide my conceptual understanding of space and time as interconnected social constructions, in what follows I introduce some analytic distinctions that guide the operationalization of space and time in the empirical studies of this dissertation. These distinctions constitute an intersection between theory and methodology since their definition relies on the theoretical discussion presented above, but they are crucial to define the analytical focus of each study of the dissertation and contribute to define how data are manipulated to foreground specific layers of space-time. I call these categories analytic layers, in order to distinguish them from the categories used above to discuss the multiple types of spatiality and temporality that coexist in learning contexts (conceived as heterotopia). All the layers that are presented below might be applied to define the analytical focus in relation to all the types of space and time discussed in section 3 of this chapter. For example, researching the layer of *duration* of an event or process can be done in relation to the individual feeling of the flow of time experienced by participants (psycho-physiological time), to the social organization of time expressed in calendars, agendas, or other time reckoning devices, or to the physical flow of time measured through clocks. In my dissertation, as argued above, I consider these types of temporality as interconnected: for example, the way in which the duration of events is expressed in discourse relates to the subjective feelings associated with the duration of the event by the speaker, but also to social conventions of time reckoning and to the physical, irreversible, flow of time.

Concerning time, I have primarily imported the four analytic layers defined by Zerubavel (1985) in his influential work on the sociology of time: Duration, Temporal location, Sequential structure, Rate of recurrence. First, duration can be defined as the amount of time during which an entity exists or a process lasts, be it in psychological, social or physical time. Second, the temporal location concerns the identification of the moment in which an event happens, which is achievable in relation to other events that function as a reference frame. The sequential structure can be defined as the temporal order in which a series of interconnected events develops or a series of actions is organized within the frame of a larger activity. Finally, the rate of recurrence describes how often an event happens within a given timescale. These are key layers of the experience of time that are part of our common sense understanding of the temporal developments of events. However, they are not sufficient to fully grasp how people make sense of, and arrange, the time

of their practices. Therefore, I added two further ones, namely, Synchrony and Meaning of time.

The first additional layer (Synchrony[3]) is meant to account specifically for collaborative processes where multiple participants can engage contemporaneously in parallel or in complementary actions. Given my analytical interest in collaborative learning, this layer is relevant for my studies. This layer is only apparently overlapping with the Sequential structure. Indeed, while a sequential structure can describe the sequence of subsequent actions carried out by an individual or a group, synchrony results from the partial overlapping and complementary function of two or more sequential structures carried out at the same time. In other words, it accounts for the parallel dimension of collaborative processes. The difference between sequential and synchronic layers is well exemplified by the difference between sequential and parallel programming, where the second involves the simultaneous execution of processes while the first involves a consecutive and ordered execution of processes. In a similar way, collaborative processes might involve both synchronic (parallel) and sequential actions.

The second additional layer is intended to account for the subjective – or intersubjective - meanings that participants associate to time. Indeed, as discussed above, time is not just a reality external to human activities. Participants in learning activities subjectively feel the flow of time and associate to it socially negotiated meanings and values. In other words, we do not face only "time as it is" (Valsiner, 2011), but also construct "time as could be" and "time as should be". According to Valsiner, each point in time in the future entails "a variety of equally potential (not yet actualized) trajectories" (p. 142), some of which will never be actualized. These trajectories constitute the horizon of possibilities within which human action takes place, and they can be reflected on by the participants in any activity. In particular, Valsiner directs attention to two kinds of social constructions of temporality, called "time as could be" (according to human free will) and "time as should be" (according to one's values). These kinds of temporality are loaded with values and define the meaning-making process on the temporal dimension. The meanings associated to the "time as it is" emerge from a comparison with imagined temporalities. This layer is strictly related to sense-making and is related to the connotations that time acquires in relation to participants' will and values. In this sense, this layer accounts for the (discursive) social negotiation of time mentioned in a previous section. In Table 3 I summarize these layers for the

[3] Throughout his work, Zerubavel (1985) introduces also the concepts of temporal symmetry and temporal complementarity as forms of coordination. The category of Synchrony, as defined in the present chapter, is overarching these two concepts.

analysis of time, proposing some examples of how they might appear in discursive data.

Table 3. Summary of the layers for the analysis of time.

Layers of time	Example
Duration	The lecture lasted **one hour**
Temporal location	The class took place **at 10 AM**
Sequential structure	The writing of the essay **was followed by** evaluation by the teacher
Rate of recurrence	I am attending **two math classes each week.**
Synchrony	**While** Marc was searching for further information, I wrote the introduction.
Connotation of time	**I am worried,** we do not have time to complete this task. /Time **is money.**

Concerning space, a first distinction made in the literature (which is valid also for time) is between location and extent (Fairclough, 2004). While 'spatial location' concerns the position that a person or an object occupies within a given frame of spatial reference, 'extent' might concern, for example, the size of a room or the distance between two objects. In addition, space is characterized by a structural layer that describes the shape of objects and the spatial arrangements of the settings of the activity in different spatial scales. As shown by Kirsch (1995), spatial arrangements are crucial for human activity and they have profound implications for cognitive processes. For example, spatial arrangements of the workspace might facilitate experts' performance in a working task by reducing the cognitive load of the task. One way to realize this is to encode information in the environment, thus reducing the load on working memory.

Finally, space – in the same way than time – is charged with values and meanings. As brilliantly discussed by van Eijk and Roth (2010), places are lived entities, and the names used to articulate them can have a huge ideological power, contributing to define the meanings associate to them: "stripping a place from its indigenous name can be seen as a form of silencing the indigenous voice and hence as a form of colonization" (p. 881). Furthermore, the meanings associated to places and spaces can be very different for different strata of the society. Some studies reviewed by Leander and colleagues (2010), have shown that parents and children can associate very different meanings to places. While the children see "the outdoors, or open spaces, utility sites, and home spaces" as a playground where they are willing to spend time autonomously; for parents, often these places

are associated to concerns for the children's safety. As for time, this layer of spatial analysis is strictly related to sense-making and to the connotations that space acquires in relation to participants' will and values. In this sense, this layer accounts for the reflexivity of the experience of space. In Table 4 I summarize these layers for the analysis of space, proposing some examples of how they might appear in discursive data. Just as for time, these layers are interconnected and therefore the limitations of an approach analysing them in isolation have to be taken into account.

Table 4. Layers of space

Layers of space	Example
Extent (Length/distance/size)	The chemistry laboratory is in a **small** building, **about 500 meters** on the left.
Spatial location	The teacher stands **in front of the blackboard**.
Spatial arrangement/Shape/Setting	The students' chairs were **arranged in a circle**.
Connotation of space	Being so **close to her** resulted in a **sense of intimacy**.

As I have argued above, space and time are not independent. They interact with each other. Therefore, to develop a theory of chronotope it is fundamental to find a framework that allows one to account for the intersection between space and time. By comparing the different layers identified for space and time, it is possible to note some isomorphisms. Some of the layers of time seem to match the ones of space and vice-versa. This points to more general categories that are valid for both space and time. Indeed, some authors, such as Fairclough (2004), have recognized that location and extent apply to both space and time. In what follows, I take a systematic approach and attempt to outline all facets of the isomorphism between them. Working with such a synthetic approach, I have abstracted four main layers that apply both to space and to time (Location, Extent, Organizing, and Connotation) and incorporated all of the layers presented in Table 3 and Table 4. Moreover, I have identified four corresponding phenomena that result from their interaction in the spatial and temporal dimension (Presence; Movement and transition; Organization of activities, and Sensemaking). In Table 5, I summarize the result of this synthesizing work.

First, as temporal location and spatial location match each other, it is possible to abstract a general layer, "location", which is valid for both time and space. The question arises, then, of what are the results of the interaction of temporal and

spatial location. In my analysis, this results in the phenomenon of presence. Indeed, a participant is present in a social situation when both his/her spatial and temporal locations[4] coincide with the spatial and temporal location of the situation.

Second, the layers of duration and spatial extent might be abstracted into a general category of extent. This category, in terms of space-time corresponds to the analysis of movements and trajectories, which involve tracing the distances (i.e., changes in space) covered through space over more or less extended periods of time.

Third, I have abstracted a structural layer of space-time that I named *space-time organizing*. I prefer to use the term *organizing*, as the process of organizing points to a work of structuring which recognizes the agentive role played by participants in arranging activities and institutions. In particular, Weick has emphasized that organization emerges from an act of sensemaking, where people attempt at ordering and shaping the flux of action, channelling it toward certain ends: "The operative image of organization is one in which organization emerges through sensemaking, not one in which organization precedes sensemaking or one in which sensemaking is produced by organization" (Weick et al., 2010, see also Weick, 1995). I find Weick's understanding of organization fully consistent with the dialogical perspective presented in this dissertation. Thus, sequential structures, spatial arrangements, and so on, are considered here as emerging results of the reflexive process of organizing.

Fourth, I have abstracted the layer of connotation which addresses the social construction of space and time through acts of sensemaking. This layer corresponds to the analysis of how participants make sense of temporal and spatial relations, and how this relates to their discursive framing of social and learning situations. This layer is the most strictly related to the "experiential and phenomenological" account of learning (Säljö, 2009), where space and time are treated as concepts socially constructed and negotiated by the participants themselves.

[4] Here location is not meant to have a strictly physical meaning. As I argued above, and will further discuss in article I, location in the virtual space is important for the phenomenon of *presence* in contemporary learning practices.

Table 5. Summary of layers of space-time

Layers	Time	Space	Time-space
Position	Temporal location	Spatial location	Presence/social presence
Extent	Duration	Length/distance/size	Movement/Transition/trajectory
Organizing	Sequential structure/Rate of recurrence/Synchrony	Spatial arrangements/Shape/Setting	Organization of activities
Connotation	Connotation of time/sense of time	Connotation of space/sense of place	Sense-making (space and time as social constructs)

Note that all of the layers I have discussed above might be analysed both from a quantitative or a qualitative perspective. For example, spatial location might be approached from a quantitative perspective by measuring the physical position of the participants and representing them in a Cartesian space. At the same time, a qualitative approach might discuss the function that some spatial positions have for the development of an educational activity, regardless of a rigorous measurement and representation of the physical space. Furthermore, it is important to note that all of these categories might be applied to any activity at the same time; the separation shown in the tables is analytical, not ontological. Finally, the boundaries between these layers are not impermeable. For example, a spatial arrangement of object might be conceived as the combination of the spatial locations of all the objects considered in the analysis. However, each layer is meant to foreground a specific analytic focus: The concept of location foregrounds the analysis of the positioning of people and objects during the interaction addressing the "where" someone is located or something is happening in relation to physical, symbolic and social spaces. Spatial arrangements, by comparison, foreground the analysis of patterns of organization of the space resulting in more or less stable arrangements of the workspace.

These layers are foundational for the structure of this dissertation. Indeed, each of the studies presented in the dissertation concerns one of these layers, or a combination of them. Before the presentation of the methods chosen for the empirical investigations, I will briefly discuss the research questions and the definition of the units of analysis.

7 Research questions

The main aim of this dissertation is to discuss how the organization of space-time is achieved in technology-mediated learning practices. In order to address this aim, I have developed four specific research questions that were addressed in each study. In the present section, I do not simply report the research questions literally as they were formulated in each article. This is because as the theoretical framework emerging from the studies was developing, the research questions have also become formulated in a clearer manner. Indeed, all of my studies can be considered as addressing one of the aspects of space-time that were theoretically framed above, even though the big picture was not yet visible when the single studies were carried out. In what follows, I present and briefly discuss the main research question of each study:

How are presence and social presence perceived during a technology-mediated learning task? (Article I)

In order to address the complexity of *presence* in technology- rich environments, scholars have developed the constructs of (tele-)presence and social presence (Riva, 2009). As argued above, presence is a construct that is strictly related to spatial and temporal location. This research question is aimed at exploring the use of these concepts in technology-mediated learning, using some data to illuminate how teachers participating in a technology-mediated learning task locate each other both in the physical space of the room and in the virtual space of the computer, and to discuss what kinds of implications these processes have for the coordination of collaborative learning.

How do participants in a collaborative media design task discursively negotiate the space-time of their activity while interpreting the task? (Article II)

This research question encompasses both the process of perception of space-time and the process of organizing the activity in a future-oriented process. While studies on task interpretation have already demonstrated the relevance of the institutional context for the students' sensemaking concerning the task (e.g., Lantz-Andersson et al., 2009), the role played by space-time frames has not yet been addressed. Thus, through this research question I explore how participants discursively situate the task in space and time and how this affects the interpretation of the task, which is crucial mediator of the students' engagement in the learning

tasks set by the teachers. This research question concerns the layer of sensemaking, which involves a reflexive process of imagining "space-time as could be" and defining "space-time as should be."

Which configurations of space-time are enacted by the participants in the here and now of situated interaction? And how are they related to the learning process? (Article III)

This research question is related to the process of enactment – which is defined in the next section of this chapter referring to the work of Weick (1995) – and to the implications that it has for learning. In particular, I seek to examine the performative aspect of space-time, that is, how participants in a technology-mediated collaborative learning task move in space-time and whether their movements allow one to recognize specific spatial and temporal arrangements that are of value for the learning process. I analyse if and how different configurations of enacted space-time are characterized in terms of tempo and speed of the activity and what qualitative changes in learning are associated with these configurations. The analytical focus is on the movements and trajectories that participants perform across the available virtual, symbolic and physical spaces.

Which patterns of space-time organization of the context emerge during the appropriation of educational software? (Article IV)

While it is clear from previous research that experts in a profession develop "intelligent" and systematic ways of organizing the complex contexts of their activities (Kirsch, 1995); there is a need to better understand when and how learners explore, pick up and exploit the different types of instruments available in the environment. Particularly interesting in this respect is the process of appropriation, when participants are familiarizing themselves for the first time with a new environment. Indeed, it is reasonable to expect that the way in which participants explore and use the resources present in the environment will have an effect on how they will develop usage schemata, learning to navigate it skilfully. This research question is aimed at checking the existence and significance of patterns in the alternation of events where participants explore the context of learning and events where they exploit a stable set of tools as resources for learning, expecting that some of these patterns might provide cues for supporting or scaffolding the process of appropriation.

8 Methodological framework

As largely discussed in the previous sections of this chapter, *chronotope* is a complex, multi-layered concept that is not easy to operationalize for empirical analysis. I argue that defining a methodology for chronotopic analysis requires to consider the methodological implications of four features of chronotope that I have discussed. In the following lines I briefly summarize these features of chronotope and the associated methodological implications. In this way, I define the theoretical-methodological premises that have guided my choice of the methods for examining space-time relations.

First, I argued that chronotope implies a dialogical understanding of space-time, where meaning-making processes are crucial units of analysis. Therefore, there is a need to adopt methods able to grasp the discursive and semiotic processes through which participants to educational activities negotiate the organization of space and time.

Second, the dialogic understanding of space and time involves the hybridization of representational and embodied worlds, so that both material and semiotic elements are equally relevant for interpretation (Leander, 2001). Thus, there is a need to use methods that are able to trace bodily actions and the movement of materials during and across activities, and to detect the ways in which these are intertwined with discourses and signs.

Third, space and time are interdependent social constructions, so the methods devised for examining them should allow to implement a coordinated analysis and to grasp their potential interdependence in the local sites of investigation. This does not mean that each empirical occurrence should encompass both spatial and temporal relations. For example, it is possible (as I discuss in study II), that only spatial relations are dominant in some discursive units. However, it is crucial that the methods applied to the data allow to grasp also temporal relations, as far as there is something to grasp concerning their interdependence.

Fourth, chronotope is relevant at different spatial and temporal scales, from the historical development of national schooling systems in a society to the space-time coordination of actions during a single learning task. This requires that each study using the concept of chronotope should clarify the unit of analysis and adapt the methodology to the chosen unit of analysis. In my analysis, I focus on the space-time relations emerging during the collaborative solution of a collaborative task by small groups. Therefore, the methods are adapted to this unit of analysis.

On the one hand, space-time relations encompass multiple types of space and time, multiple possible layers as analytical foci, and multiple spatial and temporal scales. On the other hand, space-time frames work as an often implicit and invisible ground for activity (Morson & Emerson, 1990) that is not easy to observe. Furthermore, there are not yet clear guidelines for analysing it: "there is not a clearly defined sense in Bakhtin of how to proceed in chronotopic interpretation. Such analysis is complex in that chronotopes are not merely obvious representations of space-time" (Leander, 2001, p. 652). This implies that the analysis is still largely explorative and unsystematic. Even the generation of research questions and the definition of units of analysis turns out to be a laborious process.

In the next section, I will discuss how I have determined the units of analysis and the units of data for each of my studies. The unit of data is a pragmatic-technical construction that defines how data were segmented, and it differs from the theoretical-methodological question of the unit of analysis which defines which objects or processes are examined (Toiviainen, 2003).

8.1 Defining units of chronotopic analysis

Until now I have developed a conceptualization of space-time as chronotope that involves a coordinated account of a) multiple spatialities and temporalities (material, social and symbolic; imagined and normative); b) multiple spatial and temporal scales (from micro-analysis of situated interaction to history of educational systems); and c) multiple layers of space-time (location, extent, organization and connotation) that are relevant for examining educational activities. Much of the complexity inherent in the concept has been addressed throughout the previous sections. In this section, I will attempt to put together the pieces that I have analytically discriminated in the previous sections by discussing the units of analysis for my studies. Indeed, the chosen unit of analysis of a study defines which kind of scales, layers and types of space-time can be examined. The definition of the units of analysis is a crucial step for research because it defines the boundaries between what is considered and what is ignored by the research, making "some things easy to see, and others impossible to see" (Hutchins, 2010, p. 706).

Before proceeding to the definition of the units of analysis for my studies, it is important to mention that I do not consider chronotope as a unit of analysis in itself. Chronotope, in the perspective presented here, is a conceptual tool that allows one to reach a sociocultural understanding of spacetime. As discussed above, this understanding requires a focus on how human beings socially negotiate and bodily enact space and time in activity. That is, space and time are not only scientific concepts in physics, they are also everyday concepts that people use to regulate their own lives through calendars, clocks, maps, agendas, purposeful spatial

arrangements of objects on desks, and so on. The meaning making associated with the organization of space and time and the spatial and temporal arrangements typical of human social practices require conceptualizations that are different from the ones devised in physics because they are different phenomena than physical ones. Neither Newton's absolute space, nor Einstein's spacetime is appropriate to explain how students and teachers frame space and time in dialogical interaction, nor why they bodily enact institutionally prescribed configurations in space and time (e.g., standing in a line, sitting every day at the same desk at school, and so on). I have argued that Bakhtin's conceptualization of chronotope lends itself well for this purpose. Indeed, it clearly introduces a sociocultural understanding of space and time that is characterized by the set of assumptions and ideas discussed above. Thus, if chronotope is not a unit of analysis, there is the need to discuss what are possible units of analysis for such a sociocultural conceptualization of space-time.

My argument here is that chronotope maintains its relevance across a wide range of units of analysis. As I discussed above, analyses of school systems and of situated interactions can both be performed from a chronotopic perspective. What distinguishes chronotopic analysis from other kinds of analysis is not the definition of a specific unit to be examined, but the objective to put space-time relation on the forefront of sociocultural research, investigating how different configurations of space-time can function as premises for learning (Ritella, Ligorio & Hakkarainen, 2017). The question, then, is to understand what can count as a chronotopic unit of analysis according to the theoretical discussion presented above.

As asserted by Lemke (2000), dynamic theories of complex systems privilege processes as units of analysis, since "things", "organisms", "persons" and "institutions" are static notions if not conceived in terms of the processes in which they are involved. All the elements of complex systems are constituted and continuously transformed within processes. This line of thought is common is sociocultural research. For example, Wertch (1995) proposed human action as the unit of analysis for sociocultural research:

> Such an approach contrasts with describing and interpreting attitudes, concepts, linguistic and knowledge structures, and other such units we often encounter in psychology. As will become apparent, these other units often can be extremely useful in analysing one or another aspect of action, and employing them is therefore not necessarily antithetical to an analysis of action. However, in an action approach, they are viewed as moments, or aspects interacting with others in a more inclusive system. (p. 61)

Wertsch, in discussing this claim, argues that action – understood as a process – is not a novel unit of analysis, since the roots of this conceptualizations can be found in the writings of Bakhtin, Vygotsky, Leont'ev, Bourdieu, Burke, Dewey, Habermas, Mead and others, who all focus on "concrete, dynamic human action existing in real spatiotemporal and social contexts" (Wertsch, 1995, p. 62). Thus, for Wertsch, the focus on action allows one to overcome the problematic de-contextualizing work that is accomplished in some traditions of theorizing. In this sense, Bakhtin (1986) insisted on a focus on the utterance as a form of action to be examined in the context of the dialogues to which it participates, in contrast with other investigators who grounded their work on linguistic abstractions such as *langue* and the sentence. In particular, from a dialogical perspective, a dynamic understanding of process involves an emphasis on the presence of the "Other's perspective", which might bring tensions, conflicts, disagreements, and discrepancies between perspectives, evaluations and accounts (Linell, 2009).

It is clear, then, that a sociocultural – dialogical – understanding of space-time requires a processual unit of analysis. In this sense, we should follow Latour (2004), not speaking of time, space, and actant but rather of "temporalization, spatialization, actantialization" or "more elegantly, of timing, spacing, acting." (p. 178). But which processes – which kinds of actions – are the units that fit well for uncovering the specific timing, spacing, acting of pedagogic activity? One clarification is needed before answering this question: in order to keep the argumentation concise and consistent with the nature of this summary, I will circumscribe the definition of the units of analysis to *the context and analytic scope chosen for my investigations, that is, the collaborative accomplishment of learning tasks by small groups over projects lasting a few weeks within a bounded learning site (a school, a university).* While, as a sociocultural researcher, I recognize the crucial role of larger-scale processes such as historical developments of school systems, which function as ground for the activities I analyse, I am particularly interested in the micro-genesis of patterns of organization within local, learning sites. This scale has an advantage for the analysis carried out in my studies: the organization of activities in space and time is often an implicit process, as mentioned above. However, during collaborative activities participants need to coordinate their efforts and negotiate with each other the spatial and temporal frames, so that processes that usually are implicit during individual activity might – to some degree – be more easily detectable in the data;

In what follows, I present the processes that in my view are the most relevant for the examination of space-time relations within the local practices of learning that I have observed. These processes constitute the specific units of analysis that I have defined for each of my studies. They have not been clear since the beginning of the research presented here, but emerged as a result of my engagement with the field of study. Thus, in a way, their identification might be considered as

one level of results of the work done in this dissertation. This is related to the fact that I have an approach inspired by ethnography, which is characterized by the progressive development of theory, rather than the testing pre-existent hypotheses (Hammersley & Atkinson, 2007). It advances in a non-linear way and is characterized by the continuous interaction of theory and data throughout the process (Engle, Conant & Greeno, 2007). Thus, the identification of the units of analysis has been informed by both engagement with the field and theoretical and methodological reasoning. In sum, I have identified five interdependent processes: (a) the perception of given space-time relations; (b) the discursive framing of space-time; (c) the enactment of space-time through the movement of bodies and objects; (d) the emergence of patterns of organization of space-time; (e) the development of cultural models and taken-for-granted views. In the studies presented in this dissertation, I have focused on the first four of these processes, while the development of cultural models will be discussed as a future direction for chronotopic analysis. In what follows, I will briefly discuss each of these processes, outlining how these units of analysis can be operationally detected in the data, defining "units of data."

The first process that I have addressed in my studies is *the process of segmenting the context in space and time* that I have discussed when introducing the concept of heterotopia. Basically, this is a process of active perceiving, of organizing the sensible world as it is perceived moment by moment. An integral part of this process is to position oneself and the others within a culturally structured environment, which in the literature is addressed by using the concepts of sense of presence and social presence (see Study I). In order to study this aspect of the organization of space-time, in the first study of the dissertation, I have extracted and qualitatively analysed some fragments of discursive interaction where it was possible to detect how the participants in a group activity perceived and positioned themselves and the others in relation to the multiple physical, social and virtual spaces that they were dynamically organizing during the activity. One aspect of this process that I did not analyze in Study I, but was partially addressed in Study II is the discursive, meaning making associated with the perception of the space-time of the activity. This involves making sense of the constraints and opportunities that emerge from the institutional regulation and technological dimension of space-time. This interpretative process partially overlaps the "framing of context": when participants frame a context, they also define it in terms of what spaces are relevant for the activity and what temporal boundaries and time-structures are relevant (Engle, 2006). Chronotope is preferable to framing because it allows a specific focus on the role that space-time plays in the learning process.

The second process, which is strictly connected with the previous one, is *the discursive organization of the activity, in a future-orientated process, involving the selection of tools and workspaces, and the organization of the schedule. While the process of perception concerns the segmentation of what is perceived as given, the discursive organization of the activity concerns the discursive construction of not-yet-realized space-time frames.* In this process, the types of temporality that Valsiner (2011) calls "time as could be" and "time as should be" are crucial (see section 6 of this chapter). This aspect is especially important when complex orchestration is needed to organise the activity and co-ordinate individual efforts successfully. Especially when a teacher adopts ill-structured collaborative tasks in technology-rich environments, the learners have some degree of freedom in the arrangement of their individual and shared learning environment and the time structure of the activity. They discursively define how they will co-operate: they might decide to work individually at subtasks and share their contributions through an intranet or they might choose to sit in a circle to discuss crucial issues, using a smart-board to visualize shared artifacts and other things. In my second study, I have explored this process, discussing how a group of students constructed space-time frames when interpreting the task set by teachers. The perceived space-time constraints and opportunities played a great role in defining their interpretation of the task. In this study, I detected from the data the topical episodes (Linell, 2009) that revealed the discursive space-times associated with the interpretation of the task, including also normative space-times.

The third process concerns *the movement of bodies and objects during the activity, which is interdependent with the discursive envisioning of space-time discussed above.* Participants in every learning activity engage in embodied actions aimed at arranging the space-time of their activity by means of dynamic configurations of body orientation, gaze and disposition of artifacts in space. For example, participants can arrange their bodies and the relevant resources in specific configurations that have an impact on how the collaborative processes unfold. The concept of enactment is crucial in this process. Weick (1995) in his examination of organizational sensemaking, uses the concept of enactment to "preserve the fact that, in organizational life, people often produce part of the environment they face" (p. 30). For Weick, through action people create the material environment that becomes the constraints and opportunities for their activities. In this sense, by moving their bodies and objects participants transform the environment also in terms of spatial and temporal relations, producing configurations of space-time that can become constraints and opportunities for learning. The reference to the body and to material objects does not imply that only physical spaces are relevant for this process (Markauskaite & Goodyear, 2016). Indeed, the heterotopia of contemporary learning practices is dominated by the presence of multiple virtual

spaces. Small movements of the body can result in radical transformation of the space. For example, a click on the mouse can open a social networking website; a quick glance of the eyes allows one to navigate between different windows open on the screen, turning the page of a book presents the participants with a novel chapter and new symbolic contents. Thus, the concept of enactment implies the movement of the body, but given the presence of symbolic and virtual spaces in the context of learning, the movements are not limited to the physical environment. In Study III of this dissertation, I have analysed how participants in a professional development course, used their bodies to enact different types of configurations of participation, which had an impact on the pace of the learning process and on the quality of that process. In this study, the specific unit of data was the so-called "change of scene", that is a change in the configuration of participation realized through embodied movements across physical, symbolic and virtual spaces. Detecting the "changes of scene" allowed one to examine the process through which the participants moved their bodies and objects across the multiple spaces available.

The fourth process, which I call *emergence of patterns of space-time, concerns the fact that when people create and organize the material environment through the process of enactment, the same environment becomes an emergent reality*. According to Sawyer (2005), the concept of emergence accounts for the processes whereby the properties of a system result from but are "irreducible" to the "properties of the system components" (p. 4). Sawyer mentions the V shape of bird flocks as an emergent phenomenon, which is the result of the interaction between pairs of birds. In this case, the V shape cannot be reduced to the properties of single birds. Rather, it is a property of the system that emerges from the local interaction between the components of the system in a "de-centralized" way, without any "coordinator" (Resnick, 1997). In a similar way, it is possible that during collaborative learning activities groups can organize their bodies around the technology in some recurring spatial and temporal configurations, for example forming circles around a table or semi-circles around a smart-board. In the same way, it is possible that some types of spaces and times are associated to some specific phases of the activity; or that some types of movements in space are repeated regularly throughout the activity by the agents, and so on. In other words, when people move in space, exploring it, or using the available tools for learning, these movements can generate patterns of organization that characterize the activity. In their study of networked learning, Gourlay and Oliver (2017) describe some space-time patterns that characterize students' accounts of learning with technology:

> What also became apparent was the way in which movement between these spaces formed part of the rhythm of studying; certain spaces were strung together in sequences (e.g., reading on the bus, accessing files on a computer in the library, searching for books on the library shelves, etc.), and these were often associated with specific phases of studying (e.g., working in the library when looking for resources at an early stage of writing an essay, visiting a field site when undertaking empirical studies, etc.). (p. 80)

These types of patterns might be invisible to the participant even though it might have a strong impact on the collaborative activity, and thus it requires scientific investigation. In particular, this process is interesting in relation to the stabilization of the space-time organization of activities that takes place, for example, during the appropriation of a new technology. I have partially addressed this process in Study IV, where I detected some patterns of organization of space-time that emerged from video-recorded interactions of a group of teachers appropriating a software suite. In this study, I interpreted, diachronically, patterns related to the exploration of the environment by the participants. In particular, I identified two types of events: 1) events in which the participants explore the space and actively search for resources in the environment and 2) events characterized by a focus on a stable set of resources. On one level, I performed a qualitative analysis where the single events worked as unit of data. In this case, the result was an in-depth analysis of how the exploration of the environment was carried out by the participants during the event. However, what is interesting in relation to the process of pattern emergence discussed here is that it was possible to identify some patterns in the distribution of these types of events throughout two sessions of collaborative problem solving. At this level, the units of data were not in the single event, but in their diachronic alternation during the two sessions, examined in terms of space-time organization (rate of recurrence of events, sequential organization of action, temporal stability of spatial arrangements, and so on).

The last process concerns the *emergence and possible transformation of taken-for-granted views and cultural models that individuals use as the background against which they make sense of a situation, including expectations and assumptions about how the space and time of activities "should" be framed.* Participants in a learning activity have expectations and assumptions regarding the organization of space and the flow of time for their practices (Bloome et al., 2009). Furthermore, learning to perform well in complex tasks involves the development of techniques concerning the planning and optimization of temporally-ordered sequences of actions (that is, scripts and procedures typical of the task), and the spatial arrangement of bodies and artifacts available in the environment in which

the task is typically accomplished. These techniques reduce the "memory loads of tasks, the amount of internal computation necessary" or "simplify the visual search and categorization that is inevitably involved in performance" (Kirsh, 1995, p. 65). Although this process is important for chronotopic analysis, it has not yet been in the main focus of my studies, but I am planning to address it in the future.

In Table 6 below I represent my studies in relation to both the processes and the layers of space-time (which were defined in section 6 of this extended summary) on which they focus.

Table 6. Layers of space-time and units of analysis in the fours studies.

	Perception	Social negotiation	Enactment	Emergence
Location	Study I: Sense of presence			
Movement			Study III: Tempo of activity	
Organization				Study IV: Patterns of context exploration
Meaning	Study II: Interpretation of task	Study II: Interpretation of task		

8.2 Methods of analyses

For chronotopic analysis I adopted a qualitative approach inspired by ethnography (Hammersley & Atkinson, 2007) that involves different methods of data collection and analysis. In all of my studies I use video records as a main source of data which include learning tasks accomplished by the studied small groups in their learning sites. The data allow for detailed accounts of the investigated social processes (Goldman et al., 2014). The secondary data consist of field notes written during the participant observation; collection of documentation concerning the

observed activities; and informal exchanges with the participants at the beginning and at the end of each session of observation. The secondary data are retrieved whenever they may clarify the interpretation of speech or actions from the video.

Since language and communication play a crucial role in the social negotiation of space-time I have adopted some "tools of inquiry" (Gee, 2001) borrowed from discourse analysis. Discourse analysis is often used in conjunction with other forms of social analysis, and it is "best framed within ethnography" (Fairclough, 2004, p. 15). According to Fairclough, a trans-disciplinary approach to discourse analysis allows one to "operationalize" social theoretical perspectives and insights for textual analysis in order to enhance our analytic power. Therefore, discourse analysis can be fruitfully used to work with the categories of specific theoretical perspectives – here, the theory of chronotope – to investigate social phenomena as they unfold in discourse. Discourse analysis is developed starting from particular motivations and research questions, so it is always selective and depends primarily on the perspective from which the analysis is conducted: "no analysis of a text can tell us all there is to be said about it – there is no such thing as a complete and definitive analysis of a text" (Fairclough, 2007, p14). Thus, discourse analysis works as a flexible tool that can be adapted also to the specific research questions of my dissertation.

The discursive framing of space-time is of extreme relevance for understanding how participants conceive the context of their activity. In order to discuss this point I will use an anecdotal example by Schegloff (1972):

> Were I now to formulate where my notes are, it would be correct to say that they are: right in front of me, next to the telephone, on the desk, in my office, in the office, in Room 213, in Lewisohn Hall, on campus, at school, at Columbia, in Morningside Heights, on the upper West Side, in Manhattan, in New York City, in New York State, in the North east, on the Eastern seaboard, in the United States, etc. Each of these terms could in some sense be correct... were its relevance provided for. (p. 81)

The text above clearly shows that the same activity can be located by the speaker within a great number of different spatial frames. Locating an activity as happening "in my office" or "in the United States" reveals how the speaker conceive the relevant context for the activity. The same is true for time: saying that a learning activity takes place on Thursday morning or in the post-modern historical period reveals what the speaker considers to be the relevant context. Throughout the studies presented in this dissertation (in particular in Study II), I have analysed discursive data to detect what kind of space-time frames emerged from participants' discourse.

In order to accomplish this task, I have used the markers that allow one to detect space-time frames in discourse, as they were identified by discourse analysts. For example, the tense and aspect of verbs are markers of time (Fairclough, 2007). Specific phrases with prepositions are often used to indicate positions, transitions and settings, i.e., space (van Leuveen, 2008). Moreover, also some gestures, especially deictic gestures as pointing (Goodwin, 2003b) are often involved in defining space and time. However, the analysis cannot be carried out just by the identification of such markers in texts. Indeed, sometimes space-time relations can emerge in interaction without the specific markers or can even be taken as granted as implicit assumptions; sometimes the same marker can be used in different ways (e.g., metaphorically), so they not necessarily denote space-time relations in any simplistic way. Thus, a qualitative analysis of interactional events is required, in order to grasp how participants make sense of the space-time context, and envision not-yet-existent space-time frames.

For such analysis, I have worked with the notion of situated meaning presented by Gee (1999, 2014). Situated meanings are the meanings that "words, phrases, sentences, and sequences of sentences take in actual contexts of use" (Gee, 2014, p. 49). Such meanings do not correspond to the dictionary meaning of words. Indeed, utterances are always ambiguous and may potentially be interpreted in multiple ways (Gee, 1999). Semiotics and linguistic theory have developed multiple strategies to help analysts to "disambiguate" (Eco, 2011) the situated meaning of words and utterances in their context. That is, they provide tools for understanding which of the multiple potential meanings of an utterance are relevant in a given context. Cues like meta-discourse, lexical choices, intonation, gestures, gaze trajectories and so on, may help the analyst to make reasonable inferences regarding the situated meaning that emerges in the investigated interactions. As mentioned above, this work is interpretive and always "open to revision" (Gee, 1999, p. 54).

One problem with the analysis of space-time in discourse is that everything could be potentially relevant for interpretation (Duranti, in Goodwin, 2003a). As I have argued above, various aspects of context can play a role in defining space-time relations and the role that they play in the learning process. In particular, for chronotopic analysis, the interplay between material and semiotic elements is crucial. Therefore, it is important to develop a methodology able to analyze utterances in their context of use, considering other elements other than words for interpretation.

Video data are helpful in this regard as they also allow analysis of non-discursive elements of interaction, such as body orientation, gaze, gestures, use of various semiotic tools, which are reported in the literature to be other important aspects for the interpretation of situated interaction (Goodwin, 2000, 2003; Kendon, 2004; McNeill, 2002). The framework for discourse analysis developed by Gee

(2014) allows integrating these aspects with the analysis of texts. Therefore, in this work I use a holistic approach, in which these elements have been on the background but integrated in the analysis when the researchers noticed that they helped to interpret the observed interaction.

Gestures, as pointed out by Kendon (2004) may be used by speakers to complete sentences (speech-framed gestures), to accompany speech and enrich its meaning (gesticulation), or constitute utterances on its own (emblems and signs). Therefore, when conducting discourse analysis on face-to-face encounters, it is important to not overlook how gestures can enrich or transform the emergence of situated meanings. The interest here is not specifically in the role of gestures, but I considered their presence when they were relevant to investigate the organization of space-time.

Body positions and gaze are not meaningful in themselves; they assume meanings depending on the activity engaged in by participants (Kendon, 2004). They are continuously interpreted by participants (Goodwin, 2003b) and may signal, for example, the beginning or end of the activity, who the speaker is addressing, who is recognized by the group to be a participant in the activity, to which element of the context participants are attentive, and so on. In the field of multimodal semiotics (Unsworth, 2011), where language is treated as one semiotic system among others, visual representations, arrangements of buildings, furniture, and virtual spaces also contribute to the investigation of situated meaning-making. Although all of these dimensions are potentially relevant for my investigations, I did not analyze each of them systematically. I analyzed them insofar as they appeared to be relevant for the analysis of each study in connection to the specific research questions and units of analysis adopted.

When engaging in this type of analysis, researchers are not only interested in the explicit meanings of utterances, but interpret also implicit meanings. Indeed, speakers inevitably make assumptions that are not explicitly stated: "what is 'said' in a text is 'said' against the background of what is 'unsaid' but taken as given (Fairclough, 2004, p. 40; see also Searle 1979). Assumptions are important for space-time analysis because often the negotiation of space-time is implicit and requires inferential interpretation. In order to uncover assumptions, the researcher needs to ask what assumptions are necessary so that the text makes sense. In particular, in this dissertation I am interested in the assumptions regarding the organization of space-time of learning.

Since such qualitative analysis is labor intensive, it can be productively applied to "samples of research material" rather than large bodies of data (Fairclough, 2004, p. 6). Therefore, in my studies I firstly carried out an exploration of the data and made some preliminary interpretations. As stated by Goldman and colleagues (2014) video clips become data after the researchers select the relevant "events"

for their research purposes. In particular, I progressively developed my interpretations starting from the research questions and hypotheses that motivated each study. Based on these preliminary interpretations, I further specified the research questions and used them to define the criteria for selecting the relevant events for qualitative analysis. Following the argument by Duranti and Goodwin (1992), I focused in particular on transitional moments, detecting the movements of participants within and across physical, social and virtual spaces. Once these criteria were defined, I engaged in an "analytic search of the data corpus" (Heat et al., 2010), that is, I went through repeated searches in the data to find the clips that met the analytic criteria. The length of the selected clips varied depending on the specific unit of analysis of each study and on the contents of each clip. While some clips contain only a few embodied actions or speech turns, others include more articulated interactive exchanges. In all this process, I met my supervisors regularly, asked them to review the selected data and discussed with them my interpretations and analytic criteria, in order to inter-subjectively validate them.

During the searches in the data, the relevant clips have been coded according to the dimensions and categories developed within each study. In all the articles, these categories were not purely theoretical nor purely inductively constructed from the data. As mentioned above, this type of qualitative research is characterized by the progressive development of theory, rather than testing pre-set hypotheses. It advances in a non-linear way and is characterized by the continuous interaction of theory and data throughout the process (see Denzin & Lincoln, 2005).

Since I engaged in multiple searches of the data after the coding, I progressively refined the selection, adding and deleting events from the selection. Specifically, I deleted events when their relevance became unconvincing, as the interpretation became more rich and specific. During the last search for each study, I did not make any substantial modification to the selection, so we assumed that the selection may be considered definitive. As noted by Gee (1999, p. 54) when the interpretations cease to change, it is reasonable to infer that "we have reached the limits of what contextual information was relevant to the producers and interpreters of the utterance or to our research interests." The video clips that were considered relevant have been transcribed in order to obtain transcriptions able to make "visible" the investigated phenomena (Bezemer & Mavers, 2011).

Finally, only in study IV, I have enriched this framework adopting some qualitative statistical analysis – the chi square test (Field, 2009) – in order to examine the possible patterns in the frequencies and in the diachronic sequencing and alternation of the selected events. The chi square test allows one to compare the frequencies observed under certain categories to the frequencies that might be expected to get in those categories by chance. In this way, it is possible to determine if there is a relationship between different coded events. I am aware that the way

in which the test was used was not totally in line with the methodological assumptions on which the test relies. In particular, the coding system that I developed did not fully respect the assumption of independence of observation, so the quantitative results should be treated cautiously. However, I decided to apply this test because it could help me to identify some possible patterns to be qualitatively interpreted. So, the test was not treated as a proof of some theoretical claim but as a further aid for interpreting the frequencies of the selected events.

In this section, I have outlined the general methodology adopted for chronotopic analysis in my studies. In sum, I have used a qualitative approach inspired by ethnography in order to trace and examine the interactive construction of space-time in a way that respected the theoretical framework adopted. In the following section, I present an extended abstract of each study, specifying the research contexts in which the studies were carried out, the research questions and methods adopted, and the main results.

9 Summary and main findings of the studies

In Table 7 I summarize the main aspects of the four studies of this dissertation: their focus, context, research question, methods, unit of analysis, unit of data and findings.

Table 7: Summary of the studies included in the dissertation

Study	Context	Research questions	Methods	Unit of analysis	Unit of data	Findings
Study I: Presence in a multi-space	Professional development training course for teachers	How are presence and social presence perceived during a technology-mediated learning task?	Video analysis, qualitative analysis of episodes where participants mark their presence and social presence	Perceiving oneself and the others in space and time	Interactional event	The way in which participants mark presence across physical, social and virtual spaces crucial for coordination
Study II: Space-time frames and task interpretation	Media-design project course at university of applied sciences	How do the students frame space-time while discussing a collaborative task? How do the space-time frames affect task interpretation?	Video analysis, discourse analysis, qualitative analysis of topical episodes concerning task interpretation and space-time framing	Discursive framing of space-time	Topical episode	Discursively defining time structure of tasks, monitoring tasks and considering space-time constraints as essential for task interpretation
Study III: Tempo of collaborative learning	Professional development training course for teachers	Which configurations of space-time are enacted by the participants? How are they related to the learning process?	Video analysis, qualitative analysis of video-clips marked by changes of scene	Enactment of space-time frames	Change of scene	Three tempos are associated with qualitatively different patterns of coordination and collaboration.
Study IV: Exploration of the environment and space-time patterns	Professional development training course for teachers	Which patterns of space-time organization of the context emerge during the appropriation of educational software?	Video analysis, qualitative analysis of events where the participants explore the environment	Emergence of patterns of organization of space-time	Event of exploration (opening-space) vs event of focused problem solving (closing-space)	Collective exploration of the environment in crucial moments; two different chronotopes: one for instrumental genesis, the other for collaborative Problem solving

9.1 Study I: Presence, social presence and heterotopia: the self and the others in a multi-space

Research site: This study involved a training course for a group of secondary school teachers, during which they familiarized themselves with a software suite designed to support face-to-face interaction. The aim of this activity was to jointly develop a shared educational scenario on career guidance, to be subsequently implemented in the classroom. The course required six sessions, with the voluntary participation of 10 teachers, all women, from different schools. During the six training sessions, the teachers became familiar with the software package and worked in groups in order to develop a pedagogical scenario using the software.

Aims: The aim of this study was to examine how the participants in the activity displayed their sense of presence and social presence in a situation of learning where the use of technologies enables different types of online and offline participation. The objective is not to present a complete and full designed research, but to discuss the role of presence in some recorded interactions that permit one to clarify how presence and social presence are related to the issue of coordination across multiple physical and symbolic spaces.

Method: I collected video data during six meetings with the teachers. The videos were analysed using a qualitative ethnographic methodology that allowed one to identify the fragments of discursive interaction where it was possible to detect how the participants perceived and positioned themselves and the others in relation to the multiple physical, social and virtual spaces that they were dynamically organizing during the activity. Such video clips were transcribed and qualitatively analysed by using the software ELAN, which permits one to apply labels and comments to videos. Field notes and logs recorded by the educational software were used as secondary, data sets to support the interpretation of the videos. Two researchers carried out the analysis and discussed the significance of each selected clip.

Results: In this study, I analysed social and physical processes in a situation in which multiple spaces were available: the physical space of the room, the social space opened up by verbal communication, the virtual spaces generated by the computer. For the participants, situating themselves and their peers within and across these spaces was not a trivial task, also because some of the spaces did not afford means for signalling one's presence. When the participants were not able to perceive their reciprocal co-presence within some of the available spaces, they actively moved across different spaces in order to re-establish a sense of social presence, which was essential for the coordination of collective actions. In sum,

the study shows how – through mediated action – the teachers define their presence in multiple physical and virtual spaces at the same time, and how they actively monitor the presence of the others in the virtual space in order to coordinate. In the excerpt analysed, the teachers used both the social space of verbal communication and the movements of the body within the physical spaces of the room in order to display to each other "where" they were and how to coordinate. This study demonstrates that perceiving oneself and the others within a technology rich environment is an active process that takes place at the boundary between different spaces, rather than within each space separately.

9.2 Study II: Interpreting the task and building chronotopes as interdependent processes: the case of a project course

Research site: This investigation involved an interdisciplinary project course held at Metropolia University. The students of the course worked in teams of 4-5 participants to develop a product or service based on requirements from partner companies. Intermediate tasks were the development of artifacts (e.g., business plan) evaluated by teachers. The course lasted 16 weeks, and the students worked together for ten hours per week, in a technologically rich environment involving a smart-board, tablets, and notebooks. Groups were autonomous in selecting the tools they considered appropriate at the different stages of the course. Nine students volunteered, allowing the researcher to video record the teamwork and participating in stimulated-recall group interviews.

Aims: The main aim of this study is to examine the discursive framing of space-time (in terms of organization of workspace, schedule of the collaboration, and so on) and how the emergent space-time frames impact the interpretation of the task by the students. The research question of this study may be summarized as follow: How do the students frame space and time while discussing and performing a collaborative task? How are the emerging space-time frames characterized?

Method: I selected nine sessions to be observed and recorded. I also described in field notes not recorded interactions with students, and my impressions about the ongoing collaboration. Moreover, I complemented the collection of video records with screen records of computer-mediated activity whenever students used a smartboard for collaborating. I synchronized those records with the video-audio record in order to permit a coordinated analysis. The synchronized videos were analyzed using Transana. Finally, I have access to most of the artifacts that students have shared during the course. These and the field notes are used as secondary data. For the data analysis, I firstly carried out an exploration of the data and developed the hypothesis reported above. Then, I selected, transcribed and coded

the episodes in which (a) students were explicitly discussing their interpretation of the task (e.g., explaining to each other what they think teacher are expecting); (2) the students were referring to space-time coordinates in their speech (e.g., deciding about the schedule); (3) the students were taking decisions implicitly framing the task or the chronotope, according to a coding scheme aimed at detecting both task interpretation and space-time configurations. Moreover, I conducted stimulated recall interviews 5-6 days after the video collection and analyzed them using discourse analysis.

Results: In the situation analysed in this study, the students were dealing with a complex, open-ended task, where they were expected to design an innovative product or service that could address some "ill-structured" (Jonassen, 2000) business problems provided by representatives of partner companies. For example, an international humanitarian institution invited the students to design a product that could convince people to wash their hands more frequently. This type of open-ended task, even when scaffolded by providing well-designed sub-tasks that guide the learning process, allows for multiple interpretations of the task to emerge. In particular, the students developed both 1) interpretations that tended to expand the scope and complexity of the task (expansive interpretations) and 2) interpretations that tended to reduce the scope and complexity of the task (reductive interpretations). These different interpretations were subject to frequent negotiation, and often the students changed their interpretation during the activity. The students' discourse allowed one to infer that normative space-times (space-time as should be) and possible space-times (space-time as could be) were used to generate and evaluate different interpretations of the task. The students, depending also on their background, had different assumptions regarding the space-time frames required by a given task and different perceptions of the space-time constraints of the activity. These perceptions and assumptions were used to evaluate the emerging interpretations of the task, contributing to the definition of how the students fluctuated between different interpretations and how they decided which interpretation they should accomplish. In other words, I detected an interpretative loop through which the students iteratively redefined the scope of the task and regulated the definition of their goals, based also on their understanding of the activity space-time.

9.3 Study III: The collaborative construction of chronotopes during computer-supported collaborative professional tasks

Research site: This study involved a training course for a group of secondary school teachers, during which they familiarized themselves with a software suite designed to support face-to-face interaction. The aim of this activity was to jointly develop a shared educational scenario on career guidance, to be subsequently implemented in the classroom. The course required six sessions, with the voluntary participation of 10 teachers, all women, from different schools. During the six training sessions, the teachers became familiar with the software package and worked in groups in order to develop a pedagogical scenario using the software.

Aim: This study focused on the analysis of the tempo of collaborative processes mediated by technology. The aim was to analyse how participants in a professional development course, used their bodies to enact different types of configurations of participation, which had an impact on the pace of the learning process and on the quality of that process. The main research question leading the analysis was as follows: How is the collaborative process organized in terms of changes in the tempo of the activity?

Methods: I collected video data during six meetings with the teachers and detected the movements of teachers across the *heterotopia* (as defined above). Two researchers analyzed the video using a qualitative ethnographic methodology and identified the clips where participants moved across different spaces of the heterotopia (e.g., physically moved in the room, or switched from oral communication to technology-mediated collaboration, and so on). Such video clips were coded in terms of variations in the pace of the collaboration by using the software ELAN, which permits one to apply labels and comments to videos. Field notes and logs recorded by the educational software were used as secondary data sets to support the interpretation of the videos. Two researchers carried out the analysis and discussed the significance of each selected clip.

Results: In this study, I have examined how a group of teachers attending a professional development course moved across multiple virtual, social and physical spaces generating different configurations of participation, each with its own tempo. When the activity required in-depth reflection, we have found that the participants focused on a fine-grained space, making use of external representations to reflect on their ideas, also trying to optimize the external representation to enhance the group thinking. The general impression was that these instances of collaborative activity – which were labelled as adagio, using musical metaphor – were characterized by a slow tempo alongside an intense stream of thoughts. However, the need to speed up the activity and reach a conclusion sometimes urged

the participants move in space and reach a new configuration of participation (which were labelled as andante). In particular, one of the excerpts presented in the article shows that in order to conclude the ongoing activity in time, the participants left the chairs where they sat and gathered around one workstation, physically restricting the interactive space, creating a feeling of closeness. In this way, an acceleration of the tempo was achieved also by means of a re-configuration of the space. Similarly, we have found a third chronotope – allegretto – where the coordination of different spaces (the virtual space, the physical space of the room, and the social space of verbal communication) generated an accelerated tempo, permitting a particularly quick-paced participation and enabling a given task to be carried out in a relatively short time. This study allows one to discuss how the participants "enact" (Weick, 1996) space-time configurations of participation, having their own tempo, which are strictly interconnected with the quality of the collaborative process. Each tempo characterized quite different patterns of coordination and different tempos were associated with qualitatively different outcomes. In particular, the appropriation of novel elements introduced by the researchers (the use of educational software, and collaborative design of pedagogical scenarios) played a crucial role in defining the tempo and the quality of the collaboration.

9.4 Study IV: The role of context in a collaborative problem solving task

Research site: This study involved a training course for a group of secondary school teachers, during which they familiarized themselves with a software suite designed to support face-to-face interaction. This study involved a training course for a group of secondary school teachers, during which they familiarised with a software suite designed to support face-to-face interaction. The aim of this activity was to jointly develop a shared educational scenario on career guidance, to be subsequently implemented in the classroom. The course required six sessions, with the voluntary participation of 10 teachers, all women, from different schools.

During the six training sessions, the teachers became familiar with the software package and worked in groups in order to develop a pedagogical scenario using the software.

Aims: The aim of this investigation is to examine how the participants explore the environment and use the available resources during a collaborative problem solving task. Our research questions are: (1) How do teachers explore and shape the space of their problem solving? (2) How do they select and use the resources

available during the collaborative problem solving task? (3) What patterns of management of the resources present in the context can be recognised during the temporal development of the activity?

Methods: I and my supervisors coded the video by using the software ELAN. Field notes and logs recorded by the educational software were used as secondary data sets to support the interpretation of the videos. In sum, we identified in the video the occurrences of two types of events: 1) Opening-space events, in which teachers explored the tools and actively searched for resources for manipulating the problem space; 2) Closing-space events, in which teachers focused on a stable problem space shaped by the use of a specific set of tools, without considering the remaining part of the context. Moreover, since the participants' activity regarded both the appropriation of educational software (CoFFEE) and the planning of an ICT-mediated pedagogical scenario, we coded every event either in terms of whether there was a problem solving related to the use of CoFFEE or to the collaborative PS task. Finally, given the significance of the external resources for our analysis, we noted which tools were explored or used in each event. In order to look diachronically at the data, each meeting was divided into two segments lasting about 1 hour each. Then, I reported the occurrence of codes in tables and discussed the results with my supervisors. Finally, some paradigmatic episodes were transcribed using a simplified version of the Jefferson notation system (Jefferson, 1984) and qualitatively analyzed to disclose the fine-grained details of the investigated processes.

Results: In this study, I have detected the patterns emerging while a group of teachers explored the context and used the available resources during a professional development course. These patterns are considered as foundational elements of the chronotope of PS; they are particularly relevant when participants face complex environments that have not been fully appropriated, as it was the case in this data set. Indeed, the main aim of the training course was to assist the appropriation of an educational software suite by the participants. I detected two different chronotopes in the data: the first one about the appropriation of CoFFEE, characterised by a frequent interruption of the flow of activity (fragmentation) and the exploration of multiple resources (heterogeneity); the second one about the collective PS task, which was stable and homogeneous, with an exploration of the context limited to specific moments. In addition, it was interesting to learn that collective actions of exploration, where the whole group explored the environment to advance the collaboration, were very rare compared with individual ones. Our qualitative analysis showed that these collective moments of exploration – although very rare – were important for advancing the collaborative problem solving and for the inclusion of novel elements in the joint problem space. Indeed, these were moments that allowed the participants to reframe challenging situations encountered by the group and made collective agency possible.

10 Discussion

The main objective of this dissertation was to study the organization of space and time during technology-mediated learning. As I have argued in section 2, contemporary societies are experiencing deep mutations in the space-time frames that function as a ground for learning, creating an urgent need for scientific investigation on the topic. The Bakhtinian concept of chronotope has recently been deployed as a theoretical tool for addressing this research topic from a dialogical perspective (Ritella et al., 2017). By examining the learning activities taking place in two different research sites, this dissertation contributes to the literature on chronotope and provides some empirical evidence of how spatial and temporal relations were dynamically perceived, socially negotiated and bodily enacted by participants during technology-mediated collaborative learning.

Through the four studies that compose the dissertation I have examined four, interconnected processes, an approach which allows one to discuss how spatial and temporal relations may play a crucial role in learning processes. As I have mentioned in section 8.1, the identification of these processes as units of analysis for examining the space-time relations of learning has in itself been a result of my engagement with the field of study. This is related to the fact that I adopted an approach inspired by ethnography, which is characterized the continuous interaction of theory and data throughout the process (see section 8).

In what follows, I will briefly discuss the findings of my studies and their significance to the scientific understanding of these processes. In particular, I will emphasize the theoretical, methodological and pedagogical contributions of my work, as well as its limitations. Discussing the theoretical contribution, I intend to emphasize that the results of these studies have contributed to define the theoretical framework of the whole dissertation and - from a broader perspective - to the development of a theory of space and time as chronotope in education. The methodological contribution involves developing a methodology for grasping the often implicit, invisible processes involved in the organization of space-time, examined in the dissertation articles. With pedagogical contribution, I refer to the potential significance for educational practice that can be inferred from the findings of my studies.

The discussion of the theoretical, methodological and pedagogical implications is organized in thematic sections addressing specific topics of research to which this dissertation contributes. The first topic, addressed in section 10.1, is the development of knowledge-creation pedagogy. I claim that my research contributes to understanding how groups of learners self-organize knowledge-crea-

tion practice and suggests advice for scaffolding it. The second theme is the transformation of space-time that characterizes digital and mobile learning practices. I claim that my research contributes to our understanding of how teachers and learners learn to successfully orchestrate complex instrumental ensembles, how they move across multiple spaces that characterize technology-rich learning environments in order to coordinate collaborative actions.

Finally, I attempt at drawing a theoretical model of how space and time are organized in collaborative learning practices. Although in each article I have examined mainly one of the processes involved, they are not to be considered as isolated. In section 10.5, thus, I will specifically discuss the interdependencies between the different processes that were separately analysed in each study, presenting a tentative model of how space-time frames are organized in interaction and how they play a role in learning, building both on the work that I have done for the identification of the units of analysis and on the results of my empirical investigations.

10.1 Chronotope of knowledge creating pedagogies

Chronotope was initially devised by Bakhtin (1981) to examine the prototypical spatial settings and the sequences of temporal segments that characterize each literary genre. The translation of this concept in research on learning and education required moving from the analysis of literary texts to the analysis of "knowledge practices" (Hakkarainen, 2009). If we follow Miller's notion that genres' definition should be centered "not on the substance or the form of discourse but on the action it is used to accomplish" (Miller, 1984, p. 151), then educational and knowledge practices also constitute their own genres. With this claim, I want to emphasize that the educational practices stemming from the adoption of any pedagogical approach constitute distinctive forms of social action, involving different ways of speaking, writing and acting according to a typical motive.

As with literary genres, genres of educational practice are also characterized by specific ways of organizing space and time (see Section 2 and Section 5 of this extended summary). For example, as mentioned above, the flipped classroom approach is characterized by the inversion of the space-time organization typical of traditional schooling (Bergmann & Sams, 2012, 2014). The place-based learning approach, in turn, is characterized by a movement from the classroom to the different places in which local communities live, linking educational practices to the culture of the communities inhabiting them (Rajala, 2016). The contribution of

chronotope research in education, thus, is to examine how the space-time organization of learning practices contributes to carrying out the social action for which they were developed in the first place. In particular, in this dissertation I have examined how space and time are organized within one particular *genre* of knowledge practices, that is, knowledge creation (Nonaka & Konno, 1998; Engeström, 1999; Paavola et al., 2005, 2014), and what kind of implications the emerging space-time relations have for the knowledge-creation pedagogy.

In both the learning contexts that I have analysed, the learners were asked to engage in knowledge practices typical of knowledge creation. In the first case, a group of teachers was asked to design technology-mediated learning activities for their students; in the second case a group of students engaged in the design of a website based on the requirements of a client. This type of open-ended design task in the knowledge creation approach are often arranged in ways that leave to learners a high degree of freedom concerning the organization of the collaboration. In opposition to other approaches that adopt different kinds of "external scripts" (Fischer et al., 2013) to guide students' efforts, the practices of knowledge creation are considered as creative, self-organizing processes. Thus, they are characterized by a limited level of structuration that is imposed by the teacher and the learning environment. This approach is supposed to maximize "the intelligence operative among the students in proportion to the intelligence contributed by the teacher and the teacher's tools (of which external scripting would be one kind of tool)" (Bereiter et al., 2017).

One challenge faced by teachers adopting this approach is that it partially shifts the control of the organization of learning practices from the teachers and instructional designers to the self-organizing groups of students. If a substantial part of organizing learning practices is carried out by groups of learners, to fully grasp the process of knowledge creation we need to examine how students come to fruitfully self-organize the space-time of their own practices. The main contribution of my dissertation to the literature on knowledge creation is that I have generated knowledge concerning the way in which the students accomplish this type of self-organization by discursively framing and bodily enacting space-time frames. In Study II, for example, I have examined how the students perceive the space-time constraints of the learning situation, how they discursively represent the space-time of their collaboration and how this process of organizing space-time might contribute to task interpretation and self-regulation (Ryan & Deci, 2006). My analysis shows that often the students discussed – and sometimes changed – their interpretation of the collaborative task in association with implicit or explicit notions concerning the space-time organization of the activity that functioned as perceived constraints for the activity. Thus, the interpretation of the task was revealed to be a developmental process (inter)dependent on students' perception of the

space-time relations of the ongoing activity. Therefore, the task and the chronotope appear to be emergent (and interdependent) features of the learning process, and they appear as strictly interconnected topics in students' discourse. At the theoretical level, the implication of this claim is that the discursive negotiation of space and time is a further dimension of context involved in the process of task interpretation, additional to the institutional aspects already identified by previous research (e.g., Säljö & Windhamm, 1993; Lantz-Anderson et al., 2009).

This finding is not only relevant to the knowledge-creation approach. Indeed, as many pedagogical approaches are proposing a transformation of the spatial and temporal frames of learning (see section 2), for the students participating to novel learning experiences might require a re-framing of their expectations and habits concerning where and when learning takes place. Understanding how the students frame space and time can inform teachers and instructional designers, helping them to ensure that divergent assumptions concerning space-time frames will not induce students to deviate from the task set by the teachers. When teachers assign a task that meets specific pedagogical goals, it is important to support the process of task interpretation to ensure that the students perform the task in ways that allow them to achieve the set pedagogical goals. The results of my research suggest that possible differences between teachers and students in framing the space-time of the task might cause misunderstandings concerning the nature of the task. For example, students might interpret a knowledge creation task in a reductive way, working on the compilation of documentation for teachers – thus setting for themselves a "task-completion goal" (Ng & Bereiter, 1991) – rather than focusing on the creative and collaborative processes required for the development of innovative ideas.

In a similar way, the embodied enactment of space-time that I examined in study III reveals that learners might generate different configurations of space-time, some of which might be not functional for the learning process. For example, they might orchestrate the activity as an "allegretto" (see section 9.3), arranging spaces for a quick accomplishment of the task whereas the teachers might aim at generating in-depth reflection, which requires a different organization of space-time. Thus, extending our knowledge on these configurations might provide cues for teachers in scaffolding the learning process, helping students in orchestrating space and managing time in line with the teachers' pedagogical aims.

In order to guide the students' interpretation of the task according to the pedagogical goals intended by the teacher, one might adopt one of the following strategies:

1. address potentially misleading assumptions about the space-time in which the task is embedded, in dialogue with the students;
2. explore together with the students alternative ways to conceptualize the space-time of the activity;

3. increase awareness of the implicit processes of space-time framing by providing feedback tools that students can use to enhance self-organization.

These strategies are not meant to provide scripts that could limit the students' agency and self-organization, but to provide aids enhancing the self-organizing capability of the groups. In other words, in order to fruitfully engage in knowledge creation, the students need to develop the skills necessary to self-organize their collaborative work. Teachers might support the development of these skills by providing different kinds of tools and scaffolds that would leave the responsibility of knowledge creation to students, but support them in a dynamic way, according to their current learning needs. Study IV of this dissertation might provide insights for reaching this aim. Indeed, detecting opening and closing space events might be a way to collect data about the knowledge-creation process and either guide teachers' scaffolding intervention or provide feedback tools that students can use to represent their activity and enhance self-organization.

10.2 Theoretical framing of transforming socio-digital learning environments

One crucial aspect to be considered when examining the (self) organization of learning is related to the advent of digital technology (see Section 2). Contemporary society relies on complex instrumental ensembles for the management of knowledge, and the concepts of digital literacy and media literacy have emerged to account for "the engagement with digitally mediated information" (Säljö, 2012). In order to fully participate to societal life, people should be able to participate in knowledge practices mediated by Information and Communication Technology (ICT), as was clearly stated by the European Commission (2004). One aspect of digital literacy is that contemporary knowledge practices require the ability to orchestrate complex instrumental ensembles that mediate collaborative processes. Some examples of this kind of orchestration can be found in Study III of this dissertation. The teachers of this study attended a course during which they familiarized themselves with an educational software suite designed to support face-to-face interaction. This software suite provided multiple representational tools and allowed multiple possibilities of orchestrating these tools during the activity. Often the participants were using multiple tools in a coordinated way and, at times, they moved across virtual and physical spaces in order to find optimal configurations of tools for their local needs. The chronotopes that we detected in

Study III were functional ways of organizing the space-time of the digitally mediated activity.

The accomplishment of these effective configurations of participation, however, is not a trivial task and in many cases the teachers experienced breakdowns of the flow of activity and difficulties in coordination. Paradigmatic is the difficulty that the teachers experienced in signalling and perceiving each other's presence across multiple virtual and social spaces, that I examined in Study I. This study discussed the complexity of signalling one's presence in situations where participants have to locate themselves and the others not only in a specific virtual environment but across the multiple physical, social and virtual spaces available in a typical situation of collaborative learning, when technology is used in face-to-face settings. Indeed, being online does not imply that one stops being in a physical environment and what happens online cannot be considered as separate by what happens offline.

In this sense, my studies address the current transformation of the space-time of learning where the boundaries between physical and virtual spaces are currently blurred by emerging practices of using digital technologies (Goodyear et al., 2017). In Bakhtins's sense, these situations – where virtual spaces are more and more available in face-to-face situations, in the classrooms, in the laboratories, or even during field trips – constitute their own chronotopes, that is, different ways of conceiving the space-time of learning. These transformations were not yet tangible when the concept of (tele)presence was firstly developed. Indeed, traditionally the examination of presence and social presence has been examined mainly within isolated, distant, virtual environments (Riva, 2009). In fact, some authors within this literature consider presence to stand for tele-presence, implying that it concerns exclusively distant presence achieved by means of a virtual environment (Biocca, 1997). Thus, to study contemporary educational practices mediated by technology should involve an account of how participants situate themselves and the others at the boundary between multiple virtual, physical, social and symbolic spaces, going beyond the traditional conceptualization of presence.

Clearly, learning to orchestrate multiple technological tools in complex situations is a developmental process closely linked to the process of instrumental genesis (Beguin & Rabardel, 2000). The concept of instrumental genesis has been used primarily to analyse what kind of "utilization schemes" the users of a technological tool develop, what kinds of functions a tool plays within a class of situations and what kinds of structural modifications the tool undergoes in order to accomplish that function permanently (Lonchamp, 2012). However, for better understanding of contemporary learning practices there is a need to examine how learners develop the ability to effectively arrange and use the multiple material and symbolic resources available in complex and technologically rich environ-

ments (Lund & Rasmussen, 2008). When learners face complex instrumental ensembles, they have to learn not only what functions each tool can play, but also how it can be fruitfully used in combination with the other available tools, and what kind of functions can be played by different combinations of the available tools. I argue that a space-time perspective, based on the concept of chronotope, can be fruitful in this respect and contribute to enrich the notion of instrumental genesis. As learners develop the competence to orchestrate new tools and use them jointly, it is likely that the configurations in which these tools are combined (in terms of temporal sequences and spatial arrangements) will be stabilized.

The problem that I have addressed in Study IV is relevant in this respect. Indeed, in this study I have examined the process through which a group of teachers learning an educational software suite explored the environment, at the boundary between different material and symbolic resources, and how their use of the different tools of the suite stabilized during two sessions of usage. This study illustrates the importance of the exploration of the multiple resources present in the environment as participants try to develop novel technology-mediated knowledge practices. In particular, collective explorative events, in which teachers jointly moved across the different virtual, social, symbolic and physical spaces, were revealed to be crucial for the process of knowledge creation. These instances of collaboration resemble instances of "exploratory talk" (Wegerif, 1996; Mercer & Wegerif, 1999), as participants engaged critically and constructively with each other's ideas to advance the knowledge-creation process. What my chronotopic research adds to the conceptualization of this kind of constructive way of engaging in collaborative activity is showing that it involves not only the exploration of the different ideas emerging from dialogue, but also an active exploration of the resources available in the environment, in its physical, social and virtual dimensions. Considering these patterns of exploration of the context might be valuable for better understanding the dynamics that make exploratory talk an effective teaching approach also at the practical level, especially within technology-rich environments that characterize contemporary learning sites. Adopting a chronotopic perspective, future research might prove that some ways of exploring the different tools available in the context might generate more fruitful exploration of ideas compared with other ones. In addition, the analysis of these kinds of patterns might provide insights for the optimization of teaching strategies. Although my research was explorative and do not allow one to draw clear conclusions in this sense, these patterns might have an impact on learning outcomes. For example, it is reasonable to speculate that during the phases of appropriation characterized by a fragmented and heterogeneous chronotope, the intervention of the teacher to support dialogue could be more valuable for learning because learners would be

keen to find aids for advancing in their problem solving. In phases where the chronotope is characterized by the stable use of tools, instead, it might be experienced as a disturbance and an interruption of the flow, possibily jeopardizing the learning process.

The analysis of these patterns is especially relevant for contemporary education because more and more virtual environments are able to provide automatically generated, adaptive just-in-time scaffolds able to support the students' learning (Kickmeier-Rust & D. Albert, 2010; Gerard et al., 2015). Examining space-time patterns of this type might allow one to improve the way in which these scaffolds are provided to students (either by the teacher or by the technology); such scaffolds might support the students in solving trivial technical problems that might emerge from the process of instrumental genesis and freeing cognitive capacity for significant learning experiences. The operationalization of opening-space and closing-space might be used as a starting point for further research aimed at testing both the role of context exploration and the space-time location of scaffolds in different phases of the learning process.

10.3 Toward a model of space-time organizing

This dissertation contributes to characterizing chronotope as a scientific concept for uncovering the often-implicit processes through which participants in collaborative learning tasks organize the space-time of their activities. Although this concept is attracting growing interest in learning and instruction (see section 5), it is still an emerging concept not yet fully developed. Indeed, even though Bakhtin's theorization intended to generalize the application of chronotope to the entire domain of social analysis and social sciences, he used this concept primarily to examine space-time frames typical of different genres of literary work. I am participating - together with other authors (such as Renshaw, 2014; Leander, 2001; Matusov; 2009; Rajala & Kumpulainen, 2016) – in the project of translating this concept in the specific field of learning and education, which has its own constraints and features. In particular, the contribution of my dissertation to the literature is the application of chronotope to examine the space-time organization of technology-mediated collaborative learning. In sum, the four studies that compose the dissertation uncover different aspects related to the organization of space and time in a local context of technology-mediated learning. Put together, the investigated processes allow one to build a provisional model of how space and time were organized in that context. Indeed, the processes that I have detected and used as units of analysis in each study are interconnected with each other as shown in Figure 1.

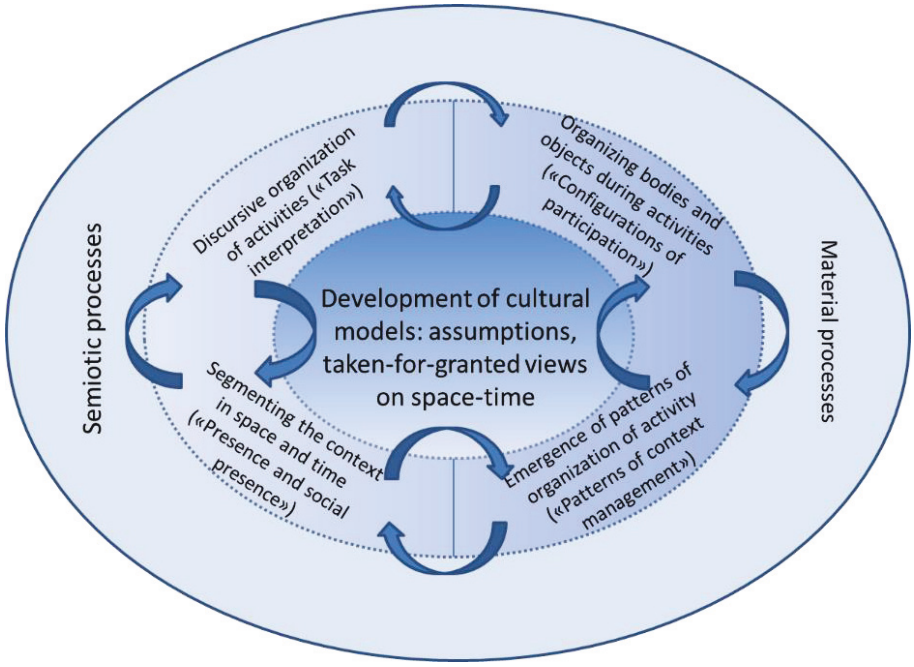

Figure 1: Summary of processes involved in the organization of space-time during the collaborative accomplishment of a collaborative learning task by small groups

In Figure 1 I have represented the material and embodied side of space-time on the right and the discursive aspect on the left. In brackets, it is possible to see the main focus of the article where each process was examined. As it is represented in the figure by means of arrows, the processes that I have explored are strictly interwoven with one another. First, the way in which the learners discursively frame space and time, as I show in Study II, can have an impact on how they engage in the learning tasks set by teachers, and on how they move across the multiple space-times that function as context for their activity. Indeed, Study II shows that the students' discursive framing of space-time is strictly interconnected with the decision making concerning how they will engage in the task, in particular concerning the temporal organization of sub-tasks. In turn, the embodied enactment of space and time through bodies and objects, which I have explored in Study III, leads to the emergence of space-time patterns, such as the ones that I have examined in Study IV. Indeed, the patterns that I have discussed in study IV are not the result of a specific planning by the participants, but *emerge socially* (Sawyer, 2005) as a result of the interaction between learners and the context of

activity in which they operate. In addition, given the reflexive nature of human experience (Marsico et al., 2015), all of these aspects of space-time are also objects of perception and sensemaking by participants, who situate themselves and their peers within pre-existent space-times (Study I). Finally, the emerging meanings connected to the perceived space-time frames are interconnected with the sensemaking that guides participants' embodied action, leading to novel patterns of organization of space-time. Even though the model sketched here is not yet fully developed, it represents well the results of the research carried out for this dissertation, both in terms of defining the processes involved in the organization of space and time, and of discussing the findings of my articles.

10.4 Limitations and further directions

A major limitation of my dissertation is that the model I propose for outlining how collaborative learning practices does not consider the larger sociocultural processes involved. Because of practical and methodological choices, I have focused on how learners self-organize their activities in space and time, leaving the larger context on the background. The reference here is to the historical development of school systems, to the emergence and spreading of novel technologies, to the evolution of dominant discourses concerning education within the larger society. For example, I did not carry out an historical analysis in the contexts that I analysed. This kind of analysis might reveal, for example, what are the typical approaches adopted within that institutional context across extended periods of time. In turn, this knowledge might disclose further insights on the "cultural models" (Gee, 1999; Holland & Quinn, 1987) and associated space-time frames that the students have appropriated when participating to the practices of that institution before the courses that I examined. I have mentioned the concept of "cultural models" in my discussion of how spatial and temporal frames might be interiorized by participants in learning activities, becoming part of the tacit theories, common-sense storylines, metaphorical elaborations or prototypical images – shared by a social group – through which people make sense of their experience. The impression that I have from my experience in the field is that studying these cultural models is crucial for advancing our understanding of the organization of learning practices in space and time. Thus, the model that I sketched in Section 10.4 should be considered as an incomplete working hypothesis more than a final model. It is important for future research to investigate how the processes that I have described are interconnected with such larger socio-cultural processes that I have overlooked because of methodological limitations. All of these macro-level

processes have been briefly discussed as a background, but they have not been a specific analytical focus, even though they still require further investigation.

A second limitation is that my studies were carried out in a single group in a very specific context, so further research is needed to ascertain if the findings can be generalized to other settings. In particular, I expect that different educational activities might implement a different equilibrium between the structuration of the task by teachers and instructional designers and the self-organization of students. Thus, I expect that further research might detect different modalities for organizing space-time depending on level of structuration of the task and the level of scaffolding intervention of the teacher, but it should confirm the tight interconnection between the different processes that I have examined in my studies. Perhaps, one future direction for chronotopic research might be to study in what conditions different types of spatio-temporal structuration imposed by teachers are appropriate to boost the students' learning, and what kind of scaffolding can help students to learn how to self-organize their learning activities in time and space.

A third limitation is that my studies did not involve any assessment of the students' learning. Therefore, further research is needed to verify the value of the implications of space-time frames that I examined for the development of educational practice, or to examine their impact on the actual skills and competencies that the participants develop. For example, while it was clear from my analysis in study III that the collaborative process was qualitatively different depending on the evolving space-time frames, it is not yet clear to what degree participants developed different kinds of knowledge, skills or competencies in relation with the chronotopes that we have identified. Similarly, in study II, my analysis shows that the students interpret the task differently depending on their social construction of space-time frames, but again a further step is needed to understand what kind of implications these interpretations have for learning. Thus, a better understanding of how chronotopic research may deal with the assessment of learning in association with the examination of the spatial-temporal dimension of pedagogical activities is an aspect to be further developed. This is a crucial task for future research, because it will allow investigators to significantly increase the societal value of chronotopic research. Only by accomplishing this task would it be possible to study the effects of different modes of organising pedagogical activities, and in turn inform the design of more and more sophisticated educational practices.

11 Conclusions

To conclude this extended summary, I start from a quotation by Dewey (1916/2008):

> "we never educate directly but indirectly by means of the environment. Whether we permit chance environments to do the work, or whether we design environments for the purpose makes a great difference." (p. 17)

This statement reminds us that the way in which we orchestrate learning environments, as teachers, as students, or as designers, has a great impact on how we teach and learn. In particular, I have argued that the way in which space and time are arranged in educational settings has an effect on learning within those socially (and institutionally) constructed space-time frames. The problem addressed by the dissertation, at the theoretical level, is that considering the space-time organization of learning as a topic for educational theory is crucial for improving our understanding of learning and education. This kind of research can be done from several points of view: the point of view of teachers and instructional designers that structure the space-time organization of tasks; the point of view of self-organizing groups of students striving to engage in knowledge creation tasks; or even the point of view of individual, self-regulating students participating to online courses or MOOCs. Developing knowledge on how the (spatial and temporal) organization of the context affects learning practices can assist teachers in designing learning environments and tasks deliberately in order to stimulate learning and reach educational goals; it can raise students' consciousness on the often-implicit ways in which they organise their activities in space and time; it can provide guidance for enhancing the self-organization of groups of students during knowledge creation. In this dissertation, I focused on the self-organization of space-time accomplished by groups of learners within the framework of two activities arranged according to the knowledge creation metaphor. Discussing my findings, I have suggested ways in which teachers could support this type of self-organization and enhance students' learning.

This type of research is important because in the present historical period we are facing radical transformations of space-time, as I discussed in section 2 of this extended summary. The integration of digital technology in learning practices, the emergence of new pedagogical paradigms and educational policy are radically transforming learning space-times. The effects of these transformations on learning and education are not yet fully understood. My contribution to this aim, in this dissertation, is to propose that spatio-temporal analysis based on the dialogical

theory of chronotope might contribute to the examination of how spaces become specifically educational or learning spaces; how they might enable or inhibit learning and collaboration, how they can open or limit possibilities for new practices and knowledge (see Goodyear & Carvalho, 2017, p. 246). The point is not to introduce a new paradigm in research on learning, re-framing learning as a pattern of space-time organization. Chronotopic research, in my view, is not to be understood as a stand-alone framework for research on learning. Rather, it constitute a research program that can contribute to fill a research gap, as we are missing scientific concepts to analyse the impact that different ways of organizing space and time have on learning. Based on my doctoral work, I argue that the concept of chronotope is a valuable conceptual tool for examining how the organization of space and time affects learning practices from a socio-cultural perspective.

Adopting the chronotopic perspective discussed in this dissertation can allow one to build theoretically solid research programs aimed at addressing this research gap. I argue that chronotope has three advantages when compared with competing notions and conceptualizations of space and time: 1) its analytical focus includes the examination of the potential interdependency between space and time; 2) it allows us to examine space and time as social constructions, negotiated in dialogical interaction, thus to consider the complexity of the multiple spatialities and temporalities involved in learning; 3) it involves the analysis of both the material organization and the discursive negotiation of space and time (see Ritella et al., 2017 for a further discussion). I also argue that my dissertation offers some methodological guidance in operationalizing space-time relations, in a way that is consistent with the theoretical assumptions held by the dialogical approach adopted.

This type of research is important also because, as Markauskaite and Goodyear (2017) indicate, learning the complex knowledge that students need to acquire in contemporary education cannot be thought as the

> construction of decontextualised symbolic structures in the mind, but [as] the very coordination of what is in the mind and what is outside of it, including perception, action, embodied skill and other forms of engagement with the environment and with other people. (p. 137)

This shift toward a situated understanding of knowledge creation – which is typical of the dialogical, object-centered and socio-cultural perspectives on which I have built my studies – implies that we need to take into consideration the coordination of conceptual thought with the embodied engagement with the environment, the social interaction between different types of participants, and the use of multiple digital tools generating novel virtual spaces for learning. Understanding

how people organize all of these resources by means of spatial and temporal coordinates, is the difficult challenge that I decided to address in this dissertation.

In a future perspective, learning how to organize the space-time of one's activities and life trajectory can have an intrinsic pedagogical value as well. Within a socio-cultural context in which many traditional boundaries are blurring, it is more and more important that people develop the competence to deliberately manage the space-time of their lives. For example, many workers in contemporary society are finding it difficult to orchestrate space-times of work distributed across multiple tasks and locations, and to preserve space-times of leisure that are often invaded by work tasks by means of so called "Work Extending Technologies" (Carr & Hancock, 2006).

Following this argument, there emerges the need to examine one aspect of chronotope which has been marginal in this dissertation, that is, the relationship between shifting space-time relations and the changing identities of the participants. As Latour (2004) puts it "there are always three shiftings simultaneously at work in each account: a shift in space, a shift in time, and a shift in actor or actant" (p. 178). As chronotopes provide grounds for the development and expression of different identities (see section 5 of this chapter), it is crucial not only to understand how participants manage and construct space-time relations, but also how their own identities transform and develop in this process.

Living in contemporary society, thus, requires non-trivial efforts and competences to deal with conflicting space-time frames characterizing work, home and family lives. In particular, the emergence of virtual spaces and their integration in everyday activities breaks the space-time boundaries between spheres of activity characterizing society just a few decades ago. Enhancing students' awareness and reflection on how these emerging physical-social-virtual-symbolic space-time frames can be orchestrated by individuals, groups and institutions might help them to self-regulate and organize their life-long trajectories. In this way, the organization of physical-social-symbolic-virtual space-times could be considered as an emerging higher psychological function (Vygotsky, 1978), which might allow us to cope more effectively with the complex transformations and blurring of boundaries that characterize contemporary societies.

In order to help people manage these complex space-time frames, however, we need solid scientific research allowing us to develop knowledge on the underlying processes of space-time organization. As is by now clear to the reader, the reaching of this goal is a challenge that is still to be fully addressed. My studies have explored only a small fraction of this field of investigation, which is yet underdeveloped. I hope that this work will be considered by the readers as a fruitful step in this direction of development and that its reading will help to better understand the spatial and temporal relations of learning that I examined, stimulating further inquiry able to overcome the challenges that I faced and I could not yet solve.

12 References

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