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Introducing the Virtual Microscope 2.1 at the Medical University of Graz

The Impact of Educational Technology in Teaching Practices at the Department of Pathology

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Abstract

Digital technology has permeated almost every aspect of our lives, and its impact is quite crucial in diverse ways. However, education has been somehow resistant toward digital technologies and it is not easy to properly assess how they have influenced teaching and learning. In this thesis I inquire about the virtual microscope (VM) 2.1 implemented for histopathology courses at Medical University of Graz. I focus on how has this technology impacted teaching practices, teachers' adaptation with it, the relationship professor-student, and the general impact in the pedagogical approaches regarding microscopy. I have conducted four interviews with professors and two with tutors at the department of pathology (Med Uni Graz). The theoretical background is based on Actor-Network Theory. To make sense of the impact that VM 2.1 has had on teaching and learning, we have to see closely the interactions and roleplay by the different actors in this network, as well as tracing how the material or the technological is influencing medical education. After a careful analysis of the interviews, based on Grounded Theory, it emerged that this technology has influenced teaching by making it more comfortable and easier, and raising the professors' expectations regarding their students. At the same time VM 2.1 has impacted learning microscopy by improving all the main functionalities such as visualization, magnification, and the explanatory feature; but also by enabling students to better study for their exams and seminars with the learning content available before class. Nevertheless, it is not easy to define the success of this technology in education because the students' feedback is missing. Medical education is very complex, because it comprises cognitive skills that could be trained through technology, but also more practical embodied skills which are intuitive and based on rehearsing.

Die digitale Technologie hat fast jeden Aspekt unseres Lebens durchdrungen und ihre Auswirkungen sind auf vielfältige Weise entscheidend. Ausbildungssituationen erscheinen jedoch bis dato resistent gegenüber dem Einsatz digitaler Technologien. Es ist daher nicht einfach zu beurteilen wie Digitalisierung das Lehren und Lernen beeinflusst hat. In dieser Arbeit untersuche ich den Einsatz des "virtuellen Mikroskop (VM) 2.1" innerhalb des histopathologischen Kurses an der Medizinischen Universität Graz. Ich konzentriere mich dabei auf die Auswirkungen dieser Technologie auf Unterrichtspraktiken und Anpassungen der Lehrenden, auf die Beziehung zwischen Professor und Schüler sowie die allgemeinen Auswirkungen auf die pädagogischen Ansätze zur Mikroskopie. Ich habe vier Interviews mit Professoren und zwei mit Tutoren der Abteilung für Pathologie (Med Uni Graz) geführt. Den theoretischen Rahmen dieser Arbeit bildet die Akteur-Network-Theorie. Um die Auswirkungen von VM 2.1 auf das Lehren und Lernen zu verstehen, müssen die Wechselwirkungen und das Rollenspiel der verschiedenen Akteure in diesem Netzwerk genau beobachtet werden und verfolgt werden, wie das Material oder die Technologie die medizinische Ausbildung beeinflusst. Nach einer sorgfältigen Analyse der Interviews, die auf der Grounded Theory basieren, stellte sich heraus, dass diese Technologie den Unterricht beeinflusst hat, indem sie ihn komfortabler und einfacher gemacht und die Erwartungen der Professoren an ihre Studenten erhöht hat. Gleichzeitig hat VM 2.1 die Lernmikroskopie beeinflusst, indem es alle wichtigen Funktionalitäten wie Visualisierung, Vergrößerung und Erklärungsfunktion verbessert hat, aber auch indem es den Studenten ermöglicht hat, mit den vor dem Unterricht verfügbaren Lerninhalten besser für ihre Prüfungen und Seminare zu lernen. Dennoch ist es nicht einfach, den Erfolg dieser Technologie in der Ausbildung zu definieren, da das Feedback der Studierenden fehlt. Die medizinische Ausbildung ist sehr komplex, da sie kognitive Fähigkeiten umfasst, die durch Technologie trainiert werden könnten, aber auch praktischere, verkörperte Fähigkeiten, die intuitiver und auf wiederholten Übungen basierend sind.

Contents

1. Introduction

We are often not aware of how much technology we use in our everyday life for different tasks. For instance, we may start our day by brushing our teeth with an electric brusher. Some people the moment they wake up take their smartphones and check their emails, the latest news, or any of the many social networks such as Facebook, Twitter, Instagram, and so forth. Most of us unfortunately without the alarm clock of our smartphone wouldn't even wake up in time to go to school, work, or a meeting. Thus, more frequently than not we tend to think about technologies as odd entities that we take for granted in terms of their features and functions. But what if the smartphones don't work as they are supposed to and the alarm doesn't ring in that certain hour in the morning? What if the PC that you are writing your thesis breaks down and all your materials are there? What if somebody steals it?

These unfortunate, but possible scenarios, are just a reminder that we depend on technology for many daily tasks. It resembles the idea argued by Actor-Network Theory[1] scholars, that we are not aware of a network until it breaks down (Latour 1983; Law 1992). These networks are created through a constant mobilization of different actors that have specific roles and enact them in a certain context. When this context is stabilized from these actions, this constitutes a network. Digital technologies and how we use them for different tasks constitute a network in which different human and nonhuman actors have agency through their actions (Latour 2005). Users, IT specialists, retailers, and the technologies itself are but a few actors that participate in this network.

My aim in this thesis is to uncover or understand how certain technologies influence learning and knowledge. Some technologies in education, as in our everyday life, are so embedded in our practices that we often take them for granted or as odd entities. The blackboard, the interactive whiteboard, the textbook, and now the color-printed textbooks, motion picture, radio, and television are just a few technologies introduced in education (Selwyn 2011). Nevertheless, some educational researchers argue that technology especially the digital one has failed to truly change education (see Laurillard 2008). Others think the opposite, that digital technologies have transformed education and will go even further in the future (Selwyn 2011, 2013). Thus, digital technologies and especially Information and Communication Technologies (ICT) have been promoted as the main developments that will influence educational provision and pedagogical approaches.

eLearning, which stems from ICT, has been regarded as one of the main tools to achieve goal-oriented learning through digital technology (Welle-Strand and Thune 2003). There is an intertwinement of technology, organization, and pedagogy concerning eLearning in higher education. While in popular culture eLearning is closely associated with online or remote learning, it encompasses also Learning Management Systems (LMS) (Ellis 2009), Course Management Systems (CMS), and

[1] Will be discussed in length in Chapter 4: Theoretical Framework and Sensitizing Concepts.

Virtual Learning Environments (VLE) (Lin and Chen 2013). There are clear political and economic rationales for adopting digital technologies in all educational levels. Beastall (2006) when discussing about the effects of introducing digital technology in UK higher education concludes that government agendas are responsible for implementing strategies of educational technologies (see also Selwyn and Gorard 2005). The use of new technologies has been associated with new power relations concerning educational institutions and the "values of individualization, marketization, and new capitalism in educational contexts" (Facer and Selwyn 2013, p. 212). As Selwyn and Facer (2013) argue, researchers should focus on the political rationales behind education and technology because there are many stakeholders interacting in these fields. These actors are in a constant interplay, struggle, and negotiation to shape the implementation and adoption of the new technologies in educational institutions, and it concerns school curricula, resources, and social justice (for instance mitigating exclusion and fostering inclusion).

The economic reasoning concerning eLearning has two facets: the 'micro' and the 'macro'. The microeconomic factors relate with the modular character of eLearning platforms and contents. Learning objects come in smaller modules designed explicitly for a certain topic or course. They are reusable, easily distributed through ICT, and independent from other course materials (Lee 2011). The macroeconomic ones concern external factors that condition these digital technologies. Private IT companies produce and distribute hardware and software for educational purposes all over the world. They are mostly profit-driven, but there are also cases that these companies such as Microsoft, Cisco, Apple Computers, etc. engage in charity projects to implement and support educational technologies for developing countries (Selwyn 2013). Moreover, the skills developed through educational technologies have also implications in the future competencies of the students in the labor market (Selwyn 2011, 2013).

New media, eLearning platforms, and digital technologies in general promote interactive and collaborative learning environments. These platforms serve as a repository of knowledge easily accessed by the students, promote teacher-student and vice versa feedback, and also mediate interaction and communication among them (Boylan 2004). Different forums and online groups with the same goals interact more efficiently through ICT (Welle-Strand and Thune 2003; Chen and Tseng 2012). These technologies have benefits also for the marginalized communities and people with difficulties of access, such as people with disabilities (Erixon 2010). They facilitate access and alleviate problems of learning through the innovative solutions such as online learning, remote-delivered courses, open schools and universities, and so forth (Selwyn 2011, 2013).

All the elements described above come together in one way or another in this thesis. My focus on educational technologies is set in the Austrian context, at Medical University of Graz (Med Uni Graz). The department of pathology in this university has implemented a virtual microscope to teach histopathology courses. This technology is supplementary to the normal teaching and the practices with a normal physical microscope. The long history of the virtual microscopy in this department has started since 2001. In 2011, a new version of the virtual microscope (VM 2.0) was implemented along with a new eLearning platform VMC/Moodle (Rehatschek and Hye 2011). In 2018, VM 2.1 the newest version of the virtual microscope was improved in resolution and magnification, easy interface and fluid movement within the slide, and also an explanatory feature that explains what is going on in different sections.

I inquire about the teachers' experiences about how has this technology influenced teaching and education in this setting. Teachers' adaptation to this technology, and their interaction with students are the central themes that I will explore through my research questions. Medicine in general and medical education in particular seem to be a 'fertile ground' of innovative technologies (Prentice 2005, 2013). It is quite hard to imagine a hospital without state-of-the-art technologies but at the same time it is hard to learn microscopy without a microscope and why not a virtual one with easy and ready access from the eLearning platform. Modern medicine and medical education is increasingly dependent on technology, and the virtual microscope besides its interactive features where the student can easily explore the sample and get an overview of the pathologies, is also being employed in digital pathology departments all over the world (Mikula et al. 2007; Hamilton, Wang and McCullough 2012).

1.1 A Brief Contextualization of the Virtual Microscope

The virtual microscope (VM) has a long history at the Medical University of Graz dating since the 2001 with its first version. It has evolved in parallel with the evolution of imaging technologies especially with those that focus on medical settings. The new version 2.1 is quite different from the previous ones. While the basic functionalities have remained the same[2] such as visualization, minimap, points of interests, and magnification; the main improvements concern upgrading these functionalities, especially because of the innovations in imaging and ICT technologies (informal conversation with VMC/eLearning Team at Med Uni Graz).

What makes the new version (VM 2.1) more interesting is the explanatory feature which 'pops up' after a student runs over with the mouse in a marker (or POI – point of interest) and explains the structure and the pathology. The VM takes its inception from the normal slides seen with a microscope, which are digitized through a scanner, then manipulated and embedded in the eLearning platform of the medical students at Med Uni Graz. These virtual slides are integrated within the eLectures (virtual classrooms, see also Rehatschek, Hölzl and Michael Fladischer 2011; Rehatschek, Hölzl and Hruska 2011). Moreover, the slides are also integrated in the learning contents (VMC/Moodle) of classes taught with VM 2.1, where the students can access before and after the seminar.

[2] With the exception of the explanatory feature, which I will briefly mention here and expand more in the chapter concerning the empirical analysis.

1.2 Master Thesis Structure

To investigate the impact of VM 2.1 at the department of pathology at Med Uni Graz, teachers were selected because they can give valuable insights about how this educational technology has shaped higher education. Thus, the main research question addresses how VM 2.1 has reshaped teachers' daily practices in teaching histopathology courses. The main question is backed up by three research sub-questions that have specific purposes: inquiring about teachers' adaptation with this technology; their interaction with students; and the possible effects of the pedagogical approach in teaching microscopy.

Before trying to respond or shed light upon these questions the next chapter will give a general overview of the main debates in science and technology studies, medical anthropology, sociology of education, and philosophy of science. Initially, observation and microscopes will be discussed in the light of the philosophy of science and knowledge (Hacking 1983). Next, I will briefly elaborate on Galison's (1998) notion of objectivity about images and how has it evolved from the 17th century to nowadays. Then, I lay down how technology is envisioned in medical settings for teaching purposes in anatomy and surgery (Prentice 2013). The final section in this chapter discusses about the different strands of digital technology in education (Selwyn 2011, 2013).

The theoretical background and sensitizing concepts will be based on Actor-Network Theory (ANT). I have chosen this theoretical strand because it is helpful first of all to create a methodological approach of investigating the actors, their agency, and their roles in the creation and transformation of a network (Latour 2005; Law 1992). The sensitizing concepts are also drawn from this theoretical approach and they are: delegation – granting agency to nonhumans to perform routine tasks that would be bothersome and repetitive for humans (Latour 1983, 1992, 2005), and translation – four stages of interaction between the different actors where negotiation takes place to stabilize a network (Callon 1986).

The next chapter will lay down the methodology and materials used to respond to the research questions. I have conducted in-depth, open-ended interviews with four teachers and two tutors from the department of pathology in Med Uni Graz (Gubrium and Holstein 2003), with two different questionnaires[3]. The data analysis process was based on grounded theory, based on several coding instances, to make sense of the data gathered from these six interviews (Charmaz and Belgrave 2012; Charmaz 2006).

The empirical analysis chapter will present the arguments forwarded by the interviewees after the coding instances. Thus, I will mediate what the interviewees responded by staying faithful to their voice and backing up most of their arguments with quotes. This chapter will discuss several instances that came up in the six interviews, starting with a description of the fieldwork, the implementation

[3] Specific questionnaires for both, as the questions were explicitly tailored to inquire the different perspectives that the two sets of actors have concerning teaching and educational technology.

phase, and collaboration with VMC/eLearning Team. Then, I will present the main technical features of the VM. The role, purposes, and advantages of the VM will be thoroughly laid down to create a solid background for the next section, which deals with the research questions by elaborating on the impact that this technology has had on teaching so far, issues of adaptation, the relationship teacher-student, and the overall effect on the pedagogical approach. The next one will focus on blended learning rationales and a comparison between the physical microscope and VM. Finally, I will present the interviewees' claims about the future of this technology in Med Uni Graz.

The final chapter will engage with the conclusions and discussions not only regarding the arguments presented in the empirical analysis, but also the research context regarding educational technologies and medical training. The questionnaires of teachers and tutors are in the respective Annex A and B, while the informed consent in Annex C.

2. Contextualizing and Situating the Debates around Educational Technology

Educational technology is somehow missing in the science and technology studies debates. Most of the literature is focused on educational research, which is more directed towards educational and psychological accounts rather than the broader societal entanglement of technology in education (Selwyn 2011; Selwyn and Facer 2013). In this section I will focus on relevant debates that are crucial to understand the virtual microscope as an educational technology in medical settings. These debates initially will draw on observation, microscopes, and objectivity; how are medical settings fostering innovative technologies not only for diagnosis and treatment, but also to train the medical students; and the different dimensions of educational technology viewed in a sociological context.

2.1 Observation, Microscopes, Objectivity

2.1.1 Observation and Microscopes

Ian Hacking in his book (1983) "Representing and Intervening" develops a quite complex argument about the nature of observation. While, before the 1800 the notion of observation wasn't used so much in scientific endeavors (see the example of how Bacon was using different terminology although observation as a term was quite actual in his period, pp. 168-169), after the 19th century it was a constant 'incentive' for clashes among different schools of philosophy. Thus, positivism in its quest of debunking metaphysics makes a clear distinction between observation as the means to reproduce reality, and theory which cannot define reality but can just describe phenomena or make predictions.

On the other hand, philosophers of ontology such as Gustav Bergman have no interest in the distinction between the observable and theory concerning the microscope. According to him entities observed in a microscope are not real or physical things, they are just a product of our language or imagination (as cited in Hacking 1983). Scientific realism philosopher Grover Maxwell claims that there is not a clear-cut distinction between the observed and theorized objects (entities), our knowledge is further improved and progressed through advances in technology: what we couldn't have seen in the past with our naked eyes is now possible to be seen through a microscope (Hacking 1983).

Another battleground concerning the theory/observation dispute, involves the radical arguments of some philosophers. Hacking argues against the idea of observations as theory-loaded, a term coined by Hanson, because observations are subject to linguistic rules, which aren't necessarily theoretical assumptions but rather normal statements free of any theoretical claim. These linguistic rules although are not the ones that define observation, as Feyerabend claims, in experiments what counts is not observation as a "factual statement" but "doing" or action (p. 173). Nevertheless, observation and experiment are not the same thing, because there are experiments that don't conduct to any observation, as there are observations that result despite the conducted experiment.

Observation in natural sciences is closely tied with experiments as a way of intervening in nature (Hacking 1983). Philosophers of science discuss them as observation dictated by a ready-made theoretical frame. We observe in context, and scientific observation, most of all, is void without theory. Hacking refutes this argument by noting that many established experimenters in natural sciences were poor observers. Sometimes the devices that they use are more important than diligent observations and refined theory. Nevertheless, this doesn't mean that observation is theory-free, but we should be careful in what we consider theory[4], because there are also technicians trained to make observations without having any theoretical preparation.

The observant qualities of an experimenter are not only present when the experiment is taking place. Observing the instruments and apparatuses, for possible defects, is in many cases a knowledge-building practice. Observation is also a skill which can be honed by practicing and training. In natural sciences is not a matter anymore of "seeing with the naked eye" (Hacking 1983, p. 168), most of the observations involve instruments that are far reaching and more precise than our senses.

Hacking elaborates on knowledge as a representation of nature, but on the other hand he also questions this. For instance, when we see a specimen with the microscope, are we looking at 'the real thing' or just some artefacts product of an optical illusion? Hacking states that innovation in microscopes and the fact that the same thing can be seen with different devices assures us that we are seeing the specimen. When this stance takes us to the spectator theory of knowledge it becomes then quite difficult to distinguish between representation of the world by the actors and the real thing. Maybe the response lies in the distinction between theory and observation, the first being idealistic therefore mere representation of the world, while the second reporting only the real.

Seeing is transmuted in the form of observing "the opaque surface of things" and building our knowledge from there (Hacking 1983, p. 169). Rajchman (1988) drawing from Foucault's works elaborates on how observation and knowledge are tied together very loosely, as in order for us to observe and know something we have to spatialize it and then visualize: "[i]n science, seeing is more than meets the eye." (p. 96) The light microscope is one of the first instruments that made possible this progress in scientific observation (Hacking 1983). The evolution goes on with different kinds of microscopes designed purposely to overcome difficulties presented by the previous ones. Scientific and technological improvements in microscopes help biologists to observe genes and large molecules, which leads to the epistemological conclusion that maybe observation is not the best tool to separate objects of science as real or unreal.

The philosophical battles regarding microscopes can be located also in the use of prepositions. Do we see 'with' or 'through' a microscope? Since the microscopes 'use' the laws of diffraction, as

[4] See the claim about Feyerabend that was quite unclear about what is a theoretical assumption and what are mere insinuations, opinions, or just beliefs (Hacking 1983, p. 175)

stated by one of the first pioneers of the light microscope Ernst Abbe, then it becomes clear that we do not see with a microscope. On the other hand, following experiments and observation, microscopes are another way to intervene in the world, so we see through a microscope by "doing" and not simply by "looking" (Hacking 1983, p. 189). This means that in microscopy observation only is not enough. A scientist must learn how to properly use the magnification lenses, the optical effects, the reflected light, and also prepare the specimen to be visible.

How is an image obtained by the microscope? If one considers the idea of seeing through the microscope then the image is a complex operational procedure that involves lenses, optical diffraction, and specimen preparation. The concept of seeing with the microscope bears the risk of seeing something which is more of an optical illusion than the real thing. Theory is necessary in many instances when using the microscope, but is not crucial as a technician can also learn to distinguish empirically the things explained by the theory (Hacking 1983). Although theory is used in building these devices, engineering is more important in this aspect.

Concluding the discussion about microscopes, if the interactions between the specimen and the visual technique represents a good map, "then we are seeing with the microscope" (Hacking 1983, p. 208). This map is obtained after many instances of polishing the artefacts in the microscope to have the clearest image. The question put forth by positivists about 'seeing the real' with the microscope is opposed by the idea that even though we might not be sure about the reality, we can confirm the realness of what we are seeing by using different microscopes with different techniques of visualization. Although Xavier Bichat, one of the founders of histology, wanted nothing to do with microscopes in the 1800s because they were not reliable, today this is not the case especially considering the different devices available in microscopy. Theory might still be problematic in terms of observation or seeing, but what assures us about it are the "low level generalizations that enable us to control and create phenomena in the microscope" (Hacking 1983, p. 209).

2.1.2 Objectivity

Galison (1998) discussing about objectivity and how this notion gained prominence in the Western philosophy of science, states that this development was a result of "observational practices" and "a very specific *moral culture* of the scientist" (p. 332, italics in original). He doesn't delve into the intricate relationship of observation-theory-knowledge, but towards a more pragmatic approach. According to him, objectivity through observation is facilitated and triggered by instruments and devices, which are neutral and non-interventionists, contributing thus also in the ethos of the scientific morality. The observer is presented with images and needs to analyze them in order to be more objective about their nature. These images are obtained through reliable instruments, in order to avoid any type of subjectivity. But, with his peculiar capabilities the same observer must distinguish, recognize, and classify patterns, which unavoidably brings forth subjectivity.

Galison elaborates on the historical evolution of objectivity starting from the 17th century. His stance was more practical than theoretically driven, in that he is more interested to inquire about objectivity as practiced and thought by scientists, and how was the objective visual rendition of the world represented in their works. In the 17th and 18th century, natural philosophers were limited in being “true to nature” in their depictions of reality (p. 329). Objectivity was not their concern, but rather the perfect, general representation of the metaphysical images. After the 1830s, the notion of objectivity emerged along the development of imaging devices and their affordances of printed or objective images. This so-called mechanical objectivity and its proponents maintained that the artistry of the previous metaphysical ideal image must be dropped in favor of the images obtained by the imaging devices. The scientists and the philosophers must stay true to these representations by commenting their observations closely with what they see and not involve their judgement.

The mechanical objectivity resonates also with the arguments put forth by Porter (1992) that in accounting, objectivity is composed by (arbitrary) rules that promote strict measurements to confirm if something is objective or not. These codecs of rules and measurements are often praised by accountants because they avoid as much as they can their personal judgement. In mechanical objectivity the images need to be homomorphic, meaning that what was seen in nature is extrapolated and represented in the photographic image. In this way the images speak for themselves, while the scientist is just the medium of obtaining these images. This is the departure point of the opposition toward mechanical objectivity, which favored judgement and interpretation in confront of the self-denial stance maintained by the former (Galison 1998).

This movement started in the early 20th century with the scientists involved in making the different atlases, where they systematically used interpretation and their personal judgment to reproduce images of nature. Producing just images without making any sort of interpretation was not enough for the proponents of this approach (Galison 1998). Like mechanical objectivity contraposed the genius of ‘truth to nature’ because of the lack of accuracy in their representations of nature, judgement proponents criticized the automatization and proceduralist stance of the former by emphasizing the figure of the expert and their skills to observe, manipulate, and classify.

Although, Galison gives a chronologic account of these movements in the scientific image, he also clarifies that there is not a defined timeframe for each of them, as there is overlapping in time between the different approaches. At the same time, the distinctions between the mechanical objectivity on one hand and truth to nature together with judgement on the other, does not presuppose that these approaches are cognates or similar. The genius in truth to nature is far away from the interpreter of the scientific images, as the latter relies more in the knowledge obtained from the devices and the training received according to his discipline. Suchman (2002) makes the point that there is a need for a reformation of the notion of objectivity and its relationship with knowledge. Technologies have changed and reshaped this relationship as they have presented different material forms, practices, perspectives, and locations of objectivity, which need to be analyzed to make more sense of how our notion of objective knowledge is evolving (Suchman 2002).

2.2 Digital and Virtual Technology in Medical Education

2.2.1 New Technology in Medical Institutions

New technology has always been an intrinsic part of the medical settings. As in the accounts of Pasteur that found an ingenious way to isolate, reproduce, and control the microorganisms to use them in his favor (Latour 1983), in this way new technology is trying to mediate between patients and physicians. Medicine, since the 18th century, was struggling with the theoretical knowledge which was changing rapidly; but the patient on the other hand was still this stable and controllable entity (Foucault 1972). The birth of the clinic brought patient and medicine together, Foucault argues, the everyday face to face interaction between doctors and patients steered away from medical speculation and instead was based in a more scientific and realistic approach.

Clinical medicine brought this change by redefining the notion of illness: the lesion is the problem; the symptoms are its manifestation. This change in medical thinking coincided with a new definition of space, that of the clinical and laboratory environment, and also with the new technology that augmented the medical knowledge (Knorr-Cetina 1999). Moreover, the new technologies in the medical settings, especially those with an educational emphasis, are building bridges between established medical practitioners (surgeons or anatomists) and their trainees (Prentice 2013). New technology is not only associated with benefits concerning training and the education of medical trainees, but is also beneficial for diagnostics and therapeutics (Gaba 2000). In the surgical settings, there are so many devices for different purposes which add up to the complexity of a surgical operation, especially when they are used simultaneously by different practitioners. This means that to understand surgery or the modern clinical aspects, a researcher should understand the different instances of the technology use, benefits, but also accidents associated with them (Gaba 2000; Prentice 2013).

The movement of introducing innovative solutions in medical settings is top-down, led by national institutions or medical ones pushing technology designers to conceptualize and implement new visual and digital technologies in hospitals (Prentice 2013). For example, National Research Council (2000) in the US, in its "recommendations and guidelines" emphasized the "health applications of the Internet" technologies in virtual or remote surgery, distance education, clinical and consumer care (as cited in Clarke et al. 2003, p. 176). New visions regarding technology in surgical area are also promoted by Advanced Research Projects Agency (ARPA) and other agencies such as National Health Institutes (NIH), and NASA in cooperation with smaller medical institutions to promote telesurgery or telerobotics for difficult operations (Lenoir 2002). The main aims of these initiatives were to improve surgical approaches for difficult operations, increase the speed by also affording certainty for a successful procedure, and also reduce the surgical team.

The new devices, tools, or instruments will be very helpful to train new medical students and practitioners in the fields of surgery and anatomy. Two examples of technological developments that are being extensively used in US include minimally invasive surgical tools for difficult interventions, and virtual simulators to teach anatomy (Satava 1997; Prentice 2013). On the other hand, these technologies will be crucial in executing more difficult surgeries with minimum effort and an improved rate of patient recovery (Lenoir 2002). The technologically-mediated education in medical settings is challenging the traditional teaching and learning methodology. Thus, technologies will probably foster a further fragmentarization of skills in medical practitioners by shaping ever-special abilities needed for specific procedures, like minimally invasive surgery, but also distance surgery or telesurgery in which surgeons cooperate among each other remotely through the mediation of technology (Prentice 2013, 2005; Satava 1997, 2006; Lenoir 2002).

The main general problematic in these settings though, is how will the use of the ever increasing information reshape healthcare, practitioners' skills, bureaucracies, knowledge, and ultimately the bodies of the patients (Prentice 2013). There is a considerable potential in the treatment of pathologies by the surgeons, but at the same time it creates a "techno-bureaucratic system" that redistributes the body of the patients (p. 208), clinical practices, and medical knowledge. There is also the other aspect of the insurance companies and hospital managers that can use the information to minimize risks, reduce costs, or even manage the patients' eligibility for health insurance. Moreover, these technologies increase the chance for more surveillance regarding patients, as the diagnosis and treatments become part of the medical database (Lenoir 2002). This doesn't mean necessarily that hospitals or insurance companies control the patients' health, it is also a good measure that promotes preventive care.

2.2.2 Learning by Doing, Where Is the Action?

Teaching and learning in university hospitals or clinics is routed deeply in action. A medical trainee or student learns by doing, they must internalize technical skills and crafts together with procedural knowledge. Educators in anatomy and surgery teach those skills to the trainees to boost their medical intuition and judgement, essential when they are dealing with the patients (Prentice 2013). Foucault (1973) points out a relevant transition in the medical profession in the 19th century. He makes a distinction between the physician's application of medical knowledge in treating the patient, and the more practical and invasive approach that the surgeons have in their everyday practice. In this instance, the surgeons have to carefully assess the patient and later decide the course of action, which involves "perception, memory, and repetition" (Foucault 1973, p. 81).

Learning by doing in surgical operations is quite complex in its nature. Although the surgeons are aided in their procedures by different devices, such as the X-ray apparatus for cardiac catheterization, even the interaction with the device itself is sometimes more difficult than the actual procedures of inserting and guiding the catheter in the patients' body (Collins, DeVries, and Bijker 1997). Acquiring technical skills in operating these devices is crucial for surgeons, and technological advances like simulators guarantee a "reproducible curricula" that can reliably measure performance and proficiency (Fried and Feldman 2008, p. 156).

Educators in medicine are in between the dichotomy of traditional teaching and the new digital technologies that promise a better way to visualize, conceptualize, and practice in the virtual patient body (Prentice 2013, 2005). There are obligatory rituals before, during, and after the surgical operations that surgeons always observe and the students must too (Katz 1981). These rituals are a set of procedures specifically designed to increase the chances of a successful operation and minimizing the risk of complications (Katz 1981; Hirschauer 1991). Surgery presupposes two kinds of basal trainings: that of their own body (manual and practical skills) and anatomical knowledge (Hirschauer 1991). Latour (2002) addresses the technical skills also by referring to them as "techniques of the body" (p. 253).

Quite similarly when analyzing the odor kit used to train the professionals of perfume industry, Latour (2004) introduces the idea of articulation in which a trained professional learns to be affected by the objects that he has to interact with. In this way, their bodies acquire a new sensitivity and sensibility that will help them to differentiate between the different odors. Prentice (2005) further elaborates on that by introducing the notion of mutual articulation which views medical training as "a process of articulating two bodies - the patient's body and the physician's body." (p. 841) This means that the patients' body becomes a model body through practice and experience and that can turn into an 'etalon' anatomical body (Hirschauer 1991; Prentice 2005).

Part of the action in a surgical operating room is also seeing, or the medical gaze, which is not confined to the simple instance of observing something, but a clinical observation of changes in a patient and the general knowledge that derives from it (Foucault 1973). Latour (1986) argues that the scientific revolution and innovative technologies brought, among other things, an evolution in seeing. This meant a visual turn toward "optical consistency" (p. 7), which allows us to see things in other distant or unobservable places/spaces. Seeing and acting work together in surgery, and a trainee should learn that seeing is merely a part of the "embodied work" of the surgeon when they are interacting with other devices in their clinical practice (Prentice 2013, p. 171). The new technologies become part of this embodiment contributing in new perceptions of the patient's bodies. These new perceptual experiences also affect the action in the operation room and the surgeon's already embodied skills (Moreira 2004; Hirschauer 1991).

There are proposals of introducing more digital technologies in medical education for students raised as digital natives (Satava 1997; Hargittai 2010; Selwyn 2011). Medical education in surgery has benefited from many innovative technologies, virtual reality and simulators among them, which has reshaped students training in proficiency/performance criterion-based rather than the old model of apprenticeship (the master teaches in situ the student) (Satava 2008; Fried and Feldman 2008; Prentice 2013). The proponents of this approach are even moving part of the student's training outside the clinic. The ever-increasing interaction with digital imaging devices and other tools for medical practice requires developing further technical skills. Developing these skills means that training programs should be in place and carefully coordinated (Prentice 2013).

On the other hand, there are scholars that try to argument that there are also shortcomings that these new technologies bring about. They "suggest a diminished role for the perceptions, skills, and judgments that surgeons embody through years of practice, arguing that surgeons will lose some ability to act autonomously as they become increasingly embedded in technologically mediated structures of decision making, cost control, and risk management" (Prentice 2013, p. 207). Lenoir (2002) argues that the increased presence of various technologies in the surgical settings is affecting many tasks of the surgeons by substituting the human technical skills with software and information technologies.

2.2.3 Embodiment of Skills

Prentice in her 2013 book "Bodies in Formation" tries to build upon previous work of anthropology and science studies in medical settings. One of her main interests is to explore how bodies come into being through instrument-driven interactions with other bodies (medical practitioners and patients comprised). When studying social constructivism, practice is a good way to start inquiring about the ontological strata of scientific subjects and objects (Despret 2004a; Keller 1984; Knorr Cetina 2000; Mol 2002 as cited in Prentice 2013). In medical practice there are multiple objects that look ontologically different in different practices: like the same swollen arteria looked in the microscope by the pathologist, is pain perceived by the patient (Mol 2002).

Surgeons and anatomists embody techniques and internalize visual and tactile perception as part of their bodies. This is not a skill or a talent that you are possibly born with, it takes years of practice in medical and clinical settings to achieve it (Prentice 2013). Perception is an embodied process that is not divided from culture, but instead is part of it (Csordas 1990). Phenomenologically speaking perception is indeterminate, and the external world challenges our senses. Csordas (1993) makes the case of embodiment as deeply rooted in perception, which is the way we engage with the external world and at the same time how culture influences the "bodily experience" (p. 140).

Thus experience is a crucial factor, for instance anatomy teachers dissect cadavers with a precision that trainees often lack (Prentice 2013). Moreover, they have a very clear perception of internal organs and their way of explaining is often a show of oral explanations coupled with gestures that try to imitate or represent the part in the human body. Tacit knowledge is very common in the medical settings and life sciences, for example structural biologists need to develop a "*feel for* proteins" to understand their processes, activities, and constitution (Myers 2007, p. 4, italics in original). The same happens with surgeons that sometimes must imitate the routes in internal organs as seeing could be difficult in open surgery (Prentice 2013).

Embodiment is a good way to assess surgeons, anatomists, and trainees' ways of perceiving and acting, especially when technology is involved. A surgeon's body must incorporate social and technical interactions when they are performing in the operating room. The surgeon is not seeing through a monitor when operating in a minimally invasive surgery or the patient body in an open surgery. This is rather an interplay between action and seeing that constructs a kind of three-dimensional space (Satava 1997; Prentice 2013; see also Prentice 2005). Despite the fact that anatomy and surgery use visual clues all the time, the interaction of hands with the devices and the knowledge derived from it is still understudied (Prentice 2005).

2.2.4 The Cognitive Focus

The new diagnostic tools of visualization have a cognitive focus that differs from the embodiment of techniques and skills. These cognitive approaches are quite fashionable in computer science and the providers of these technologies for the medical settings. It has further divided anatomists and surgeons who support traditional ways of teaching trainees (such as dissection and surgical practice in situ) and those that have embraced technology-mediated systems which emphasize more cognitive learning through mental models (Prentice 2013, 2005). Thus, emotions, perceptions and embodiment are left out by the new devices that supposedly should replace them favoring objectivity and good medical practice (Prentice 2013, 2005; Hirschauer 1991).

Satava (2008) argues that simulators in surgery and the change of curriculum emphasize the cognitive part of learning surgical skills, procedures, and tasks that the student will use in the clinical context (p. 147). Simulators and virtual technologies are a good solution to teach the knowledge which remains tacit by focusing in the cognitive aspects of these skills (Prentice 2005). On the other hand, these technologies are reaching more towards the interaction hand-device and defining the tactile and haptic training, while moving away from visual and cognitive models.

The cognitive focus places too much (biased) emphasis on the visual, which is quite often reflected in Western thinking of medical practices and senses in general (Prentice 2013). The focus on the visual first of all severs the connection explained above between seeing and doing (see Foucault 1973). In many cases during a surgery the visual is impaired due to complications, thus surgeons and their trainees must arrange other methods to peer into the body, which makes the bodies available to action more than vision. The focus on the visual, moreover, tends to neglect other senses that medical practitioners can't do without (touch, smell, sound) and on the construction of mental representations[5] (Prentice 2013; Hirschauer 1991; Moreira 2004).

2.2.5 Rationalizing the Digital Technologies

The digital technologies introduced in medicine have created multiple interdisciplinary clusters of research and institutions that include physicians, engineers, computer scientists, and so forth (Kouzes et al. 1996). Merging these different backgrounds is changing how they perceive their work, habits, and way of thinking and acting (Prentice 2013). The rationalization of these technologies begins with the patients, whose bodies are made digital with their visual resolution in a graphical model (Satava 2006). In turn medical practitioners' bodies, too, are prone to be mathematically represented and articulated, so both of them can be included in a virtual model of practice (Prentice 2013). The designers of those technologies have embedded their own suppositions and theories in the virtual technologies, and these assumptions have changed thoroughly medical practice.

This rationalizing logic is derived from military and industrial concepts of effectivity and efficiency, especially in the operating room (Hirschauer 1991; Satava 2008). The philosophy behind that is driven by the rationales of engineers and computer scientists more than the notion of care from physicians. Prentice (2013) calls this movement an 'imaginary' that is driving medical practice in the formation of "body objects" that are designed to be part of computer-assisted educational technologies (p. 201). The new technologies will finally change also the physicians' embodiment as they will have to learn other technical skills different from the strict clinical practice. This, in turn, will shift the attention in medical settings towards technique perfection rather than clinical skills.

Prentice (2013) elaborates more on the characteristics of the rationalizing movement emerged from the technical fields. First, the bodies are transmuted in digital "body objects" that can be reused, redistributed, reshaped technologically, and also economized (p. 20). Second, medical knowledge is redistributed in many users, technologies, and practitioners. Third, mathematizing the body anatomy in virtual practices is contributing greatly to build up trainees' three-dimensional spatial skills in anatomy.

2.2.6 Teaching Anatomy Through Technology

The study of anatomy could benefit very much from the new available technology (Satava 1997). Virtual reality surgical simulators can be useful to teach the students anatomy, too. Dissection of cadavers has been for most of the modern medical practice (from 19th century to nowadays) one of the most favored ways to study anatomy in situ (Prentice 2013). The clinical settings that promoted the use of laboratories and dissecting rooms were regarded a kind of experimental lab practice for medical students to develop their anatomical knowledge (Knorr-Cetina 1999). When medical students study anatomy from the textbook they get a sense of the "abstract body" of the patient (Hirschauer 1991, p.

[5] These mental models or representations are not always right, nevertheless they are very helpful for medical practitioners in surgery and anatomy (Prentice 2013; Hirschauer 1991).

309), while the concrete bodies are explored when they practice dissection. Surgeons' understanding of anatomy passes through both the abstract and concrete bodies. One cannot know the whole anatomical constitution of the human body, which is one of the main reasons for the "disciplinary differentiation of the field" (p. 310).

Now the challenge is posed by the digital technologies that have putted forward the 'canonical' body that is the generic anatomical body, instead of the 'instantiated' one, which is the particular body (Prentice 2013). Although, technologies are pouring into medical education in studying anatomy and substituting the instantiated body, still the sense of learning through dissecting a cadaver is better as a student can actually feel the body structures. Nevertheless, medicine needs both of them as physicians can practice more generally in the canonical body and then get to clinically assess an instantiated body.

Other anatomists support this argument by stating that dissection makes a medical student aware of the bodily variations, knowing the visible parts of the body, and making other parts visible (Prentice 2013, 2005; Hirschauer 1991). The digital tools are far away in terms of tactile representation, variations of structures and pathologies, spatial relations in two-dimensions, and other subtle details (Prentice 2013). These may seem as irrelevant reasons, but many surgeons and anatomists stress the fact that medical practitioners have to be aware and in control of even the minimal details. When dealing with patients everything can go wrong and there is no turning back. While with digital technologies you can just resume and reset.

Philosophically speaking, dissection is a way of articulating and bringing together both object and subject. The students (subject) engage with anatomy and body structures in order to gain knowledge about medicine (object) (Hirschauer 1991; Prentice 2013). The decline in dissection practices is not only a consequence of the availability of digital teaching devices (Prentice 2013). Shortages in research, difficulty in sustaining a donor program, and the decrease in anatomy teachers, are among the most important reasons for it. Nevertheless, even among the most dedicated technology proponent runs a kind of 'fear' of teaching away from the 'instantiated body'. The real body is the one that eventually any trainee will have to deal sooner or later in clinical practice (Hirschauer 1991; Prentice 2013).

The decline in dissection practices has given a further upheave to the efforts for a digital anatomy program. Since mid-2000s commercial programs of digital anatomy were available in the US. In tune with this, digital tools were also available for anatomy teaching, even though these were only regarded as supplementary, because traditional anatomy teaching was still well-established. Physicians, anatomists, educational technologists are still making concerted efforts to develop new applications for digital anatomy programs. These efforts sometimes have failed to contribute in teaching and learning, while some of them are quite sophisticated, such as the Visible Human Project (Prentice 2013).

2.2.7 Simulation and Virtual Technologies

In new multidisciplinary medical institutions patient's bodies are making possible the transition between 'body object' together with virtual and simulation technologies (Prentice 2005, 2013). The first step toward virtual and remote medicine is the monitor, as it is an extension of the patient's body (Prentice 2013). Satava (1997) states that virtual reality and telepresence are going to revolutionize medicine, as the body of the patient is "electronically mediated" and represented as a flow of information together with three-dimensional images (p. 19). One of the main principles in this sense is the idea of representing real bodies within a computer model and simulate basically everything from physiology, processes, disfunctions, and mechanisms (Satava 2006).

The patients' body is not the only body that can contribute to virtual technologies in medicine (Prentice 2013). One hand surgeon explains that he was able to form mental models of the shoulder for instance, and travel through it three-dimensionally without any help from visualization tools. This was an embodied skill learned through hundred cases of practicing shoulder surgery (Prentice 2013; Csordas 1993). These mental models are curiously in line with what proponents of virtual technology think could be useful to develop. Especially, in simulation and imaging medicine this kind of visualizing tools are very handy to travel through bodies into different complexes of organs, tissues, and blood vessels (Satava 2006). As Prentice (2013) figuratively puts it "his imaginary navigation of the body was also an imaginary of technology." (p. 193)

In these multidisciplinary institutions research about virtual technologies encompasses different domains such as engineering, medical knowledge, and computer languages (Prentice 2013). In the age of Information and Communication Technologies (ICT) the different medical devices such as simulators, computer modelling, telepresence, and robotics aren't just instruments, they are information management systems (Satava 2006). Researchers, Prentice (2013) accounts, were very curious about the other fields involved in these multidisciplinary projects. Negotiations between different groups of expertise were always present, as education technologists and physicians were giving their ideas about how to construct the best practices in surgical and anatomy teaching, while the computer scientists were designing the models to implement these ideas. The communities formed around "object worlds" of conceptual and material objects concerning bodies in medical settings (Bucciarelli 1994, p. 62 as cited in Prentice 2013).

Richard Satava, a surgeon that strongly promotes the use of technology in clinical settings, argues that surgical simulation design and implementation will boost medical teaching by assessing skills of trainees and residents based on the skills and knowledge acquired independently from the teacher (Satava 2006, 2008; Prentice 2013; Lenoir 2002). Surgical simulation is based on virtual bodies interacting with both medical practitioner and devices (Satava 2006, 2008). Through a mathematical language and digital rationales, the virtual body creates a new embodiment, a virtual one as a product of the interaction between the user and technology. Thus, surgeons are left without a kinesthetic or manual feeling of the body, when they practice with simulated bodies (Prentice 2013, 2005). Nevertheless, simulation especially in minimally invasive surgery is also using mannequins that simulate the tactile and haptic feelings of the practitioner (Prentice 2005).

There are other physicians, however, that aren't comfortable with the images or videos obtained with virtual technology (Prentice 2013). Dr. Anna Wilson describes the case of a patient that had developed arthritis due to a torn biceps. The video was made with a shoulder arthroscopy and showed different patterns through a rotating camera. Even zooming 20 to 30 times, the images on the camera were quite abstract in comparison with an open surgery that Prentice had been present. Technology in this case was more a hindrance than a handy tool. Anatomists using the Visible Human Project or virtual bodies use them minimally, only to identify structures in anatomical cross-sections. However, researchers and medical practitioners in other labs around the world were using extensively virtual and simulation technologies for the patient's and their own benefits (Satava 2006, 2008; Lenoir 2002).

There are ongoing efforts to build better and better simulation technology devices. For instance, there are physical simulators where a mannequin packed with sensors resembles a human body, but there are also virtual-reality simulators where graphics present only in the computer are the surrogate of the patient body (Prentice 2005, 2013). Researchers cite many reasons for the extensive focus on this technology. Simulation is reversible not like surgery, and students can practice as much as they want in order to improve their skills (Prentice 2013; Satava 2006, 2008). Student progress can be tracked and documented, while suggestions for the improvement of the technique can be given by the computer. Basic skills for new trainees can be taught with simulators before entering the clinical practice and this was made possible by changing the curriculum of the surgical practice (Satava 2008).

It is quite difficult to build virtual simulators for surgery. The actual practices in clinical settings should be disassembled in their different elements (the embodied skills), techniques should be thoroughly analyzed, and the different bodily structures and their physiology imitated in perfection (Prentice 2013). After this stage, computer scientists should devise mathematical models, software, hardware, and programming language, to embed all the previous elements in a virtual model (Prentice 2005, 2013). The physical feeling in surgeries and 'the body object' of the patient are recomposed in a computed form (Prentice 2013), and this has the potential to develop different techniques such as "modeling, simulation, virtual prototyping, virtual testing and evaluation, mechanical rehearsal" (Satava 2006, p. 3).

Most of the virtual simulators are produced to teach minimally invasive surgery (Lenoir 2002; Satava 1997; Prentice 2013). Prentice (2013) elaborates more on the reasons why this subdiscipline in surgery could benefit more from these innovative technologies. First, monitors are the eyes of the surgeon in minimally invasive surgery, as the practitioner is forced to work in small spatial sections of the patients' body. Second, this kind of surgery requires working with a fulcrum[6] in a three-dimensional space represented in two-dimensions. Third, open surgeries are very difficult to imitate and integrate in a virtual simulator.

Nevertheless, the virtual simulator technologies are still in prototype phase and their adoption in the medical education settings is been slow and not evenly distributed (Satava 2008). The challenges in design and usability that this technology has ahead makes their future and present unstable (Prentice 2013). The problem is also assessing and defining how much does it contribute in developing the surgical skills of the trainees. Satava (2008) argues that the fourth generation of simulators in surgery that are well-implemented in the medical curricula, are helping the trainees developing a feeling for surgical interventions and boosting their beginners' skills. On the other hand, other practitioners also acknowledge that they are not a 'miracle of technology', as it is contributing modestly on their skills and techniques (Prentice 2013).

2.3 Digital Technologies and Education

This section is based mainly on Neil Selwyn works regarding the sociological approaches regarding digital technologies in education. First to be discussed is the digital divide among teachers and students which seems to affect the implementation and adoption of technology in schools. Second, what is school 2.0 and what are some of the educational practices that promise change in terms of schooling? Third, education, technology, and learning theories will be analyzed separately to view them in an isolated optics and make a better sense of them. Fourth, how has motion picture, radio, television, and microelectronics been envisioned regarding education and what were the main reasons for their failure? Fifth, what are the external and internal imperatives in education? Why is change in education hard to define? What is the impact of technology in teaching?

Sixth, how is the future of educational technology envisioned by past and present research? Seventh, it is necessary also to delineate the importance of a critical stance toward optimistic accounts regarding the impact of digital technology in education to understand better its essential effects. Eighth, how is globalization featuring in educational technologies, and what are the roles of the national governments or international organizations? Finally, how are discourses of social justice reflected in educational technologies?

2.3.1 The Digital Divide

The injection of digital technologies in education started since the 1980s, and has continued to grow in the second decade of the 2000s (Selwyn 2011; Sianou-Kyrgiou and Tsiplakides 2012). The increased

[6] As used here it means that the small cut in minimally invasive surgery acts at the same time as the entrance point and the supporting structure from where the surgeon works.

presence of technology in education is often associated with a narrative of success in teaching and learning. Moreover, the 'boom' of internet and ICT use in everyday life has triggered different studies regarding the socio-economic factors influencing the access and use of technology (Sianou-Kyrgiou and Tsiplakides 2012). One of the conclusions emerged from these studies is that social inequalities are evident, mainly because the level of technology use and savviness defines the ability to compete in the job market. Despite the increasing implementation of digital technologies in schools and educational institutions, there is a kind of 'digital divide' that hinders the process of implementation and benefits from these technologies (Sianou-Kyrgiou and Tsiplakides 2012). But what is a digital divide concretely?

This term has been in use since 1990s to expose the differences in the possibilities of accessing the Internet and ICTs from individuals, groups, or societies, conditioned by social factors such as income, race, gender, nationality, and so forth. (Sianou-Kyrgiou and Tsiplakides 2012). The digital divide is branched in three aspects: the global divide, the social divide, and the democratic divide. Another aspect of this digital divide directly related with education and digital technologies, are the so-called 'digital natives' and 'digital immigrants' (Selwyn and Facer 2013; Selwyn 2011; Hargittai 2010).

Digital natives are the new generation of students that are born and raised during the 'peak' of digital technologies (Hargittai 2010). Supposedly, this new generation of technology-savvy students are more practical in adopting and using technology not only in educational settings but in their everyday life. In this sense, educational commentators claim that there is a big divide between capable students and fumble teachers in using technology (Hargittai 2010). Marc Prensky refers to the teachers born before 1980s as 'digital immigrants' that "[are] forced to adapt to a world of digital media after (many) years of leading 'pre-digital' lifestyles. In this sense, most 'digital immigrant' teachers are seen to be largely 'out of the loop' of technological change, leaving little opportunity for these adults to alter their practices or modes of provision to fit with their students' digital native way-of-being." (Selwyn 2011, pp. 125-126) Thus, teachers are 'forced' to construct learning contents for technology-enhanced classrooms, but the task is difficult considering factors such as time, insufficient technologies, technical skills, and ICT management (Dimitriadis 2012).

Although young people or the generation of the digital natives are supposedly more capable of understanding and adopting technology, there are differences between the connected and the more marginalized communities. Moreover, there is not any empirical evidence to back up digital natives' theories, and there is not a fair distribution of skills even among college students (Hargittai 2010). Studies in higher education regarding the use of ICT by students determine that social factors influence the adoption of these technologies (Sianou-Kyrgiou and Tsiplakides 2012). In Smith and Caruso survey, the authors report a steadiness of computer ownership among college students (98%), as well as a gender difference in the use of certain technologies; Cotten and Jelenewicz reporting on college students use of internet in the US, claim that there is a 'multilayered' digital divide among students of different races and genders (as cited in Sianou-Kyrgiou and Tsiplakides 2012, p. 58). Selwyn and Facer (2013) state that the notions such as digital natives can be used to cloud the social differences among students, promote certain policies regarding education, and as a marketing strategy for certain educational systems. This kind of research has a clear intentional scope to highlight digital cultures and the 'limping' mainstream education.

2.3.2 School 2.0

Beside the debates regarding the digital divide there is an immediate necessity to assess the impact that technology has had so far in education and pedagogical approaches (Sianou-Kyrgiou and Tsiplakides 2012; Selwyn 2011, 2012). Educational institutions have displayed a certain reluctance in adopting the new digital technology, thus resisting to the potential changes that they could bring in education and pedagogy. This is especially evident when considering the major effects that technology has had on other areas of our everyday life (Selwyn 2012).

Selwyn (2012) inquiries about the way educational institutions are fostering digital technologies, and the radical changes that technology 'threatens' to bring in formal education. School 2.0 as Web 2.0 is regarded as the new frontier for our society, with the potential to change the approach toward education and knowledge production, and the possible effects on culture and society. To address the above questions and the emergence of technology in education, a researcher should approach schools and technology considering their structure and ongoing processes (Selwyn 2011, 2012). The structures of school are not only the traditional elements of architecture but hierarchies, curriculum, and the organization of time schedule. Processes, beside the practices such as teaching and learning, extend to the socialization with peers and teachers, rules and rights, as well as the different forms of control.

There are three notions that Selwyn (2012) uses to depict the transformative role of technology: virtual schooling, reschooling, and deschooling. Virtual schooling defies the spatial and temporal constraints of the normal schools, as teaching material can be delivered and accessed according to the needs of the user-student. Millions of dollars have been injected into the educational system in the US to implement programs such as 'Virtual High School', demonstrating thus a willingness to experiment and deliver a new way of education. Among the many benefits of virtual schools is the flexibility of the organization (hierarchies and leading roles), and their profile as efficient and competitive institutions in comparison to the traditional school format.

Virtual schooling takes the experience of the education "outside of the conventional school" (Selwyn 2012, p. 5), reschooling brings it back within the "building of the school". Processes and structures take place within schools and they are facilitated by digital technologies that reshape the curriculums and the assessment procedures, which are fundamental to the pedagogical approach. Examples include efforts in many countries to promote a new way of digitally assessing what is learned in terms of decision-making, adaptation to different contexts or situations, and collaboration with other peers or institutions. Similarly, curriculum changes include several instances of collaboration between teachers, students, and other administrative staff in schools, together with publication rules and modes of inquiry in the classroom. Beside these two developments, academics and educational technologists alike are veering towards changing also the schools' architecture. These proposals are framed in the context of adapting the space or the buildings to digital technologies for a better access and effective use from teachers, students, and staff (Selwyn 2012).

While, virtual schooling and reschooling coexist and boost the traditional idea of the school, deschooling is quite different from these rationales. Deschooling refers to the practices and ideas that defy traditional schools in their spatiality and temporality, along with their cornerstone imperatives such as curriculum, qualifications, and assessment. Digital technologies are the means by which those ends are met. There are different examples that represent forms of deschooling. For instance 'The School of Everything' is an online space where people in the UK meet according to their needs to learn or offers of teaching. This resonates with other different movements aiming for home-schooling or self-directed learning. One such learning community is 'Free World U' which offers online learning for school children in collaboration with the community of parents and learners. These kinds of practices are growing especially among neoconservative or fundamentalist religious groups that don't want to purse the normal curriculums of the schools (Selwyn 2012).

The concepts presented here although elaborated by many researchers and educational technologists are still at the "periphery of contemporary educational provision" (Selwyn 2012, p. 7). Thus other questions are: Do schools and schooling need a thorough reformation headed by digital technology? Are digital technologies up to the task for this arduous undertaking? Some authors in educational research think that indeed technology can change schools for the better in terms of teaching and learning. This is reflected in the individual freedoms that technology promotes, and the right of people to choose their mode of learning, taking education closer to the individual and societal needs. Several educational technologists claim that dysfunctions of the schools are becoming more evident through digital technologies, which can also help in 'fixing them'.

2.3.3 Deconstructing the Elements of Educational Technology

Education, technology, and theories of learning are important elements entangled with each other. Untangling and discussing them in an 'isolated' context can help us to think in perspective. This means that educational technologies, learning, teaching, and the influence these elements have on each other will be easier to understand once we have a proper apprehension of what do they represent as single entities.

2.3.3.1 Education

Researchers addressing the question of what education is, unavoidably identify it with formal education. This is the institutionalized (public or private) and broadly accepted educational activity that starts with the compulsory elementary school and proceeds with the next less compulsory educational instances such as high school, college, and university[7]. Beside the normal system, formal education comprises also the distance learning options, work-based trainings, and part-time studying. On the other hand, informal education is not restricted within institutionalized education, but comprises any other form of learning which is outside this 'boundary'. Self-teaching and learning, but also mentoring, or flexible group learning are some of the examples of informal education (Selwyn 2011).

But before making full sense of education in itself, we have to also address the concept of learning. Many take this concept for granted in terms of definitions, but in academic debates and texts there is no single definition broadly accepted for it. Learning is generally defined as an individual process where the learner acquires a new skill or knowledge, as stated by Ivan Illich[8]. Other scholars such as Benjamin Bloom argue in favor of three instances of learning: psychomotor skills (learning by doing), the affective learning (in the emotional or character spheres), and the cognitive learning (intellectual skills and knowledge acquisition) (Selwyn 2011).

Another sphere of serious debate is whether learning is a product or a process. The behaviorist model for instance considers learning as an end-product that changes the behavior of the learner. The 'folk' theories of learning view it as an outcome or product that helps in gaining more knowledge about a certain topic or subject (Selwyn 2011). On the other hand are the definitions of learning as an ongoing process. Contraposing the fixed notion of learning as a product, some scholars define learning as: uncovering abstract meanings which have a shady or shifting nature; going back and forth through different elements to make sense of a subject; understanding and interpreting an ever-changing and still unknown reality; and the continuous reinterpretation of knowledge. When analyzing the educational technologies, researchers should take in account other more disentangled aspects of learning and teaching.

2.3.3.2 Technology

Technology is a process in which humans shape and adapt nature to their needs with the help of different tools. Humans have used technology since Paleolithic era to adapt the hostile environment, to survive, for decoration, and so on (Selwyn 2011). Nevertheless, technology should not be seen as just material artefacts, which used skillfully could change human condition. The nowadays use of this term refers to more than just its materiality and goes further by stressing the societal aspects of technology (see also

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[7] Obviously, the educational systems are different from country to country, I am simplifying it to the US model based on the examples that the author refers to (Selwyn 2011).

[8] One of the main critics of western educational system or mass education. He is the author of the book "Deschooling Society" in 1971, which advances the critical reflection of the educational institutions in the western societies.

Latour 1992, 2005; Pinch and Bijker 1984). As suggested by Lievrouw and Livingstone's (2002), technology has three distinctive aspect, albeit entangled with each other: artefacts and devices; activities and practices; as well as context (cited from Selwyn 2011, p. 8).

Technologies are not neutral and deterministic but they help in shaping human activities and are also shaped by them (Winner 1986; Latour 2005). The modern technologies are constantly improving our way of living and making overly difficult tasks easier, for instance imagine the physical barriers that the telephone has helped avoiding. Technology has undoubtedly a transformative force, but as Selwyn (2011) warns "it is important to adopt a more objective perspective on the presumed benefits and transformations of technology. In particular, any technology must be seen in terms of the limits and structures that it imposes as well as the opportunities that it may offer for individual action and agency." (p. 9)

Analog technologies were the dominant ones up until the end of the 20th century (Selwyn 2011). The technologies that will be presented in the next subsection, for instance, are the main ones (analog) that were also introduced in education. Digital technologies are envisioned as a proficient way to improve the human lives and society. The advantages that these technologies have in comparison to analog ones are the fast pace with which they progress and the interactive features that they promote (Selwyn 2011). In the beginning of the 21st century (less than 20 years ago) the dominating technologies were the analogue ones, now they have become obsolete. The smartphones are the perfect example of how digital technology has 'ousted' the analogue telephones.

Internet-based technologies have affected and could potentially increase their influence in education. The modern digital technologies are heavily fueled by the Internet, which through the World Wide Web fosters interconnection between different devices; the possibility to share information and knowledge with different tools; social networking that promotes ongoing relationships between academics or students from different countries; and other online tools necessary for education. There is a "mass socialization" of collectives centered around the internet that brings different people into a connected community (Shirky 2008, p. 136 as cited in Selwyn 2011). These new technologies are becoming more convergent[9], offer a secure way of data management, defy space and time, and can be integrated in different settings. (Selwyn 2011).

2.3.3.3 Theories of Learning

Education is regarded as the ability of humans to learn. Be it a process or an outcome, formal or informal, many academics of educational technology refer to education as "learning sciences" (Selwyn 2011, p. 64). Technology in education is linked with improved intelligence, cognitive functions, and problem-solving capabilities. Digital technologies are seen as inherently positive and desirable tools to

[9] Different technologies that can do the same tasks.

be implemented and adopted in different educational systems and institutions. They, nowadays, are continuously driven by cognitive-learning rationales, so it is imperative to carefully reflect upon theories of learning and educational technologies. In this sphere is important to ask questions regarding how could technology support learning? Why it is not otherwise? What types of learning are more prone to be influenced by technologies and why some others are not? (Selwyn 2011)

The first theory of learning to emerge from psychology, mostly influential in the 1950s and 1960s, is the behaviorist one. It was promoted particularly by B.F. Skinner[10] and focused in the users' interaction with technology and how it was reflected in their behavior. Behaviorists are more concerned with the effects, impacts and outcomes rather than the normal process of learning. Skinner elaborated the idea of operant conditioning, in which if the learner reacts appropriately to the external environmental stimuli then they are rewarded accordingly (Selwyn 2011). Nevertheless, Selwyn (2011) and other educationalists criticize this theory of learning as it portrays the learner as an excessively passive recipient of education. However, the behaviorist theories helped fostering technology in education by proposing the then-known "programmable instruction", which promotes a curriculum designed in small and measurable units of learning products (p. 68). Behaviorist conceptions of learning have had a great influence in education, but their view of learning as cause-effect relationships have undermined their applicability further in educational provision.

The cognitivist theories of learning inquire about the mental processes and actions that influence and are influenced by learning activities. Learning is considered internal to the thought and mental processes. This theory promotes a quite technologically-driven perspective of learning as it brings together cognitive psychology and computation. The latter is based on a schematic description of the mind as computer-like models based on cognitive functions such as input, output, sensorial registers, and memory (Selwyn 2011). Cognitivist theories of learning with their emphasis on computational-like approaches hint to the ability of the users in better controlling the learning activities. Nevertheless, they place too much emphasis on the individuals and their capabilities to learn, disregarding the social nature of learning.

During the 1980s and 1990s the constructivist theories of learning, with distinguished authors such as Jean Piaget, incorporated also the social dimensions of education. They regard learning as a problem-solving practice, in which learners proactively construct their own understanding of the issue by evoking knowledge from previous experiences and practices "of exploration, inquiry, interpretation and meaning-making." (Selwyn 2011, p. 73). In this context, learning is activity-based and teachers are more facilitators of knowledge than the direct source of it. Technology[11] is another facilitator of

[10] One of the main promotors of the theory of behaviorism in psychology and social sciences, who has put forth the principle of reinforcement and the operant conditioning.
[11] David Jonassen (1994) gives a set of principles that underpin educational technology in constructivist theories: case-based learning examples and real-world virtual representations; real or possible tasks in meaningful contexts

knowledge and learning in the constructivist perspective. Constructionist theories of learning take a step toward considering the other dimensions of education, nevertheless they do not escape the individualistic idea of learning.

A growing number of psychologists in the past 20 years, however, are turning their attention and focus toward the societal and cultural factors that influence learning. This is viewed as grounded in social practices, notwithstanding the behaviorist, cognitivist, and constructivist stances that influence education. The socio-cultural theories of learning take their genesis from Lev Vygotsky ideas that learning has a social and cultural nature which involves certain tools and resources. These socially-shaped resources include material artefacts, technologies, semiotic and linguistic systems. Language and speech, as argued by Vygotsky, support the cognitive development of an individual, which in turn is able to interact with others (Selwyn 2011). This theory views learning as a social activity that promotes interaction, based on solidarity where more-able and less-able learners share meanings and knowledge between them, and technology stimulates the learning environment, communication, and knowledge acquisition.

Nevertheless, we should keep in mind that none of the theories discussed above has emerged during the prominence of digital technologies, that is why the arguments presented here apply more to practices of technology-enhanced learning, than educational reality nowadays (Selwyn 2011). There are other scholars of education that have brought forth the idea that digital technologies in education demand a new learning theory designed precisely for them. Indeed, ongoing discussions are implying that technology is probably not affecting learning in itself, but the way learners seek information. This could be in line with notions such as “connectivism” (elaborated by Siemans, as cited from Selwyn 2011, p. 81) and “knowledge spaces” where internet technology is a major player in conveying and storing knowledge. However, this ‘prolific pool’ of knowledge and information, as argued by some educational researchers, is having its toll in the intellectual capabilities of learners by decreasing their ability to learn and memorize knowledge, because it is ‘safely stored’ somewhere and it can be easily accessed.

2.3.4 A Brief History of Technology in Education

Educational technology is not a 20th century development. Technological tools and artefacts have been recovered since 2700 BC in Mesopotamia such as the abacus. From the hieroglyphs and written language, to the chalkboards and printed texts, educational technology tells us a story of how human history and knowledge has developed in centuries. Some of these technological artefacts are still used today in different educational systems. However, if we want to make sense of digital technology in

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and not abstract knowledge; providing a complex picture of the reality and avoiding simplistic representation; avoiding knowledge reproduction and promoting knowledge construction; fostering and supporting collaborative learning through social interaction; and encouraging reflective approaches towards knowledge and experience (cited from Selwyn 2011).

education then we have to look back in the most recent technologies, those of the 20th century. This period of time has been particularly prolific in developing new and innovative technologies such as radio, television, movies, and also digital technologies. Although these technologies have since been an integral part of our society, their impact and implementation in education has been tottering and unstable (Selwyn 2011).

One of the first technologies experimented with in educational systems was the motion picture[12], heralded as a mean to open up the horizons of the school and classroom to the wide world, partly because of the popularity of silent films in Europe and the US in the early 20th century. Thomas Edison was one of the pioneers that invested extensively in this technology, introducing educational film in many schools across the US. Educational content was developed as well to be introduced in schools, and after two decades the distribution of film rooms and equipment was covering nearly 25 states in the US (Selwyn 2011). Motion picture was viewed as a powerful means of delivering public education in fighting ignorance. Research about its impact in learning is not conclusive. There are accounts that information and concepts were better grasped through educational film than the traditional methods (Allen 1956, as cited in Selwyn 2011), but there is also research that wasn't certain about its effects in education.

Educational radio was thought as a means to deliver education especially in the higher levels. The first educational radio was implemented at the University of Wisconsin in the US, other universities and colleges followed suit with the 'Schools of the Air' realized in collaboration with commercial broadcasting networks to take education in remote areas. These programs were tailored to offer distinctive school subjects fitting the normal curricula (Selwyn 2011). Radio was enthusiastically discussed by educationalists as it was delivering educational materials with low costs. The live broadcasting was seen as a motivator for students to engage with the content, shrinking spatial boundaries, and its democratic features allowing different voices to be heard.

Educational television was the other technology extensively tried in the US educational system. The development came in 1952 when the US Federal Communications Commission decided to promote 242 channels for educational purposes (Selwyn 2011). Educational television channels were accompanied by even a greater enthusiasm than radio and film. It was argued by educational technologists that the television with its focus on the images would help in making abstract learning materials more concrete. Educational television in constructivist terms (see previous subsection) is the closest thing to a representation of the reality, making it an effective tool to teach concrete knowledge. Several studies argued its value in education together with successful projects and initiatives of using television in schools.

[12] Teachers used to project strips of film with a narrative text in which they had to continuously change the strips.

The early digital period of educational technologies started with the microelectronic revolution, electronic devices with minute silicon chips that could outperform the analog technologies in processing power and robustness, all in a relatively small device. Starting from the pocket calculator, to portable devices, and the personal computers, one of the most used microchip technologies in education was the non-networked computer, mainly because this device was developed in university settings (Selwyn 2011). Its use for learning and teaching purposes had started since the 1960s with the initial focus on natural sciences (the so-called ‘numeric uses’) and progressing within the same decade in computer-assisted instruction for many other topics (Selwyn 2011).

At the end of 1960s the use of computers was introduced into many areas of education such as: tutoring and coaching the students by delivering the materials and monitoring their responses; promoting the learning of new skills with different repeated drills; organizing problem-solving activities in an interactive way; dialogical exercises in English to improve students’ speaking abilities; simulating different laboratory settings and hosting the practice of these skills; using it as a database repository with query functions; and educational games (Martin and Norman 1970, as cited in Selwyn 2011). Many private companies in the computer or IT industry (IBM, Apple, and Tandy) grasped the chance to develop and distribute these devices in educational settings across the US by increasing its presence in schools up to 81% in a national scale. In a study conducted in Palo Alto, California, it was observed that computer terminals, screens, and light pens could improve the pupils’ ability to learn arithmetic.

Despite the enthusiasm accompanying all these technologies, in one way or another they couldn’t impact education as many technologists thought. There were several reasons for each of these technologies, but the main ones converge with each other. First, either teachers rarely used the technology in classroom, or they lacked the skills, training, and expertise to properly adopt it for educational purposes. Second, in many schools the appropriate devices, receivers, supporting equipment, signal problems, and maintenance were not properly addressed, which resulted in undermining the normal adoption of these technologies. Third, the school curriculum either was not adapted to integrate them, such as television for example, or these technologies weren’t used in problem-solving drills but just reproducing practices (Selwyn 2011).

2.3.5 Changing Education

What is the impact of technology in society today? How far-reaching are the transformations triggered by it? Many researchers argue that governance, big organizations, and stark bureaucracies are ‘loosening their grip’ in society because of the fluidity and fast-pace developments of digital technologies. Their impact extends not only in the broader political domain but also towards society and its individuals. These technologies are very individualistic-driven as people use them in their everyday life, not only for strict personal purposes but also to bring people together and organize them better. The dependence on institutionalized or formalized ways of using technologies is dropping especially in education, as individuals can chose how, where, and when to use digital tools (Selwyn 2011).

2.3.5.1 External and Internal Imperatives of Technology Use

The external imperatives of using technology in education refer to the factors, institutions, and organizations, outside the educational domain, that promote the adoption and implementation of technology in education. On the other hand, internal imperatives are cradled and promoted within educational systems towards digital technologies (Selwyn 2011). One of the main external imperatives discussed in the academic environment but also in broader societal venues is the idea that in order for education to keep the pace of the modern society, it is necessary to adopt digital technologies constantly and diligently (Selwyn 2011). Many commentators, however, state that education is fumble in quickly implementing and adopting the new technologies commercially available.

Just ‘keeping-up with the pace’ is not the most relevant imperative in this aspect, there is continuously a demand for education to reflect and ‘stay tuned’ to the latest technological developments in society. Educational technologists argue that it is an obligation to embrace the societal and economical values promoted by the digital technologies. These changes are mainly triggered by the constant and continuous improvement of ICT and the demand to apply them in education as part of the knowledge economy, or even knowledge society (Selwyn 2011). In this sense, the ever-demanding technical skills are a must in today labor market, which indirectly implies that educational settings should provide their students with this kind of skills. Moreover, even in the individual plane the ability to use digital technologies is an “essential life-skill”, in order for people to be fully integrated and provide for the “information society” (Selwyn 2011, pp. 23-24).

Nevertheless, the actors that are pushing the agendas for more digital technology in education are not only government, organizations, or private companies. The consumers of education are also pressing for more technology in education due to the generation of digital natives that demand for an ever-increasing technology presence in all the areas of their life. These trends in promoting digital technologies in education are not a feature of only rich and developed countries. Other less developed or developing countries are working out detailed plans and strategies for the introduction of more technology in education (Selwyn 2011).

These top-down external imperatives come from a range of different actors that are not necessarily close to educational systems. The internal imperatives surface from bottom-up actions and activities in order to improve different aspects of education. Thus, technology is believed to be the right tool to improve and address some core processes and aspects of education. One area of education that technology could impact and improve is the learners’ abilities to enhance the cognitive functions and thinking skills. Moreover, they will have more freedom to choose their own way of using technologies. Teachers could benefit from the “interactive presentation devices” to better deliver learning content in the classroom (Selwyn 2011, p. 26). Technologies can help teachers also in the procedural tasks (grading and preparing teaching materials) to assist them in their everyday job. Finally, digital technologies can improve the managing of educational institutions, modernizing them, and promoting an efficient delivery of education not confined only to the classroom.

2.3.5.2 Scrutinizing Change in Education

The external and internal imperatives of education have clear implications on schools, teaching, and learning, nevertheless they are not so easy to define or assessed as they have a very shifty nature. The different claims of how has technology changed education should be seen in a contestable fashion, which means that to avoid ungrounded enthusiasm, further scrutiny is necessary to assess the level of transformation. Many of the claims by educationalists presented in this section, are not empirical observations or research outcomes, but perceived values of what educational technologies ought to bring, or even abstract notions and enthusiastic accounts about digital technologies in education (Selwyn 2011).

Digital technologies are not some sort of 'technical fixes', ready-made and ready-employable to fix the problems in educational institutions. The imperatives discussed above promote a new way of thinking about the intricate relationships between teachers, students, knowledge, and educational institutions. First, an issue to be addressed is the role of the teacher not only as that of a guiding instructor, but an initiator and facilitator of instruction. Another aspect of teaching that needs readdressing is the dynamic change from preparing the learning content in isolation to the collaboration with other teachers. Students, on the other hand, should be more proactive in their learning quests and engage in knowledge production together with their teachers. Educational institutions should make a 'leap forward' to be more open to the society and not an isolated educational entity. Parents are also a crucial actor as they should get more involved in their children education rather than being passive and leaving everything to the teachers or tutors (Selwyn 2011).

There are other commentators with more radical views about the impact and change that technology should bring in education. These ideas promote more informal learning environments and avoid established educational institutions in favor of flexible ones where the learner can choose the modalities of learning, the type of knowledge, and the relevant skills he wants to acquire or improve. According to these scenarios, either the education and technology will be continuously implemented in the existing educational institutions with few changes, or it will change to a knowledge and information economy where the current educational institutions will be obsolete (Selwyn 2011; Sianou-Kyrgiou and Tsiplakides 2012).

2.3.5.3 Impact on Teaching

There are many definitions associated with teachers, such as educators, guiding the learning process, instructors, tutors, coaches and trainers. While these definitions are quite clear and straightforward, the notion of teaching is still contested among many educational commentators and researchers. Some educationalists state that teaching is an art because it involves delivering the learning contents intuitively and in an expressive way. On the other hand, teaching is regarded by others as a science because the teacher approaches the teaching practice objectively, constructing logical connections between learning contents, as well as using reason and common sense to conduct the lesson (Selwyn 2011).

The first impact of technology is to support teachers pedagogically and enhance their role in creating the learning content, delivering it, monitoring the student's progress, better plan their teaching schedule and materials, get updated information about new knowledge on their field, and improve their pedagogic skills in general. Inside the classroom, digital technologies such as the interactive whiteboard could be an important asset for the teacher by delivering the materials in a more engaging and interactive way. Moreover, the administrative and bureaucratic tasks that a teacher has to perform everyday are greatly facilitated by the computer or the internet technologies in general (Selwyn 2011).

Nevertheless, there are radical accounts that predict the disappearance of the teacher and their crucial role in education. For instance, the development of virtual technologies such as 'virtual campuses' but also online learning in general, are based principally on the ability of the learner to select the learning materials and have them delivered through digital channels (tutorials, videos, interactive presentations, and so on). This may not necessarily mean that the teacher as a profession will cease to exist, but foreseeable reductions are predicted by many educational technologists, especially when considering initiatives such as Mega-Universities and Mega-schools that are mainly based on distance education and supported by the communities (Selwyn 2011).

On the other hand, there are educational theorists that have taken a milder stance toward what the role of the teachers will be in a future education system. Their conventional role may change due to technology, probably more in the realm of the co-construction of the learning process and as a facilitator of knowledge rather than the main instructor (Selwyn 2011). The teacher's role will be probably secondary as the communities of peers will engage extensively in collaborative learning and distributed knowledge, as promoted by ICT and new social media technologies. Other commentators dismiss the teacher's role as a facilitator by shrinking it in a more technical one or as a scientific expert rather than as an instructor and educator.

2.3.6 The Future of Educational Technology

Beside the history of educational technologies, their changes and impact on the school system, it is important to also present the envisioned future of these technologies. The future accounts in this subsection are presented to give an overview of the research done in this aspect, and not bring forth a predictive narrative of how will these technologies affect education in the future. In this context, two are the main approaches regarding the future of educational technologies: analyzing the claims of research done before the age of digital technology and their future vision regarding education, and also assessing the claims put forth by nowadays research and their vision 20 or 30 years from now (Selwyn 2011).

One of the first "'past' future portrayals of education" described by Selwyn (2011) was the "Project 2000" carried on by Apple Computers in 1988 to predict how education, technology and society will evolve in the year 2000 (p.168). They took a two-fold approach by predicting the technologies that will be developed by then, and how could users better adopt them to bring meaningful changes in education. Although the winners of this project foresaw the development of technologies, we actually use today such as touch screen tablets, laser technologies, micro SD cards, and GPS-connected devices; they failed to correctly address how they will be used in educational activities and practices. Other accounts were more fantastic in describing the future of education and pedagogical approaches. Tom Stonier and Cathy Conlin's (1985) accounts anticipate a de-institutionalized educational system due to technology, in which students and pupils will be having long cultural exchange experiences in different countries of the world facilitated by computer-connected phone calls with their families (cited from Selwyn 2011). In UK, technologists were also arguing that the printed text will be virtually gone by the first decades of the 21st century, the educational system would be more flexible and de-institutionalized, while technologies will be better adopted by students rather than their teachers.

The present-day forecasts of educational technology extend their threshold to the next decades of this century (years 2025 or 2030). Remaining in the UK context, Beyond Current Horizons engaged 100 academics to make predictions about educational technologies by 2025 and their socio-economic impact. They made some short-term forecasts such as the increased power of computing and the emergence of innovative digital devices; the shift from networked to ubiquitous computing; and the migration of many human functions to external devices based on algorithms (Selwyn 2011). Socio-technical future predictions for education revolved around the issues of having more information and the role of education in focusing it topically; individuals owning more information than institutions; and the convivence with technological devices as a normal status quo.

The future forecasts from past and present research about education are inevitably politically-driven in that they always remain faithful to a certain ideology of education. This means that these futures rather than predictive ones are more prescriptive in their nature. Thus, the probability of these predictions is not quite based on critical research or common-sense reasoning about education per se, but is guided by political or economic rationales (Selwyn 2011). That should further incite researchers to address these issues critically and consider all the elements before writing present or future accounts about educational technology.

2.3.7 Critical Research

Research in educational technology from a sociological perspective is quite 'tricky' as the reality is not easily-defined, contrary to the depictions of some educational technologists (see Selwyn 2011, 2013). It is a messy arrangement of networks, strategies, stakeholders, pedagogies, and technologies. Law (2004) argues that reality is quite intricate and messy to be assembled and explained by a single method or even by a combination of methods. Not only methods and their combinations have their own limitations, but the researcher that 'intrudes' into a certain reality is also responsible of adding more to the messiness and complicating its analysis (see also Law 1992, 2008).

Digital technology is a prominent feature in educational provision, with government, private companies, and international organizations pushing their agendas regarding policy and economic rationales in education (Selwyn 2011, 2013). Yet, even with this far-reaching involvement of stakeholders and instances little is done in terms of research analyzing the different aspects such as politics, culture, economy, and so on (Selwyn and Facer 2013). Although there is an increasing body of research in different peer-reviewed journals[13], this is mostly concerning social-psychological perspectives or learning sciences and not strictly social sciences. It is necessary to have a more focused research, especially from a sociological perspective, as framed by Selwyn and Facer (2013): "This is research and writing that is well able to discuss how educational technologies *could* and *should* be used, but less competent and confident in discussing how and why educational technologies are *actually* being used. Moreover, this is research and writing that is ill equipped to support the building of an achievable political or institutional project to realize desirable change." (p. 3, italics in original)

But why do we need to be aware of the political rationales behind technology in education? First of all, the actors involved in these settings range from the public to the private sector. These actors interact with each other in different frames and formats by negotiating solutions, imparting orders to each other (top-down), changing hierarchies, and implementing or adopting these technologies in education. These kinds of interactions are often viewed as a struggle for dominance and power, and the societal conflict that results from them can be assessed and understood in terms of power relations, cultural and political rationales, as well as economic effectivity and efficiency (Selwyn and Facer 2013).

Besides the fact that researchers should be aware about the political rationales, they also should avoid what Boody (2001) has called a "means-end thinking" (p. 7, cited from Selwyn and Facer 2013). Digital technologies in education are a complex reality that is not quantifiable economically in terms of efficiency, like developing the tools and injecting them into the mainstream education with the idea that they will definitely impact and improve teaching and learning (Selwyn and Facer 2013; Selwyn 2013; see also Law 2004). These means-end ways of thinking are not able to grasp the intricate nature of

[13] Mostly are what could be called instrumentalist accounts that do not shed light upon important aspects such as "implications of educational technology in education for issues of social justice" (Selwyn and Facer 2013, p. 4).

educational technology, their implementation, the interaction of different actors with each other, impact or outcomes, and more importantly the unintended or 'surprising' consequences.

The other approach towards a critical research of educational technology is based on countering the technological determinism rationales and addressing technology as socially shaped (Pinch and Bijker 1984; Selwyn and Facer 2013; Selwyn 2011). This argument proceeds in dismissing the view of educational technology as an entity in itself, which defines its relationship with the different actors and is not whatsoever impacted by them. This deterministic perspective is countered by the view that places these technologies in a broader socioeconomic context with no "predetermined outcomes" during the phase of implementation and adoption (Selwyn and Facer 2013, p. 9). The different actors in this context bring with them not only their way of thinking but also their personal background and the institutions that they represent.

In order to make sense of these instances, but trying to be careful not 'falling in the trap' of social constructivism[14] (Akrich 1992), we need to 'open up the black box of technology' (Pinch and Bijker 1984). This means that all the factors concerning institutions, networks, technologies, and stakeholders should be taken in account and critically reflected upon (Selwyn and Facer 2013; Selwyn 2012). Thus, technologies are not devoid of agency (Latour 2005), but they have political significance as they are not neutral (Winner 1986); they are negotiated upon, adopted and stabilized in the educational context by a whole range of actors (Selwyn and Facer 2013; Pinch and Bijker 1984). The technologies have in this sense an "internal politics", but on the other hand they have also "external politics" by which they can prompt certain developments or halt others (Selwyn and Facer 2013, p. 10). Today's digital technologies have permeated so much our everyday life, making it very difficult to critically study them. However, researchers should try to analyze them not as fixed 'black boxes' but as contingent entities that are enacted and adopted by multiple actors.

Selwyn and Facer (2013) approach refrains from asking state-of-the-art questions about the potential of these technologies, and instead focuses on state-of-the-actual issues. They define them as "questions concerning "just what is going on" when a digital technology meets an educational setting and what institutions, histories, agents, tools, and concepts are and have been in play in this process." (p. 12) They emphasize the importance of thick qualitative descriptions of the actual use of technologies in certain educational settings, rather than forecasting what will they do in the future.

[14] Opposing technological determinism could easily direct towards a social determinism, in which society is regarded as the center of any technological development thus explaining the later with 'the social' (see Latour 2005). As also discussed in the Chapter 4, Madelene Akrich warns us about placing too much emphasis on 'the social' heading thus towards social constructivism, which is as dangerous as technological determinism.

2.3.8 Global and Local Perspectives

2.3.8.1 A Critical Perspective

A crucial issue that needs to be addressed in the light of global and local perspectives are the range of the competing interests regarding digital technology in education. One set of actors have the precedence and power to negotiate and capitalize upon technology in education. Of course these are shifting trends. Sometimes the nations or local governments are the ones that shape the educational technologies, but other times there are private companies or organizations that control the implementation and adoption of these technologies (Selwyn 2011, 2013). Such examples can be found in the different national contexts of the US and UK and their governance of education, as well as in the initiatives promoted by commercial giants such as Apple, Microsoft, and Cisco. Thus, power and interests are shifting in different hands. But who are the main actors in these power struggles?

First, are the nation states and their solid authority to decide the policies, the agendas, and the practices of implementing and adopting educational technologies. The national paradigm is the main decisive force to impose the rules and guidelines regarding the development of the educational system (Selwyn 2013). Secondly, international organizations are a powerful entity that influences the negotiation, distribution, and implementation of digital technologies in different countries. Third, private interests or the private commercial sector are also crucial actors, as they are the main developers and distributors of such technologies. Their power is not limited to the production and distribution of the goods, but also in ideologically influencing the adoption of these technologies from the educational system in place. Beside these main stakeholders, educational technology has fostered an environment where different interests are entangled, thus introducing the other set of actors that range from "advocacy networks" and "edu-businesses", to "policy entrepreneurs", and social activists (Selwyn 2013, p. 152).

Researchers should make sense of who benefits from the outcomes and developments regarding digital technology. In many cases it is not easy to properly gauge and assess the positive outcomes promoted by these actors, thus the critical approach promoted earlier in this section comes in handy. The dominant narratives served by the dominant actors should not been taken for granted, but they should be scrutinized thoroughly (Selwyn 2013; Selwyn and Facer 2013). Much of what is said or done about digital technology in education are accounts coming by Western countries (Euro-American) organizations or companies. The critical research, instead, won't be of any use if we don't consider the other countries' perspectives (as Selwyn refers to the "global South", p. 153). For instance, Cisco[15] is arranging for the delivery and implementation of educational technologies in sub-Saharan Africa, but

[15] An American company leader in the networking hardware, telecommunication tools, and other innovative high-tech products.

beside these philanthropist motivations and initiatives not all the countries in this region benefit the same way, as they have differing national values than the western ones.

Selwyn (2013) proposes to assess these initiatives in a post-colonial[16] perspective. This implies that the main motivations of the developed countries, international organizations and companies are market and profit driven, rather than simple philanthropic undertakings. Nevertheless, beside aims or purposes of 'forced modernization', undoubtedly these technologies have contributed to a certain progress in poorer regions. However, as Selwyn (2013) notes "[y]et, at the same time, it is difficult to overlook the vested interests that these dominant actors have in encouraging individuals and institutions in poorer countries to engage with and adopt 'Western' ideas, practices and devices, and therefore go some way towards becoming more productive components of the global knowledge economy." (p. 153)

In order to avoid these problems of power imbalance a possible solution for more equitable alternatives regarding educational technologies is to look into the local alternatives. Like the idea of considering the perspectives outside the Euro-American system of values, the local alternatives initially need a recontextualization of the approaches toward the implementation of digital technologies in schools. The first step towards this, is to dismiss the hyped language of 'global values' and 'better educational technologies', to a more localized approach that considers first and foremost the level of expertise and knowledge of the people in the actual settings where these technologies will be deployed. The next step is to forge a public debate and scrutinization of these technological solutions, avoiding the overly positive and hyped arguments. This normally have to include a different set of actors, representatives of the public, in order to have a democratic process of decision-making. The broader involvement contributes into an enhanced awareness about education problems; lays down the possible solutions; promotes a democratized discourse; and fosters the social shaping of educational technologies (Selwyn 2013).

A movement of empowerment should be incited to improve the status of the less-powerful or marginalized actors. Obviously, a redistribution of agency and power is not quite facile in a society, but these interventions must be carried to trigger a meaningful change for the people that lack the power to decide about educational policies. But how can this be achieved in practice? First of all, the nation states roles should be more active and committed in the areas of educational technologies. Beyond the allocation of funds and directing the policies, the states should care and intervene on behalf of marginalized communities. So they can: be the interpreter of the local conditions to the external actors trying to implement digital technologies in their educational system; control and improve the telecommunication infrastructure of their country in all regions; invite the for-profit companies to be

[16] Selwyn (2013) refers to the postcolonial studies to explain the adoption and implementation of digital technologies in former colonies of the Western countries.

more socially conscious in providing with educational technologies; and democratizing governance regarding education (Selwyn 2013).

Second, changing or somehow restricting the private companies ‘chase for profit’ and invite them to be more participatory in equitable chances of implementing educational technology. Even though many companies try to engage in this kind of ‘cool capitalism’ and promote charitable efforts especially in poorer regions of the world, their ultimate scope in many cases is still to control new markets, economic profits, and increased access to political power. This can be achieved by a concerted effort from governments, non-profit organizations, and social activism to foster a public problematization and scrutinization of their activities concerning educational technologies. Selwyn (2013) views these rationales from the developing countries perspectives as: “these new actions can be broad and far reaching. For example, we could revisit the suggestion made by the Senegalese government during the 2000s that multinational IT firms contribute to a ‘digital solidarity fund’ for less-wealthy countries to draw upon. If managed appropriately, such redistributive actions could allow national governments and local communities to purchase (or even produce) forms of educational technology that they consider to best fit their circumstances.” (p. 160)

Third, the involvement of the people should also be expanded in the different processes and activities regarding educational technologies. Their awareness and involvement could be incited by different forms of participatory engagement such as public debates and discussions, citizen dialogue, websites, community-driven meetings, and other feedback formats. This involvement, beside the democratic participatory rationales, could bring to the fore different topics and problematics about educational technology that were never addressed before as the potential users were not fully involved in the process (Selwyn 2013). Finally, in order to coordinate and facilitate these participatory and democratic activities, the academic actors should be involved as well. Their expertise and impartiality are crucial towards a critical analysis of the educational technology and their proper informed implementation. Thus, the critical approach comes again to our attention, as the academic actors should use this approach to influence the educational technology activities, and not be sidelined by the previously discussed stakeholders (Selwyn 2013; Selwyn and Facer 2013).

2.3.8.2 Globalization

In his 2013 book “Education in a Digital World: Global Perspectives on Technology and Education”, Selwyn discusses several neo-liberal values concerning digital technology and education such as freedom, self-interest, individual choices, markets, and meritocracy. In light of these values, educational technology must be seen not simply a domain concerning only technology, learning, and teaching but also the societal and economic rationales that underpin these technologies in a global scale. Digital technologies evolve with a tremendous pace, in a short period of time (less than 10 years) mobile phone technologies evolved from analog keyboards and signal to touch-screen technology and internet-connected devices. These developments have had a profound impact also in the reconceptualization of space and time (Selwyn 2013). With this new way of thinking about space and time, digital technologies (especially ICT) have been regarded as one of the main ‘engines’ of globalization. They have triggered change in societal, cultural, and political rationales, and have flattened hierarchies and simplified bureaucratic operations.

Many commentators have argued about how our society has transitioned from industrial to a post-industrial one described as information and knowledge society. Knowledge and information are the most desired and promoted products when considering the labor market and the economic development (Sianou-Kyrgiou and Tsiplakides 2012). This, in turn, is reflected in education as well, because to play a substantial role in the nowadays society an individual must train and acquire new skills to be competitive in the job market (Selwyn 2013). Life-long education takes its origin from these rationales of economic and societal developments in a knowledge or networked society. Digital technologies impact in education, according to many commentators, has been far-reaching in a global scale. From the large-scale forms of “mega schooling”, to Open-Schools and Universities all over the world, educational provision has been considerably changed by these technologies in its philosophy, pedagogy, and practices (Selwyn 2013, p. 6). Multi-billion-dollar global companies in educational technologies such as McGraw and Hill, Pearson, Thompson, and so on, have seen an exponential growth in revenues and presence in different educational systems all over the world.

Educational technology has prompted change in the way education is provided and conceptualized by putting forth new forms of collaborative and self-centered learning which is adopted globally in different educational systems. Open education resources and courses have been increasingly active to promote this new philosophy. From UK’s Open University “Open Learn” program to the Chinese and Taiwanese volunteers to translate English materials in Mandarin Chinese, it is evident that digital technology has brought a new approach in education (Selwyn 2013, p. 7). These developments have empowered teachers and educators, because they can operate without the barriers of time and space, and at the same time it has been beneficial for learners as they can choose between several learning opportunities based on a meritocratic system. Thus, one of the main impacts that globalization and technology has had in education is the increased mobility not only in research-based academic environments, but the mobility of pupils and students from less to more developed countries, especially in the international schools and universities operating with international curricula (Selwyn 2013).

Nevertheless, the globalization of education is quite unstable and doesn’t mean that has only positive effects. A skeptical view should be always adopted when discussing about the broader neo-liberal rationales of educational technology. There are many accounts from different countries that educational technology hasn’t minimized the social inequalities of access and use of these digital tools, at the contrary it has even deepened these inequalities (Selwyn 2011, 2013). A universal analysis of the digital technologies in education is risky and not accurate. The main danger is to wrongly address economy, politics, and education as prone to be changed by this ‘wave of globalization’ promoted through technology. The national economies and strategies are still important in all the aforementioned spheres. Thus a balanced account about the influence of globalization should include the local perspectives and their importance (Selwyn 2013).

2.3.8.3 National Contexts

Throughout the 1980s, when digital technology was claiming even education, many developed nations sized the opportunity to solidify the material basis for the implementation of educational technologies. In the 1990s and 2000s the policymaking in educational technology shifted towards developing different training programs for teachers and administrative staff, as well as supporting IT platforms in their national contexts (Selwyn 2013). Now in the 2010s educational policy and digital technology implementation has become a global trend involving also developing countries.

Nevertheless, the implementation of more technology in education doesn’t follow only political and economic rationales. Educational technologies can be slightly deterministic in nature, as they can be regarded as ‘the cure’ to save an ‘endangered’ educational system. Moreover, these technologies can also be used for ideological scopes, not quite educational in nature. These policies are sometimes viewed as “discursive devices” that refer to the national values, meanings, and beliefs behind an educational system (Selwyn 2013, p. 71). The national agendas clearly differ from one another, but some researchers argue that there are also similarities between them, such as the aim of implementing more technology in education to create a competitive generation of human assets in the global economy. Selwyn (2013) contends that “[a]s such, an economically determinist reading of educational technology policymaking could be said to run the risk of over-simplifying many subtle but significant divergences in the policymaking efforts of different nation states.” (p. 72)

Beside the strictly economic rationales, in many countries educational technology has been used to address issues of citizenship. For instance, the national policies in Japan and Singapore are centered around the ideas of promoting knowledge, skills, and attitudes for children to prepare them for the new modern state, its bureaucracies, values, and ideologies. Away from this collective-minded perspective, countries such as the US and UK, have been focused more in addressing problems that fall into the ‘information society’ rationales. Thus, educational technologies are seen as providing fairer and just opportunities for all the socio-economic classes (Selwyn 2013). These agendas have been also used to promote nation-building ideas, which differ from country to country. For example, while in Japan these notions revolve around free information, global incentives, and a transparent society, Chilean government with its educational policies is targeting minority groups that are somehow isolated from educational opportunities.

2.3.8.4 International Organizations

When Cold War was over, an increased role regarding educational technologies was taken by the international and supranational organizations. Two entities are worth considering in this context: Intergovernmental Organizations (IGO) such as the European Union (EU), Organization for Economic Cooperation and Development (OECD), G-20, League of Arab States, and so forth; and Supranational Organizations (SNO) such as the World Bank, United Nations, International Monetary Fund, and World Trade Organization (Selwyn 2013). These organizations or entities seek to influence the political and economic areas all around the world, and education is one of the main components to realize these scopes. They mainly intervene directly by investing in educational settings, promoting programs and initiatives, hosting academic debates and research, as well as constructing networks of academics, private companies, and policymakers. They may also operate in less direct way by influencing the discourses about education, governance, policymaking, and economical rationales (Selwyn 2013).

SNOs and IGOs have reshaped education in different ways since the 1980s with the advent of digital technologies. For instance, while the World Bank engages in more active economic and political interventions regarding the privatization and commercialization of education, OECD follows a less invasive strategy by focusing on activities that measure the effectivity and efficiency of education (Selwyn 2013). Nevertheless these organizations don’t operate on their own, they rather open up discursive and decision-making forums between national and regional governments, other international bodies, commercial enterprises, academic researchers, and the publics. The commercial interests of big IT companies (private) are also a major player in the development and implementation of digital technologies in educational institutions. For example, Microsoft is one of the pioneers in the private sector that focuses heavily in providing software and hardware to support technology in education. Their main aim is to bring a change in (worldwide) education by engaging human assets and technologies (Selwyn 2013).

2.3.9 Freedom, Fairness and Social Justice

Social inequalities regarding education have been discussed as causative agents of problems in educational technologies implementation, but in other contexts these inequalities are the byproduct of the process of technology implementation in educational systems (Selwyn and Facer 2013; Sianou-Kyrgiou and Tsiplakides 2012; Selwyn 2011, 2013). Social inequalities are located in unequal distribution of incomes, political power, societal leverage, housing, and so forth. The educational inequalities that result from them not only impact the life chances of the individuals in these social conditions, but also of their children, and probably the other generations to come. Issues of technology making education fairer and more just are quite crucial in their societal relevance. Selwyn (2011) elaborates on the idea that educational systems are somehow responsible for the social inequalities regarding their subjects (pupils, students, trainees, and so on), but the digital technologies have the potential to change this trend.

Discourses of freedom and fairness have been quite present during the technological innovation in the 20th century. One example is the development of computing in a Californian “hippy” atmosphere governed with the values of freedom, solidarity and equality; other examples are the “hacker ethic” and the promotion of free information and access to all the people without any discrimination (Selwyn 2011, p. 94). The internet in general is considered as a ‘platform’ legitimizing free use of digital technologies, sharing and acquiring information, as well as knowledge-production. This, in turn, contributes to a more just societal organization. Moreover, at a macrolevel, this technology is seen as loosening the hierarchical organization of society and institutions with its networking logic; while at a microlevel, it also influences the choices of individuals to live a life with no barriers and free to engage with technology when and where they want (Selwyn 2011).

Technology is often viewed in education along its societal equity, fairness, and democratic values. What are some societal benefits of digital technology in education? First, digital technologies can foster a greater diversity of educational provision, both formal and informal (see also subsection 2.3.3.1). Especially with the advent of the internet, this range of possibilities increased exponentially, as the learner can chose to get education from a wide range of providers without any barriers whatsoever. They can find different formats of education such as online or distance learning, as well as other forums not associated with formal education, such as Wikipedia, Google and other websites (Selwyn 2011). Second, the diversification regarding sources of education eases the educational barriers, like financial cost, remote school-settings, physical access problems (people with disabilities), type of curricula, and long-time exclusion from education. Information and communication technologies have eased these obstacles by affording remote and online education to many marginalized groups.

Third, digital technologies empower the users to choose their education and have more control over it. Individuals are able to seek their own way of learning, create and maintain connections with different educational institutions, and manage their own education as they see fit. The ‘new breed’ of learners beside the formal education, should also engage in self-learning and be reflexive about the skills they learn and the ones to improve to be more competitive in the modern job market (Selwyn 2011). Although, digital technologies such as the Internet and Web 2.0 are heralded as transformative and increasingly influencing education, other commentators claim that few learners are exploiting the advantages that technology is offering. For instance, in many cases diversity of education extends mainly in topics such as IT, English, and Business. The claim that educational technology is ‘crushing’ educational barriers doesn’t account for the other barriers that technology itself is building up for teachers and learners, such as the level of incomes, time available, knowledge or skills, and a community of support. Furthermore, researchers should also consider the individual motivation to adopt them and not just the distribution or availability of these technologies (Selwyn 2011).

3. Research Question

The virtual microscope (VM) 2.1 and its improvements have made this technology very appealing to teach microscopy in the department of pathology at Medical University of Graz. Students can access the learning content in their own timeframe and from different devices. The interactive functionalities of the explanatory feature, visualization, magnification and moving within the sample, facilitates the apprehension of the morphological structures of the sample (Int-Professor 001). My focus, however, is on the teachers' experience with this technology and how has it affected their teaching practices. To help me on this quest, besides the four interviews with the professors in the department of pathology, I have also conducted two interviews with the tutors in this department. Since they have helped a lot during the implementation phase and are actively involved in the seminars by explaining the students the histo-morphological structures of the samples, I decided to inquire also regarding their experience in how VM 2.1 has impacted learning and teaching.

Teachers are one of the main actors in the pedagogical system. They are obviously a crucial factor in the implementation of educational technologies in higher education. Maybe the claims of a digital gap between students and teachers are a reality in many educational systems concerning the application and implementation of digital technology in classrooms (Hargittai 2010; Selwyn 2011; Sianou-Kyrgiou and Tsiplakides 2012). Nevertheless, the aim of this study is to inquire thoroughly whether technology has transformed or impacted teaching practices, and this involves also assessing the digital divide (if it's the case or not) between teachers and students (Selwyn 2011; Sianou-Kyrgiou and Tsiplakides 2012). An obvious emphasis will be placed to the rapport teacher-student, and the overall impact of VM in the pedagogic approach towards microscopy in histopathology.

3.1 Main Research Question

My main research question is as follows: <u>How has the virtual microscope reshaped the teaching practices in the pathology department at Med Uni Graz?</u>

I believe that a clear research question can better highlight the scope of the research. Here, as stated before, the main aim is to study the teachers' perspectives or experiences about the usage of VM 2.1 in teaching the pathology-related courses at Med Uni Graz. The teachers' perceptions, opinions, and experiences regarding this virtual technology are a valuable 'pool' of qualitative data to better assess the effects that it had on teaching and learning microscopy. I am using the term 'reshaped' as I believe that 17 years of history (initially implemented in 2001) with a virtual microscope, the constant improvements and the update to a 2.0 and later 2.1 version, is a confirmation that it has obviously affected the teaching and learning practices at Med Uni Graz. Prompted by the theoretical strand of Actor-Network Theory (ANT) that I have employed in this thesis, I started my reflection with the following questions: How are the roles of different actors (such as teachers, tutors, VMC/eLearning Team, students, and the virtual microscope) in this setting performed and enacted? How can we make sense of the influence that digital technology has on pedagogy? How do the diverse actors, be they humans or nonhumans, change and transform teaching and learning in the department of pathology at Med Uni Graz? How is the complexity of the interplay reflected in these actors' actions after the full implementation and stabilization of VM 2.1?

Teachers, tutors, and the VMC/eLearning Team are equally crucial human actors in this setting. The first "source of action" responsible for delivering education and the primary consultants of implementing new technologies, are teachers and tutors of this department (Latour 1996, p. 373). On the other hand, the other pivotal human actor is the VMC/eLearning Team with their technical expertise that has facilitated the implementation and support of VM. The VM is the nonhuman actor (Latour 1992; Latour 1996), which as suggested by students questioned in Med Uni Graz, is giving a substantial contribute in improving their uptake of eLectures (Rehatschek and Hye 2011). The complex interplay between actors will be an overarching topic in this master thesis.

3.2 Research Sub-Questions

The sub-questions chosen as a backdrop and a supporting pillar for the main one, are also targeting teachers' experience with this digital imaging technology. As in the case of the main question I will explain the research motives behind these questions together with some issues that I want to inquire in this master thesis.

1. How are teachers adapting to this technology and to what degree is it affecting their job?
2. What about learning? How has VM 2.0 impacted their interaction with students?
3. How is pedagogy in this setting affected by the implementation of this technology?

The first sub question inquires further the teachers' own reflections regarding how they are adapting using new media applications and virtual technologies. Are there any difficulties that they encounter while engaging with this technology or other new technologies? There are long and short-term consequences of applying and adopting technologies in the medical settings and normally teachers should diligently address them as they affect their everyday job (Prentice 2013). Especially in clinical practices is quite a challenge for medical practitioners to divide themselves between engaging with patients and teaching medical students. Virtual technology supposedly should facilitate teaching in these settings and save time for medical practitioners to deliver care (Prentice 2013; Satava 2006, 2008). How has the virtual microscope affected the time-optimization of these teachers between their different tasks? Do they have more time now to engage with clinical practice and teaching?

The second question shifts the attention to the teacher-student interaction and the role that VM has played in this relationship. Maybe, teachers and tutors cannot be the spokespersons for their students', but they have their ideas about how VM has impacted this interaction. Innovative teaching environment such as those constructed around VM 2.1 and the Virtual Medical Campus (VMC) have effects and possibly improve both teaching and learning (Rehatschek and Hye 2011; Lin and Chen 2013). How is students' performance and engagement affected concerning the courses based on VM 2.1? Is there any causal relation or correlation that teachers or tutors can identify in this case? It is necessary in this research to have the students represented somehow, and the best way is to ask the teachers and tutors about the relationship with their students driven by technological change.

Finally, the third question takes on a more general quest in inquiring about any impact that this technology has had on the pedagogical approach regarding microscopy and pathology. If an application can leave its traces on the teaching practices (approach) in microscopy, then it has somehow fulfilled its first role of bringing change in education (Lin and Chen 2013; Welle-Strand and Thune 2003). How is pedagogy at Med Uni Graz affected by the implementation of VM 2.1? Are there other efforts (as the VM 2.1 example) regarding digital technology currently being implemented or planned? The collaboration between the department of pathology and the VMC/eLearning Team is a sign that the pedagogical rationales are headed toward ICT-based solutions for teaching and learning in this medical setting. How is the interplay between these two entities making possible the ongoing VM 2.1 project? How are the different instances of interacting with this technology perceived by these two actors?

4. Theoretical Framework and Sensitizing Concepts

As part of my theoretical framework I will employ Actor-Network Theory (ANT) because I believe that social sciences, especially sociology of science needs to engage thoroughly with its object of research. By engaging thoroughly, I mean that the material and the social shouldn't be detached from one another but in constant interaction and re-formation (Law 1992; Latour 2005; see also Law 2004: Glossary). In contrast with the critical sociology that often uses ontological categories such as 'society', 'science', or 'technology' as an explanation for a certain phenomenon, ANT considers these ontological entities more as outcomes or effects (Law 1992). To make sense of the changes and impact that technology has had on teaching microscopy, it is imperative to highlight the roles and actions of human and nonhuman actors in this context (Latour 2005).

The sensitizing concepts that I have chosen to reinforce the theoretical mainframe are strong tenets of ANT. These notions are translation – as we will see in the following section one of the most prominent concepts of ANT (Law 1992; Callon 1986; Latour 2005) and the principle of delegation (Latour 1992, 2005). The sensitizing concepts will help me to highlight the roles of the actors, how the network is changed and transformed, and the main impact on teaching and learning practices within the department of pathology at Medical University of Graz.

4.1 Actor-Network Theory Rationales

4.1.1 What is an Actor-Network Account

Latour in his 2005 book "Reassembling the Social: An Introduction to Actor-Network-Theory" retrospectively traces back the origin of ANT within social sciences or more specifically sociology. Thus, when reflecting about sociology of science, the new entities that 'invaded' the discourse were the objects itself, "associated with the former social entities" that several social scientists were studying[17] (p. 106). The actors which agency influences and makes other actors do things are mediators as opposed to intermediaries – the ones that doesn't cause any change or are just passive subjects. Nevertheless, the differences between them are subtle and sometimes the same actor can transition from one to the other (Latour 2005, see also Latour 1993).

The problem, Latour (1988) argues, is not to separate and isolate science and technology in their 'ivory tower', but to bring them down to the ground. The forces and factors that influence and transform them are by no means defined or explained. The initial diffidence was reflected towards the use of the term 'social'. In many cases, Latour (2005) argues, social scientists throw this adjective around to describe different phenomena, even the ones strictly related with the material objects. The social cannot be at the same time the reason and the cause behind different assemblages of humans, objects, collectives, norms, and so forth.

[17] Beside Bruno Latour, John Law and Michel Callon were the other authors engaging with ANT and also the ones that the author refers in the 2005 book.

But then, what is science? What is technology? What is knowledge? The "actor-network diagnosis" encompasses a broader view: they are products of processes, materials, artefacts, devices, organizations, and institutions (Law 1992, p. 381). These are heterogenous or hybrid products that involve at the same time society, technical enterprises, practical skills, and the conceptual basis, which are ultimately translated in the byproducts that we call scientific knowledge or technological artefacts (Law 1992; Latour 1993; Akrich 1992). In this analytical view the social, but not only, should be seen as a network of heterogenous materials with different patterns (Law 1992).

This is how Actor-Network Theory finds its departure point from social theories, but pursuing a slightly different goal. Since sociology has broaden its fields of inquiry by also including studies of science and technology, there is a need to reform the theoretical approaches, especially the sociological ones and the emphasis they put on 'the social'. ANT sets off to counter 'the sociology of the social' and instead proposes to engage in a more grassroots methodology: that of tracing the associations between different elements in a certain setting called 'the sociology of associations' (Latour 2005).

Thus, the social factors, forces, or reality are not uncontestable concepts that explain everything in science and technology. There is so much more in the actors that participate in these contexts, which is not necessarily fully explained by the observers, and moreover not by taking society as the frame of reference but rather as an element of the bigger frame. Sociology needs to seek the associations between the different actors, are they strong or weak, if it wants to make sense of a scientific or technological system (Latour 1988, 2005).

The social sometimes is shrunk to the social problems and is more considered as a 'debris' resulting from what has already been allocated to the political, economic, scientific, and technological (Latour 1988). Nevertheless, according to Jasanoff (2004) the social comprises "social practices, identities, norms, conventions, discourses, instruments and institutions" (p. 3) – scientific knowledge and technology are also part of it. The idiom of co-production brings the social and the material together, building more upon the ANT rationales of the mutual constitution of Nature and Society (Jasanoff 2004). The social is so entangled and knotted with the material that is nearly impossible to determine which phenomenon belongs to the former and which to the latter (Latour 1993). For instance, the problem of climate change is both 'man made' (social) and also natural in its expression and constitution.

Again, to the 'dismay of sociology', the social is as hard to explain, even harder than the technological, because when a social scientist tries to explain another system (for instance digital technologies in education, Selwyn 2011), it does so within the logic of this system (Law 2008). The resulting explanatory interaction between the social and the system changes both these components. Digital technology in education can be explicated through social relations of political governance, educational policy, and commercial interests, but in turn it also influences how we see the societal context. The interaction of different elements is as much material as it is social: people, organizations, technologies, institutions, knowledge, documents, and so forth are all entangled in a network and they, being also actors, have agency within this network (Law 2008).

Actor-Network Theory is often addressed as a material-semiotic approach. Material as it was interested in the objects of inquiry without distinguishing between human and nonhuman actors (Latour 1987, 2005). Semiotic because it is interested in the signs and the symbols that constitute the object of study, but it goes further by inquiring not only the representation of these symbols, but all the elements that constitute them (Latour 1993). The value of these symbols is defined by their relation to the system and the other elements that are part of this system. These entities are formed and gain their attributes from the relation with the whole network and its other constituting entities (Law 1992). This material-semiotic approach, in the optics of ANT, should inquire about how the relations of objects with humans and concepts are formed, rather than the reasons why they are formed (Latour 1993, 2005). Law (2008) addresses the material-semiotic approach from the ANT[18] perspective as "[i]t is about performativity. It is arguing that <u>realities</u> (including objects and subjects) and <u>representations</u> of those realities are being enacted or performed simultaneously." (p. 13, underlined in the original)

If we think about virtual technologies and their adoption in education, it is easy to define their semiotics. For example, what does it mean virtual in the microscopic world? What is a virtual technology in this sense? If we ought to think about 'the virtual' as a simulation in a digital device, then we might as well think that none of the microbes or cells exist in the real world[19]. But when we see them in a physical microscope, we are directly seeing these minuscule entities with its mediation (Latour 1992), so they must be real. Now here is the 'semiotic issue' and why the signs and symbols are not enough in making sense about a system or a phenomenon. If we break down the virtual microscope in its constituting elements, we will see that before the virtual rendering of the tiny cells or microbes in a digital screen, the pathologists have seen them in the physical microscope (see also Hacking 1983 about issues of what we see with the microscopes and how are we certain that it is the 'real thing'). Then, through a digital scanner they have 'translated' the real world into the virtual one (Latour 1992, 2005; Law 1992).

By adopting this kind of stance, Latour (1993) argues that researchers should trace the associations between the social and the technological, and not view them divided in two different entities. If we are placing more emphasis on the 'technological' the immediate risk is to fall into technological determinism (see also the discussion in this research context in subsection 2.3.7). On the other hand, if the 'social' is the main concept disregarding technology or science, we will blindly head

[18] Feminist studies, especially Dona Haraway works, belong also to a material-semiotic approach, which differs from actor-network accounts, despite the similarities.
[19] I am simplifying the argument for the sake of the example.

toward social constructivism (Akrich 1992; Latour 2005). The first, doesn't pay attention to the network created around technical or scientific objects. While the second disregards the material as having any sort of agency and regards as actors only the human ones (Akrich 1992).

Law (2008) stresses the fact that there is no normative distinction between the social and the technical. Jasanoff (2004) proposes the idiom of co-production to understand the relationships between the two and more entities involved in this dilemma. Moreover, it is quite difficult to comprehend the character of social change or its stability, whether are people or objects the causative drive for this change. Social realities can shape technological devices, but they also can be shaped by the latter (Law 1992). Thus, digital technology can improve educational provision through remote or online learning for people that have physical barriers regarding education, but in turn it is also reshaped by these users as they give constantly ideas and feedback about the main problems and how can they be solved in their specific context (Selwyn 2011).

4.1.2 Actors

ANT is recognized for its focus on the different actors, be they human or nonhuman, and their complex interplay in producing change or stability in a certain network. In the laboratory of Monsieur Pasteur 'strange things' were happening that shaped the way we look at microbiology and epidemiology nowadays (Latour 1988, 1983). The interaction between human actors such as Pasteur and his collaborators, and the nonhuman actors such as the different devices but mainly the microbes, changed the power relations within French society. By shifting the reality of the microbes, as causing diseases among cattle in the French rural area, to his laboratory and working on this micro-scale, Pasteur was able to change forever science and society altogether. How did he do it? "[*I]n his very scientific work, in the depth of his laboratory, Pasteur actively modifies the society of his time and he does it so directly – not indirectly – by displacing some of his most important actors*." (Latour 1983, p. 156, italics in original).

The displacement was followed by a deployment of other actors, the nonhuman ones (Latour 1987, 2005). The power of nonhuman actors such as microbes was affecting human life itself. Displacement and deployment are followed by a new alliance between the human and nonhuman actors as in the case of Pasteur, his laboratory staff and the microbes. Despite the ontological differences that they have with each other, for a researcher is more important to understand the new associations between these actors (Latour 1987). Often, we are not aware about the chain of actors contributing to a change in the network. For instance, when students learn about pathologies of the respiratory system, they have to use the microscopes to identify the pathogens; the virtual microscope guarantees furthermore the possibility to store and re-consult the physical slides; in this way not only the immediate purpose of diagnosing and learning is achieved, but it can also be used as a repository of knowledge for medical education.

Actors are the genesis underlying the critical standpoint that Actor-Network Theory has toward classical sociology. The division that the latter has created between nature and culture and for that matter between human and nonhuman actors is not in the best interests of modern social sciences. In a nutshell the division is framed as nonhumans belonging to nature and humans belonging to culture (Latour 2005). Latour advocates precisely for the opposite, that society is a hybrid construction of both entities that through purification are divided, but through mediation are brought back together. Thus, translation practices create hybrids of nature, culture, society, humans and nonhumans.

4.1.3 Networks

Networks are created in diverse ways and they can transform the society that 'hosts' them. They are almost and exclusively hybrids, shaped by different actors and factors (Latour 1983). The example of Pasteur and the discovery of the anthrax vaccine for cattle shows how changing natural macroscale conditions (cattle disease) into microscale scientific operations (isolating and identifying the causative agents, microbes), together with the new scientific discipline - statistics, constitutes a heterogenous but functional network[20]. Thus, the displacement and transformation triggered by the different actors, be they human and nonhuman, contribute in the creation and stabilization of a certain network (Latour 1993, 2005). This is a kind of 'coalition' between nature and culture, human and nonhumans, as well as technology, science and society. Actors negotiate with each other, align their interests by means of translation in order to stabilize the network (Latour 1988, 1983, 1992; Callon 1986).

As in the case of the alliance between Pasteur and the microbes, the mobilization of different actors can create a specific network, stabilize it, and change it whenever a transformative action occurs (Latour 1983, 1988). Each time that a new actor approaches a certain network translation and negotiation happens again (Callon 1986; Latour 2005). Networks based on technology are quite fragile in this sense, and because they work as a package, we barely notice them (Latour 1988, 1983; Law 1992). In this sense, actor-network theorists talk about "punctualization" as a well-functioning network, albeit precarious and unstable, which is simple to be identified and understood (Law 1992, p. 385) It is not until they break down when we usually are aware of the existence of this structure, its elements, and its inner working.

Law (1992) regards the social as a series of patterned networks comprising different heterogenous elements. The social is not limited to the human but is a hybrid construction of nonhumans, textual accounts, technologies, and scientific products. Power is distributed unevenly but that doesn't mean that the humans are the most powerful agency in every network. Sociology should try to make sense of the different bits and pieces of these networks, how are they organized, who holds

[20] Laboratory studies, especially those of Bruno Latour, are somehow the predecessors regarding the concept of network. The transformation from macro to microscale, the displacements, and then the deployment or translation of actors' interests is clearly evident in laboratories, thus giving an alternative and interesting description of how scientific facts come into being (see Latour 1983 and 1988).

and exercises power, and how is it distributed among the various actors. These networks of people and objects are not only participating in the social, but also reshaping it. This colorful participation is responsible for the "social order", if one of the entities were to miss, be it human or nonhuman, then the social order will not be the same and it can also cease to exist (Law 1992, p. 382).

Actor-networks are subject to translation. It can make some materials more durable thus exercising more power or embody relation, for instance a text or a building is a material made durable (Law 1992). Another aspect of the network and the effect that translation practices have on it, is the power to act in distance or to shrink the space by what Latour calls *immutable mobiles* – orders, information, advices, weapons and so forth (Law 1992, p. 387). Translation can assess and also contribute on the network stability by anticipating the reaction or responses of the materials and actors that should be translated. Ordering a network is difficult but also attainable through translation, the only problem is to devise and apply strategies that manage not only the actors but also the effects of their actions.

4.2 Sensitizing concepts

4.2.1 Translation

The concept of translation is an underlying cornerstone of Actor-Network Theory as discussed throughout this chapter (Latour 1992; Callon 1986; Latour 2005). Translation is a transformation, a delegation, a displacement, of action that reshuffles what the critical sociology calls the social. Thus, the social is made understandable by the multiple levels of translation in which actors interact with one another within a network (Latour 2005). Leaving aside the definition of translation in an actor-network, in this subsection I will discuss translation specifically divided in four stages to make sense of how the virtual microscope has unfolded in the context of pedagogy (Callon 1986).

Callon (1986) defines four phases (moments) of translation "during which the identity of actors, the possibility of actions and the margins of manoeuvre are negotiated and delimited" (p. 203). Before going in detail about the phases, I should clarify again some points that will also help me later in thinking about my specific case. First, an issue to be addressed is that all the actors participating in this network are equally important and with their own relevant agency. Second, the social and the material are entangled together, and the sociological analysis should not favor more the former than the latter. Third, to better study these controversies or uncertainties regarding the context of the scientific, the technological and the social, as well as the roles of the actors, social scientists must be careful and flexible (Callon 1986). How can researchers overcome all these difficulties? Initially by being impartial about Society and Nature, and about the agency of the different actors; then the accounts should be symmetric within a single repertoire for both the social and the material; and finally, stemming from the previous, the social scientist must leave aside the preconceptions about the case at hand and just follow the actors to understand the context (see also Latour 2005).

The first moment of translation is problematization. One of the actors takes the initiative to define who are the other actants. Since, they are the initiators they also take upon themselves to define the rapport or relationship that they have with each other. The first instance of identifying the actors is accompanied with a definition of common interests among them. Both instances are regarded as problematization. For example, the virtual microscope was defined by the teachers in the department of pathology (Med Uni Graz) as a good tool to improve learning microscopy. They identified the other human actors (tutors, eLearning team, and students) and also the nonhuman ones (the physical microscopes, digital scanner, and the virtual microscope). After that, they defined the interests of each party in this project in order to achieve a proper backdrop of collaboration.

Interessement is the second phase of the translation process. After problematization has defined the actors and the roles that they should play, interessement sets an entity to impose rules and the further actions that they should carry on. The links created between actors that choose to associate together are clearly separated from the others that haven't chosen to engage in the same network. In order for interessement to properly occur the main actors (the initiators of problematization) propose devices which make the other actors to redefine their identities (Callon 1986). Thus, teachers in the department of pathology engage tutors with the role of carrying out the main practical and technical processes, transforming the normal slides into digital ones. They also engage the eLearning team to make possible that these digital slides are integrated in the virtual microscope. In this way, both tutors and eLearning team have redefined their roles and identities to make sure that the virtual microscope is properly implemented.

The third phase that follows is enrolment, which "designate[s] the device by which a set of interrelated roles is defined and attributed to actors who accept them. Interessement achieves enrolment if it is successful. To describe enrolment is thus to describe the group of multilateral negotiations, trials of strength and tricks that accompany the interessements and enable them to succeed" (Callon 1986, p. 211). Finally, the last stage mobilization assesses if the actors engaged to perform the roles are spokespersons or representatives of themselves or of a nonhuman actor. In our case, the tutors have accepted to play the role designated and they are also spokespersons for the digital scanner and the physical microscopes, teachers on the other hand check what tutors have done, but also ultimately what the eLearning team has done (they are responsible of the digital images and the final product: the learning content of the virtual microscope).

4.2.2 Delegation

The idea or notion of delegation stems from the translation practices that actors are subjected to when they enter a network (Latour 1988, 1983, 1992). The action is translated, dislocated, or delegated from one actor to the other. For instance, how did Pasteur exercise the transformational force through his laboratory? He did it by taking a macroscale event such as the disease of anthrax in cattle and putting it in a microscale context (Latour 1983, 1988). He delegated agency to the microbes and the inscription devices to shrink the macroscale into microscale and thus maneuver more easily. Delegation in this way, is the agency granted to nonhumans, to carry out tasks that otherwise would be bothersome, repetitive and time consuming for us humans. The deployment of actors as mediators (entities that change something) in a network is achieved through translation and delegation (Latour 2005).

"I will define this transformation of a major effort into a minor one by the words displacement or translation or delegation or shifting" (Latour 1992, p. 154). Thus, to think about the importance of delegation is to think about the burden of different tasks for us humans, when there is the alternative of nonhumans doing it and 'not even complaining'. Again, addressing the material and its role on the social network means that we should define the degree of transformation or change to understand if this translation or delegation is successful. Delegation to humans is more complex. The roles and agencies of human actors are so diverse and their motivations to act so different that it doesn't guarantee the same reliability that nonhuman actors have in this context. Nevertheless, Latour (1992) simplifies the notion of delegation in this sense as he views it as an investment when it concerns the nonhumans, and as imparting discipline when it comes to human actors.

In this research context delegation is slightly different, especially if we refer to the translation moments discussed in the previous chapter. There are several instances of delegation among the human actors. Depending on the area of expertise and hierarchy these instances of delegation are reflected accordingly. For example, tutors being the assistants of the teachers have to scan the slides, integrate the explanatory text, and delegate them to the eLearning team in order to make the proper changes to fit the digital slides into the virtual microscope format. Thus, the initial top-down delegation from teachers to tutors is then transposed into a delegation of agency to a different area of expertise, that of informatics (eLearning team). In between, all these human actors delegate several tasks to the nonhuman ones – viewing the normal slides to the physical microscope, scanning the slides to the digital scanner device, and to the programming languages or designing software the task of embedding the digital slide into the virtual microscope format.

5. Materials and methods

I have conducted in-depth, open-ended interviews with four teachers and two tutors at the department of pathology (Med Uni Graz) to find answers regarding my research questions. Two separate questionnaires were devised for each group. Besides teachers that are in the focus of this research, tutors[21] were also crucial in the development and implementation of this technology. Moreover, being also the teaching assistants regarding the classes related with VM 2.1, their views and experiences are central to many arguments that will unfold in the next chapter of the empirical analysis.

I have interviewed all the teachers using the same interview guideline (questionnaire) to facilitate the data analysis part and to keep the focus on the research questions. The interviews with tutors were organized with a different questionnaire tailored more to the context and the role they have as teaching assistants and during the implementation of VM 2.1. Both questionnaires, and the informed consent are in Annex A, B, and C respectively. Before the actual fieldwork that took place from February to May 2018, I had one informal meeting in November 2017 with representatives of VMC/eLearning Team. During the fieldwork I had two more meetings with them and also a Professor from the New Media department.

The written materials that I have used for this thesis concern three articles from Med Uni Graz (VMC/eLearning Team). Virtual lessons based on VMC/Moodle are introduced in the diploma study of human medicine courses (Rehatschek, Hölzl and Michael Fladischer 2011; Rehatschek, Hölzl and Hruska 2011). The article that discusses the implementation of the VM 2.0[22] was the departure point for this thesis. With two of the interviewees I had one follow-up email to clarify some of their responses or arguments that were problematic after the initial coding phase. These emails will be used as background material.

The next section will discuss briefly these materials and the interviews. Then, I will discuss why I have chosen this methodology, how to think about the participants in the interview process, several strategic advices to properly conduct an interview, and finally the ethical dimensions of qualitative methods. The analytical part will focus on grounded theory, by elaborating how I engaged with initial coding to allocate possible codes and link them to a more focused and theoretical background. Finally, I will briefly elaborate on the data analysis process.

[21] The initial suggestion about interviewing the tutors in this department came from one of the professors interviewed that explained me their role during and after the implementation of VM 2.1. VMC/eLearning Team also advised me to interview them because they are the mediators of this technology and could elaborate both on teachers' and students' experiences.

[22] The previous version of the current that I am inquiring, VM 2.1.

5.1 Materials

The first written materials that I have used to understand and build up the research context are the studies conducted at Medical University of Graz. The three articles that I have used here focus on the virtual microscope and the virtual classroom. The actual eLectures at Med Uni Graz are a mixture of both. Rehatschek and Hye (2011) describe the transition from VM 1.0 to the 2.0 version and how it was embedded in the new Learning Management System (LMS) VMC/Moodle. They give an overview of the technical steps needed to implement it and also conducted an evaluation study among students to gauge the impact of the new version. This article was the starting point of my research. Rehatschek, Hölzl and Fladischer (2011) describe the implementation in 2010 of the new LMS VMC/Moodle, its technical advantages of performance and scalability, the impact on students at Med Uni Graz, and how was it used to 'host' virtual lessons. Rehatschek, Hölzl and Hruska (2011) explain the implementation of the virtual lessons in the diploma study of human medicine at Med Uni Graz and the integration within the course administration system MEDonline.

The emails exchanged with one of the professors and one of the tutors will be also considered as part of the materials. One of the professors sent me an email to explain the dynamics of how a prepared digital slide was implemented by the eLearning team and the problems that could arise[23] during the exchange of information. The tutor replied to my email where I was asking for some clarification about a phrase that was ambiguous in its meaning but crucial to make sense of the argument.

Fieldnotes of course are another good source of material for the empirical analysis as they help in recalling different parts of the interviews and the fieldwork. Discussions with the eLearning team were also noted down and served, besides the email exchanged, as a backdrop for the sections about technical details in the empirical analysis. Finally, the most important materials, where the subsequent empirical analysis is based, are the six interviews conducted at Med Uni Graz. Professors and tutors elaborate on their experiences regarding the implementation and teaching with the VM 2.1. The different interview guidelines are adapted to the interviewees' profile (tutor or professor) and inquire about the research questions together with other important aspects concerning this technology[24].

5.2 Methodology

5.2.1 Why interviews?

In-depth, open-ended interviews were chosen as the best alternative to study groups of people that are experts in certain fields (Gubrium and Holstein 2003). Robert Weiss argues why interviews are the best

[23] Wrong picture, bad resolution, or wrong text for the explanatory feature were among the main problems during the implementation, in which professors-tutors-eLearning team were in constant interaction and communication to solve them.

[24] For the interview guidelines see the Annex A and B. In the next chapter of the empirical analysis I discuss more thoroughly about the aspects concerning VM 2.1 and how the research questions were reflected in the questionnaire.

tool to study people that you don't know, as "[it] gives us access to the observation of the others; […] we can learn about settings we have never lived; […] [i]nterviewing can inform us about the nature of social life; […] [w]e can learn also, through interviewing, about people's interior experiences" (Weiss 1994, p. 1, cited from Gubrium and Holstein 2003, pp. 26-27). Järvinen (2000) emphasizes that "interviews are sites of knowledge production" (p. 384), collaborative meaning-making efforts, but also enacted by the interviewees over and over sometimes, which makes it difficult to focus on their interpretive framework as the answers can be rehearsed and practiced many times before in other interviewing contexts.

If we want to inquire about something, then we should try to capture the genuine and original voices of the respondent. Open-ended and in-depth interviews are designated to dive deep into the experiences of the respondent, his or her emotions, perceptions, perspectives, etc. (Gubrium and Holstein 2003). Despite the richness of data collected by this type of interviewing and the improved procedures, the main value stands in that this kind of interviews construct narratives collaboratively between the participants. Interviews are not just a research tool, we must also be aware of the entanglements that it has in the societal, institutional, and cultural dimensions. However, at the same time researchers should not let the broader dimensions that could affect the interview cloud the data collecting process. Interview technologies, societal contours, and the subject are constantly reflected and constructed in the qualitative interview practices (Gubrium and Holstein 2003; Järvinen 2000).

5.2.2 The Participants

Interviews *per se* are a colloquial exercise between an interviewer and the interviewee (respondent[25]), in which the researcher is inquiring about something that the respondent could provide some answers about it. Gubrium and Holstein (2003) state that the respondent gives the answers to the questions posed by the researcher in the order fashioned by the latter and are not responsible for managing the encounter and timeframe of the interview. Nevertheless, the interviewee is entitled to ask questions to clarify something and the interviewer should address them. The emerging sense of individuality, especially in the modern interview society (Gubrium and Holstein 2003), has prompted respondents to recognize that their opinions, ideas, experiences, and perceptions truly matter and can be subjected to different societal interactions. Every respondent is someone worthy to listen to and able to describe events, give factual accounts, explain and define his or her experiences, and explicate how-s and why-s to the concerned researcher. The only thing the latter should do is organize the interview in such a way that gives space to the respondent, respect them, listen carefully, and display concern about what the they have to say (Gubrium and Holstein 2003).

The interviewer must not influence the interviewees' responses and beware of anything they might say to cloud or distort meanings, or even intervening in the answers that the respondent is

[25] In this chapter I use the two terms interchangeably.

providing. Similarly, the interviewer should refrain from giving different suggestions during the interviews, or advance frames of reference that are not derived or explicitly stated by the interviewee. The process of interviewing involves neutrality from the researcher's perspective. Their role is to merely encourage answers, or being a facilitator in case the respondent is unable to give a fully accountable response to the question or is deviating from sincerely answering it.

Limiting the involvement of the researcher and engaging in such a way constantly from one interview to the other, makes a good passive interviewer that focuses more on the interviewee's accounts during open-ended interviews (Gubrium and Holstein 2003). However, since interviewing techniques in qualitative research are evolving, so has evolved the role of the passive interviewer into an active one that engages in constructing meaning from the responses of the interviewees. Certainly, this is not a one-way deterministic construction of knowledge, it is done collaboratively with the respondent, which is empowered in having an active role in the interview process (Gubrium and Holstein 2003; Järvinen 2000; Brinkmann and Kvale 2004).

5.2.3 Guiding Principles for Interviews

In this section I draw on Hermanowicz (2002) article that gives 25 strategies for studying people in bed. I want to improve my (qualitative) interview skills, and I am conscious that the main problem is the lack of experience in interviewing people based on a predefined research question and interview guideline. During my master program we had some useful exercises whose aim was to develop skills in interviewing people based on a research study (first class of Qualitative Methods, first semester). During this master program I have also tried to hone my skills of interviewing by having informal conversations with my peers and trying to 'interview' and listen to their reasoning about a question posed to them. In this way, at least, I have practiced on my listening skills and the ability to frame a conversation. Now the job gets difficult, you may be able to conduct a nice conversation in which both participants are enjoying the time, but to conduct a conversation in which you are the researcher and the respondent is the subject whose experiences, opinions, ideas, perceptions and so forth you are trying to assess, is quite another thing. Without discussing the process of data analysis (due in the upcoming sections), I will state here the main principles that I would like to frame my interviews upon.

As Hermanowicz (2002) puts it, the first thing to do when you are thinking to conduct an interview, is to pretend that it is a dating situation. The first thing is to *converse*, you can learn many things from the respondent if you have a steady flow of conversation and avoiding the mechanistic-type exchange. Then, you have to *listen*, a researcher must be able to "hear" data (p. 483), and listen not only to what is said but also to what has remained unsaid. What is *important* in your respondent accounts, what do they value the most in this narrative, what sorts of *meaning* can be conveyed here? These are other relevant aspects during the interview process. Respondents tend to give general accounts and not detailed ones; thus, interviewers must *probe* them constantly (by asking follow-up questions when is needed) in order to obtain detailed answers rather than overly general statements which translate into poor data. *Persistence* goes hand in hand with the latter as the interviewer might be forced to ask clarifying questions or stress a difficult one to obtain more information from the interviewee.

Time is also important in interviews, they should not be short or even too long, a normal timeframe should be at about one hour. This depends on how many questions the interview guideline has, twenty to thirty questions along with probes could also amount to one hour and a half interview, which is still an acceptable timeframe. Questions must be *clear*, they ought not be too much packed but not dry or unsympathetic either. They have to be short enough and specific to trigger a good response. *Structure the questions*, starting off with a strong note like introducing what your study is about, beginning the interview with introductory questions, in the middle the difficult ones, and end on a positive note (Hermanowicz 2002). After that, it is easier to divide the interview into *topical stages*, each group of questions framed in a broader stage or category following a pre-scripted dynamic (neutral, heating up, and cooling down). *Balance* is the key in the interview guideline, easy questions should be coupled with more demanding or difficult ones to better explore what are you inquiring.

An interviewer must be *candid*, if he or she is not able to do that, then will miss the meaning and the details that could otherwise be provided by the interviewee if asked in the right sincere manner. Nevertheless, the interviewer must preserve the *integrity* of the interviewee in the formal and informal rules of interviewing, showing *respect*, but also guide the respondents' answers when he or she is deviating from the question. In *embodying detached concern*, the researcher "convey[s] respect, self-confidence, and openness on the part of the interviewer." (Hermanowicz 2002, p. 493) Some technicalities before conducting the interview: *test* your questions before the actual interview to see their coherence and consistency (see also Charmaz and Belgrave 2012); *rehearse* the possible scenarios of the interview by 'knowing' your questions; and don't interview people that you *know*. *Record* the interviews to have a solid grasp on the process of data collection, unless the interviewee demands the opposite. *Take notes* immediately after finishing the interview as many insights are fresh and the memory of the encounter is vivid. *Practice* makes perfect; thus all these basic aspects of interviewing must be enacted, rehearsed, and practiced all the time to improve your skills (Hermanowicz 2002).

5.2.4 Ethics in Qualitative Research

Qualitative research interview is a collaborative exercise between the interviewer and the interviewee in which both entities contribute in knowledge production and meaning-making practices (Brinkmann and Kvale 2004; Järvinen 2000; Gubrium and Holstein 2003). By engaging in this interpersonal conversation researchers are changing the human condition in that they are exploring deeply into the life-experiences of the respondent. Thus, a qualitative research interview is imbued with moral and ethical dimensions as well (Brinkmann and Kvale 2004). Qualitative interviewing in the interview society was empowering the participants as distinct subjects holding valuable insights, depicting researchers as concerned listeners, and the overall benefit for the society (Gubrium and Holstein 2003). Brinkmann and Kvale (2004) state that interviews nowadays have also their ‘darker side’, such as reviving “social forms of domination” in the new consumers society, especially in Western countries (p. 158). In their 2004 article “Confronting the Ethics of Qualitative Research”, they question the ethical dimensions of qualitative interviews, initially by posing the comparison between ethically good qualitative approaches and the dull or uncaring quantitative methodologies; and then by laying down the ideas of micro- and macro-ethics, the first being confined inside the interview process, while the latter diversifying in the overall broad benefits of the knowledge produced by the interview.

The question shifts in how should researchers be educated to cope with the ethical reality (Brinkmann and Kvale 2004). The popularity of the qualitative research is that it is embedded in this interview society, or consumer society, in which inquiring about human experience is becoming a very demanded service, not only for knowledge production but also for consumerist purposes (Brinkmann and Kvale 2004; Gubrium and Holstein 2003). The cultural change that transitioned the industrial society to a consumer society, popularized interview as the best way to assess people thoughts, ideas, opinions, and so forth in a more approachable way. The question though remains, what kind of ethical background should the researcher take in account? Is respecting the respondent integrity during the research more than enough? Or, the cultural context of the research is more important? How can a qualitative researcher make sense of micro- and macro-ethics during and after the interviewing process?

According to Brinkmann and Kvale (2004) being a good ethical researcher involves being able to make judgements and decide in concrete situations about the ethical dimensions. Thus, being able to “thicken events” (p. 177), involves *contextualizing* the events or situations that we are in, based on the actual experience and not in theoretical principles; *narrativize* the event temporally and describe it as it is in reality, not by general ethical or moral claims from your own judgement (see also Latour 2005, in why description is better than explanation); *focus on the particular example* and don’t generalize according to ethical guidelines, any particular interview and respondent is unique and should be treated as such (pp. 177-178). In the end, the process of ethical responsible research is meant to make a researcher a good one in concrete situations, and not produce a new theory of the good, or doing ethical research, or being a morally responsible researcher. Learning to observe and make judgements based on the reality, avoids overgeneralization, and builds up capacities of making thick ethical descriptions to produce new and meaningful knowledge from the qualitative interview (Brinkmann and Kvale 2004).

The ethical dimensions of my research begin since defining the questionnaire, which will focus on teachers’ and tutors’ ideas of how the virtual microscope has changed their practices, without interfering in suggesting ideas that I have about technology in education. Their voice is more important than my preconceptions. An informed consent was devised to describe the ethical dimensions of my research, the interview process, data management, and framework of collaboration with Med Uni Graz.

The questionnaires and the informed consent format were previously sent via email to the VMC/eLearning Team at Med Uni Graz, so they had the chance to make suggestions about improving any part of these documents. I consider the teachers of pathology (for that matter also the tutors) as experts in their respective fields (teaching and clinical practice). As such, I would avoid suggesting anything or interrupt them. At the same time, I will try to be reflexive enough to capture the concrete instances of the interview to be able to discern interesting clues that could be an added asset to my data analysis process.

5.3 Data Analysis

5.3.1 Grounded Theory

Qualitative methods and especially in-depth qualitative interviewing fits very well with grounded theory for the data analysis part (Charmaz and Belgrave 2012). Open-ended interviews let the respondent to state and argue their experiences, which in turn give the interviewer useful insights regarding his inquiry (Charmaz and Belgrave 2012; Gubrium and Holstein 2003). Both, grounded theory and in-depth interviews allow for more flexibility and control from the researcher, as he is actively constructing the data and analyzing them at the same time. Thus, grounded theory is an interactive method of data collection, while immediately placing them into categories for comparative analysis with what will be collected in the future (Charmaz 2006).

The process is iterative as the data that are further collected are assigned into pre-defined categories, which will put in motion again the mechanism of coding and re-analyzing them (Charmaz and Belgrave 2012). The process though is not simple, after defining the questions for the interviews, during initial interviews there are other areas of interests that are derived from the respondents' statements, which can change that question in the next guidelines for the upcoming interviews. Although, I have stated that my questionnaire will remain intact because it is in my favor not having different guidelines for essentially the same typology of respondents, I would always take in consideration inserting some 'probe questions' (Hermanowicz 2002), in relation to interesting aspects that I have found in previous interviews.

Data collection is pivotal in grounded theory. Researchers must simultaneously analyze the data while they are assigning them categories that are derived from the coding process (discussed later in this chapter). Assigning data to pre-selected categories, though, presents an imminent risk, that of forcing data into those preconceived categories. This can make the analytical process very dull and could possibly incite misleading claims (Charmaz and Belgrave 2012). In the process of interviewing the researcher must ask the right questions without forcing responses, so it could minimize then the errors of assigning forced categories. Another must for the researcher is to pay attention to the respondents' language during the interview, and in the process of data analysis be careful not to deviate from their language. Collecting substantial in-depth data, letting the respondents to freely discuss their ideas, and inciting them to give complete accounts, limits the possibility of gathering misleading or fabricated claims that could undermine the data analysis process (Charmaz and Belgrave 2012).

Grounded theory researchers must also be careful when they take notes. There are often instances when taking notes distracts either the respondent or them. Notes, nevertheless, are very important to keep track of the conversation, return to earlier interesting points, or just as a remainder for the following stage of data collection. Charmaz and Belgrave (2012) along with the idea of taking notes, also suggest memo writing as a key habit in grounded theory. Memo writing is a middle or intermediate step that links coding to the data analysis draft. The comparative categories discussed earlier are often defined during memo writing. These pre-selected categories along with initial and focused coding are the backbones of a solid data analysis. Memo writing is a kind of facilitating tool that sparks new ideas about the data collected and the researchers' interpretation of them; minimizes the practices of forcing data into ready-made categories; takes account of the steps passed so far in the coding and data collection processes; and defines what is left to be done before the actual data analysis process (Charmaz and Belgrave 2012).

Before we go to one of the most important tenets of grounded theory, which is coding, I will briefly explain why have I chosen the constructivist stance regarding interviews, and how is it understood in the auspices of grounded theory. According to Charmaz and Belgrave (2012) "[t]he constructivist approach places priority on the studied phenomenon and sees both data and analysis as created from shared experiences and relationships with the participants" (p. 349). This stance not only engages with the facts and emotions displayed by the respondent during the interview but takes in account the surrounding environment and unexpected events as possible data to be inserted in the further analysis (Silverman 2006; Charmaz 2006). The researcher should be careful and attentive to the meaning-making practices of the respondents. Thus, the data collected or seen in this way is constructed in a broader social and epistemological context, as well as in place and time. The constructivist approach viewed in this way is an "interpretive portrayal" of the studied world (Charmaz and Belgrave 2012, p. 349), in which there are different and multiple realities. There is a mutual construction of the data between the researcher and respondent, and the researcher has the chance to experience the respondents' world and be affected by it.

Researchers in grounded theory that engage with the constructivist stance try to construct the whole interview process. This begins with defining the questionnaire; then it proceeds with studying the answers and the emotions involved during the interview, together with silences or unexpected events; and after the interview by making sense of the broader context implied from the respondents' answers (Charmaz and Belgrave 2012). Language is very crucial here, as it gives useful insights on how the respondent perceives or talks about his or her experiences, and it will be helpful in the coding process and further analysis (Charmaz and Belgrave 2012; Charmaz 2006). Constructivist grounded theorists assume that the researchers have clearly delineated and are knowledgeable about their field of study. They expect from the researchers to be reflexive and critical about their analytical constructions within the data collected, including the preconceived categories or the coding process. Constructivist grounded theorists define what is happening with the data and how this process is unfolding (Charmaz and Belgrave 2012).

5.3.2 The Coding Process

Coding is the first analytical step toward the conceptualization of the data that a researcher has collected so far. This means closer attention to them, but considering also the researchers' interests, preconceptions, and perspectives. In grounded theory, codes are "sensitizing concepts" that start developing and stabilizing refined notions or concepts (Charmaz and Belgrave 2012, p. 355; Charmaz 2006). Coding in grounded theory shapes the analytical frame and is a supporting pillar starting from data collection, and going through theoretical sampling, with the end-product of the empirical analysis. Practically, coding a certain section of the interview transcription ascribes short labels to a certain section, possibly by using gerunds and highlighting the action that takes place in this section. This must be a very reflexive process in which the researcher must code what the data is telling him, and not something else (preconceptions for instance). Coding is a process of two stages, *initial coding* where the researcher makes sense and defines the data in small sections (word by word, line by line, or incident by incident), while *focused coding* engages in a more elaborated frame were the most used or iterated codes are analyzed to make sense about the data (Charmaz and Belgrave 2012; Charmaz 2006).

Action codes tell the researcher what the respondent is doing or what is happening in that section. They are more specific and shift the attention from the main topic, but it helps grounded theorists to remain focused on the specific section and not engage with theoretical assumptions or preconceived categories. This in turn helps to compare data about the same topic but conveyed by different people; data collected from the same people but in a different timeframe; and new data with pre-established categories (Charmaz and Belgrave 2012). The action codes are a good means to sort out, separate, and select data from the initial phase to the focused one (Charmaz 2006). When the researcher is done with the initial part, he may ask about the theoretical categories that these codes belong to. Some codes depict actions which are closer to the data, some others explain or give reasons, others display perspectives, construct events, and suggest contexts (Charmaz 2006).

5.3.2.1 Initial Coding

Initial coding should be grounded on the data. Every segment is an action which must be defined having in mind the characteristics of the respondent and the context of the interview. The data should be reinstated as actions, it would shift somehow from the main topic, but in the end, it would be helpful to see through these actions and then categorize them theoretically to make sense of the research question. That is why grounded theory tries to engage with data collection conjointly with the initial analysis, in order to keep fresh the interview experience. The researcher in this phase should remain open to any possibilities concerning the theoretical categories. Comparing data with data is useful to see problematics and interesting insights in the respondent answers. In this phase a researcher might ask what type of data is this? What does it refer to? What is it suggesting, how and why? Which can be the most applicable analytical categories in this case? (Charmaz 2006).

Charmaz (2006) defines initial codes as "provisional, comparative, and grounded on the data. They are provisional because you aim to remain open to other analytic possibilities and create codes that best fit the data you have. You progressively follow up on codes that indicate that they fit the data. Then you gather data to explore and fill out these codes." (p. 48) Thus, the process is an iterative and interactive one as a researcher must go back and forth to his data while coding, and try to find possible clues and codes that fit in the broader analytical categories. This process can help a researcher identify gaps or insufficient data in the constructed codes, which is very helpful to frame the analytical process. In grounded theory you can learn about gaps in data during the earlier stages of analysis, and it can help you to locate the data sources and try to address the issue. Adopting this methodology, you have much to explore and discover in your data, and the conceptualization that follows is exactly what grounded theory stands for (Charmaz 2006).

In this master thesis I have used line-by-line coding as it works quite well with empirical problems or processes (such as the VM 2.1 and how the teachers perceive this educational technology). In open-ended, in-depth interviews this type of coding enables a researcher to get a closer look to the data provided by the respondents' answers, their experiences, their statements, insecurities, and tacit assumptions. Some strategies how to use line-by-line coding are: segmenting the data in parts or typology, defining the type of action, being careful on tacit assumptions, explaining actions and meanings, making clear the relevance of the points, comparing data, and identifying possible gaps (Charmaz 2006; Charmaz and Belgrave 2012). These strategies are helpful later to engage with the focused coding and define the axial coding categories. Studying the data in this coding instance helps to understand more the interviewees, what did they said, how, and their reasons behind it. This can lead to new ideas that can really take the research in different unexpected venues.

Line-by-line coding enables you to see the data in a new perspective. This way of coding helps you to allocate the respective data in categories and extrapolate from single actions to whole processes taking place. This prompts the researcher to adopt a critical stance, not only towards the respondent claims, but also to the data collected, and how to make sense of them analytically. On the other hand, line-by-line coding restricts the researcher's preconceptions or assumptions, and keeps him grounded on the concrete data (Charmaz 2006). These codes give also insights of what type of data to collect in the upcoming interviews. Together with line-by-line coding, I would also use *in vivo* codes, which are respondents' special terms that they use habitually, to better grasp the meanings that the pathology teachers and tutors try to convey through them.

5.3.2.2 Focused Coding

After finished with initial coding, the next phase is the focused coding instance. These codes are more selective, defined, aiming at broader categorizations, and more conceptual. To explicate broader segments of data conceptually, focused coding will concentrate on tracking the most frequent initial codes. This helps also to determine if the line-by-line codes are appropriate or misleading. The focused coding phase distills and sifts through a large amount of data. After this, it is easy to allocate meaning to initial codes, categorize, and parse them in theoretical categories (Charmaz 2006).

In grounded theory coupled with the constructivist approach the researcher acts actively upon their data. Through coding they depict actions and new threads for analysis come into the fore. Engaging constantly with coding gives researchers new insights about events, experiences, aspects, and perspectives described by the respondent, which could have passed past their attention (Charmaz 2006). Focused coding is a good test or probe for the researcher's preconceptions about the topic, or his preconceived analytical categories. Coding is an emergent process, the moment new things come up from focused coding then a comparison between categories could be useful to keep track of the changes or discover new insights (Charmaz 2006).

5.3.2.3 Axial Coding

After the line-by-line and focused coding, but even before this process, I used memo writing as a strategic technique to reflect and make sense about the data even before the fieldwork (Charmaz 2006). Before conducting the interviews, I wrote a memo for each questionnaire regarding the types of question, their focus, and what was I expecting as an answer. Memo writing was a useful exercise to start thinking in analytical categories and subcategories. The final instance of this lengthy process was axial coding. After fracturing and parsing the different codes in the initial line-by-line and focused codes, the axial ones brings them back together in wider categories and subcategories (Charmaz 2006).

Axial coding tries to make sense conceptually for the data and not simply describe them as in the initial instances. Thus, the product derived from initial coding instances is transformed into concepts that are organized in different categories and subcategories. These clusters have different analytical properties that help to make sense of what is happening; who is doing what and with what outcomes; where are the main changes taking place; why did the events unfolded this way; and how can we narrate the bigger picture by remaining faithful to the accounts. There is a conceptual relationship among categories with each other, and their subcategories (Charmaz 2006).

I didn't use the normal formula described by Strauss and Corbin (as cited in Charmaz 2006), in which the statements of the interviewees are classified in: *conditions* – the circumstances or the context described by the interviewee; *actions/interactions* – the interplay of the actors in the described situation or context; *consequences* – the outcome of this interplay (p. 61). I reflected obviously in these terms to answer the questions that emerged after the initial coding phase, but I adapted this approach to my own data and research context. The first step was to define how the interviewees responded to each question and the similar arguments in different questions. Then, I matched the tutors' and teachers' questionnaires and responses to see if they converged in some points. After that I sorted out the main differences in both questionnaires as well as in the different responses to the same questions by the teachers. Finished with this sifting phase, I divided the categories and subcategories based not only on the question posed but also the responses provided by the interviewees. The product (the following chapter) is a faithful account of the interviewees genuine voice mediated by me inasmuch as the analysis allowed me to do.

5.3.3 Data Analysis Process

The fieldwork notes were crucial to lay the backdrop for the ensuing analysis. I deliberately chose to take fewer notes during the interview process and to reproduce my impressions immediately afterwards (Hermanowicz 2002; Charmaz 2006). The main reason for this was to not distract the interviewee and pay more attention to what he or she was saying. Nonetheless, I believe that my notes represent faithfully my impressions of the interview, as the memory of it was still quite vivid. I took short notes of a non-formal conversation with a professor of pathology that didn't accepted to get interviewed, as he gave some interesting opinions about students' usage of VM[26]. I took notes also in the meetings with VMC/eLearning Team, but still contacted them from time to time to explain me some technical issues that I didn't fully understand.

To record the interviews, I chose the voice recorder of my mobile phone Samsung Galaxy S6 edge. The voice recorder is a licensed Samsung application in the current version (updated) 20.1.86.12. There are three options of recording: standard, interview, and speech-to-text. For obvious reasons I chose the second option for a more clear and lengthy recording of the interview. The resulting quality of the recording was very good, and the speech was clear and distinguishable. The only problem associated with speech were the inaudible words, which were a problem of mispronunciation or different voice pitches between the interviewer and the interviewee, rather than technical glitches of the recording device.

The interviews were transcribed with the help of two programs. Initially, I used Express Scribe version 7.01, as it has a free version with the option to buy the pro edition. The shortcuts of play/pause and rewind/forward are really easy to use, and you can export the product in a Microsoft Word version. After the 'raw' initial transcription, I installed the Speech Tools add-in for Microsoft Word 2016. This feature makes possible to introduce an Audio file in a Word document. After adapting the text in half a

[26] These opinions will be discussed in the analysis chapter, as I consider them part of the data collection process even though it wasn't recorded or a planned interview.

column for later coding instances (line-by-line), I played again each interview recording in the Word file and made the necessary corrections.

I adapted the line-by-line coding to take a whole meaningful segment, and not just the line as it was. Focused coding is more selective and tries to grasp the main reiterated or emphasized line-by-line codes that will be the basis for the accounts in the next chapter (Charmaz and Belgrave 2012; Charmaz 2006). Generally, I constructed these codes after each interview, but later (after coding all the interviews) I clustered the similar ones into same families or categories. Finally, axial coding will shape the analysis in the categories and subcategories in a coherent form, faithful to the line-by-line and focused codes emerged from the initial analysis (Charmaz 2006). Thus, each section and the following subsections of the next chapter are distinct categories which reflect the questions and the answers provided by the interviewees, but most importantly the research question and the respective sub-questions.

6. Empirical Analysis

In this chapter I will elaborate and analyze the six interviews conducted in the department of pathology at the Medical University of Graz. Informal conversations with VMC/eLearning Team will be also referred to in order to address the technical details regarding the new version of the virtual microscope (VM 2.1). Nonetheless, the aim of this thesis is not to focus in length on the technical aspects, but to rather make sense how this technology has changed teaching pathology (if this is the case), and how has it helped students in learning microscopy. Of course, the relevant technical features of the virtual microscope will be discussed properly to give a solid basis for this analysis.

The following sections will be structured based on the questionnaires and the research questions. The empirical analysis will remain faithful to the questionnaires, the respective accounts from the interviewees, and the relevant fieldnotes as an additional information. Quotes will be used to illustrate the arguments and the accounts of the respondents[27]. As a researcher, I consider myself a mediator of the arguments voiced by the interviewees. However my role wasn't confined only in organizing these arguments, but it extends to the initial coding process, the categorization of the issues, and the deeper analysis based on the previous instances. I believe that this analysis is a reflection and not a distortion of the claims made by the interviewees.

Initially I will briefly describe the fieldwork, the dynamics, and the problematics encountered. Next, I will give a brief account about the interviewees. The empirical findings will ensue by initially presenting the main technical features of the VM. After that I will present briefly the interviewees' reluctance to discuss technical details, as well as educational technology and eLearning in this context. Technology in teaching will be discussed next by describing the predecessors of VM, the origins, and the main functionalities. Then, I will elaborate on the implementation phase, the collaboration between tutors, teachers, and eLearning team, as well as the organization of teaching around this technology.

A relevant facet of the empirical analysis will highlight the role, purposes, and the advantages of VM. The research question and the three sub-questions will be addressed in the section that I will elaborate on the impact that this digital technology has had on teaching; teachers' adaptation to the technology; the interaction teacher-student; and the possible impact on the pedagogic approach. Blended learning will then be discussed in how the interviewees reflect on technology in medical education and the traditional approach based on face to face teaching. A comparison between the physical microscope and the virtual one will also back up the different arguments regarding digital technology in this setting. Finally, I will briefly describe the interviewees' accounts about the future projects based on the potential of VM at Med Uni Graz.

[27] In the actual quotes I have sometimes omitted my interruptions that do not affect the conversation.

6.1 Fieldwork

6.1.1 Organizing and Conducting the Interviews

The fieldwork for the master thesis started in late 2017 when I contacted the eLearning team. Following the meeting in early November in the New Campus at Medical University of Graz with one of the members of the eLearning team, I contacted a professor in the department of pathology to organize the interviews. After conducting an interview with this professor in February 19th, 2018; she helped me to contact another one and have a second interview the same day. She also helped me in contacting a tutor of this department to organize interviews with them as well.

After the two interviews in February 19th, a list of six other professors was provided by a student administrator in this department as possible candidates for interviewing. From the list of six professors, one of them wasn't working at Med Uni Graz anymore, and two of them declined to get interviewed with the justification that they weren't using the VM and didn't participate actively to the process of implementation for the summer semester 2018. One of them didn't respond to my emails (two) and I wasn't able to find her in the office during my two visits at the department of pathology. Thus, I managed to interview two professors of pathology and one tutor in March 26th, 2018. The final interview with another tutor was conducted on May 29th, 2018. Besides the six interviews, as an interlude I had meetings with VMC/eLearning Team and a professor from the New Media[28] regarding the technicalities of VM and how the fieldwork was going.

The interviews with professors and one of the tutors were conducted in their offices and it was very convenient in recording them with a better quality and clarity of speech. Moreover, the conversation was more comfortable due to privacy. The interview with one of the tutors was conducted in a bar and that had some problems such as inaudible phrases due to the background noise and difficulties in transcribing it. A befitting background in the professors' offices were the physical microscopes and the glass slides beside. One of the professors when I went there for the interview was actually checking those slides and recording the details of the samples. The New Campus of Med Uni Graz had spacious rooms and a well-organized structure, it wasn't hard to find the offices of the interviewees, but at the same time I had the impression that the whole building was like a maze where you could easily get lost.

The interviews were within the range of 20 to 30 minutes because of professors and tutors busy schedule. Medical professionals have the tendency to be concise and go immediately to the point, which affected greatly the time frame of the interview. They abstained in many cases to discuss further technicalities when asked for, by referring me to the eLearning team for such details. Thus, Int-Professor 003 when addressing Moodle specified that he was commenting "from the side of the user", or that there "are technical issues I don't understand completely". When I asked Int-Professor 001 about the

[28] The closest collaborators of this master thesis.

functionality of VM 2.1, she elicits me to ask the eLearning team about technicalities as she doesn't understand this part very well. Int-Tutor 005 points out that they comment on the VM and its functionalities from "the side of the end-user", as they didn't participate on programming or implementing the images and explanations in the VM.

6.1.2 Problematic Issues Related with Fieldwork

The fieldwork doesn't start and ends with the interviewing process. In my case it started since November 2017 and finished in the end of May 2018. The eLearning team gave me the contact sheet of one professor. Organizing this initial interview was a challenge in itself because of her tight schedule, as a professor and medical doctor at the same time (beside other duties as well). After many emails and discussions, we agreed on the date: February 19th. The same process of arranging via email the interview happened with Int-Professor 003, Int-Tutor 005, and Int-Tutor 006 which were conducted in March 26th and May 29th, respectively.

Int-Professor 001 and Int-Professor 003 helped me very much in contacting (in person) other professors of pathology and conduct the interviews immediately. This research has greatly benefited from the help and disponibility of all the professors and tutors participating in the interviews. Not just by agreeing to get interviewed but also by introducing and explaining my research to other professors in this department. As a personal lesson for me, I would point out that fieldwork is tricky, and beside patience, a researcher should improvise and adapt to the different situations. During the interviews many things can go wrong, such as misunderstandings, interruptions, repetitions, and so on. An interviewer should be focused and react swiftly when situations like these occur. Other problems associated with the aftermath of the interviews could range from the technical (bad quality of the recording, background noises, etc.) to the operational (initial coding and focused coding difficulties).

During the four interviews with the professors there were several interruptions due to phone calls and people visiting them in their offices (Int-Professor 001, Int-Professor 003, and Int-Professor 004). Some of these interruptions were quite short, less than one minute, which didn't affect the interviewee focus or what they were saying (Int-Professor 003). In two other cases, with Int-Professor 001 and Int-Professor 004, the interruptions were more than one minute and clearly affected their response, as they lost the point of their argument. With relatively short interviews (half an hour), every minute represents valuable data, and these interruptions disrupt the flow of thinking and the response of the interviewee.

The offices of the professors where quite comfortable to conduct the interviews for the motives mentioned earlier. On the other hand, conducting interviews in a café is quite the opposite. Unfortunately, I had to with Int-Tutor 005 and it was problematic in some respects. First, the background noises are present during all the interview recording, sometimes with a high pitch which obfuscates what we were saying. Second, it was not comfortable for both of us having an interview in a crowded place with people coming and going. This was the case initially in this interview (about 4 to 5 minutes, from my notes), but then we overcame the initial confusion and the interview was very informative.

A recurrent problem, especially with Int-Professor 004, was shifting from responding to the question posed and talking about something not directly (sometimes even not related) associated with what was asked. Since some of the questions were designed to 'feed' the research questions, these shifts were quite a hindrance in the data analysis process. The quote below is an example of shifting from the main question. While it has information that could be useful, it was not what I asked, and it will be a gap in my data in relation to this question and the category (or subcategory) derived from axial coding.

Interviewer: Ok! So, can you describe me Moodle? Do you use Moodle for teaching, the eLearning platform?

Int-Professor 004: Hm, just eLearning platform or... We don't, anyway, I don't use any eLearning platform, […] I'm teaching just on the […] teaching room with the students together, and uhm we have the slides, and, I discuss with them shortly the slides the main points […] they have to find, and after that, they have to take their own microscope and have to, microscope by themselves with some teachers.

In other cases, the interviewee didn't understand the question because either I didn't state them very clearly, or it was a long and confusing question. This is an example:

Interviewer: Uhm. Let's go to another facet […] of my interview. Do you think that learning through this technology-enhanced learning, promote a new interaction between teachers and students?

Int-Professor 002: I didn't get that question exactly?

On the other hand, there are instances when the interviewee misunderstood totally my question and in his answer was referring to a different thing. For instance:

Interviewer: Ok, so, yeah, what is the role of virtual medical campus support team?

Int-Professor 002: What is virtual medical campus?[…] Yeah, right! [laughs] so, I mean, the campus is not virtual, to start with... [laughs] It's real.

Other problematic aspects were for instance losing the line of thought while responding to the question. Nevertheless, I intervened to further clarify or elaborate the question (Int-Professor 003). Sometimes, the interviewee didn't respond to the questions directly, but later provided with an adequate response (Int-Professor 001).

Int-Professor 003: So, during this learning phase it's, hm yeah, [pause] not […] really, I think, maybe you repeat the question one time. I'm sorry!

Interviewer: No, it's just like, have you noticed comparing to the previous years, like, students can be more engaged, concerning microscopy in a sense?

***

Interviewer: Do you think that physical microscopes are still necessary for education?

Int-Professor 001: That's a tough question, because there are two groups of pathologies the hardcore microscope's fans, all around the world it's the same, and there are pathologist even using the virtual diagnostics in their routine diagnostics, so there are some institutes that totally stopped using microscope and they are doing everything with scanned slides, yeah.

[…]

Int-Professor 001: Uhm, and there are advantages and disadvantages [laughs] for it, but I think a good mixture, is probably the answer to it, because […] the classical handling of a microscope should be learned by a medical doctor, so, I would never put all the courses in purely virtual experience

During the coding processes and the analytical phase I noticed that on some really interesting issues emerged from the interviewees' response I haven't followed properly with more probe questions. While in itself the response was complete, I could have obtained further detailed accounts from the interviewee about the interesting aspects they were discussing about.

Interviewer: Any other eLearning elements that you use besides Moodle and the virtual microscope?

Int-Professor 001: /Well, two of the, of the courses are totally in uhm, virtualized, so…

Interviewer: The virtual classroom…

Int-Professor 001: Exactly, there are ten courses, yeah, ten courses with specific pathological topics and two of the ten are complete virtualized, so even the teaching of the professors is virtualized[29]*.*

Finally, inaudible words and phrases have also been a constant problem during the transcription of all interviews. While in the fifth interview understandably the café noises would hinder some words, in the other interviews it was more about mispronunciation. This, probably, because both interview participants aren't native English speakers. Nevertheless, in most of the cases these 'deficits' didn't impair the meaning of the sentence, or it was easily discernible what the interviewee was conveying. In some cases, the problem was more due to the different voice pitches (in most cases, my voice being lower than the interviewees') or when we spoke simultaneously.

6.2 The Participants

Between February and May 2018, I have conducted six interviews with four professors and two tutors at the Medical University of Graz. The informed consent signed before the interview guarantees the anonymity of the interviewees. I will give briefly a general information about them, which will be useful to keep in mind during the actual empirical analysis.

The four professors interviewed here contributed to the virtual microscope by generally checking the work of tutors, but also contributing themselves in selecting the slides and embedding the text. Two of them teach classes based on the VM 2.1, while the others teach more basic pathology. All the professors have a long career as medical practitioners in pathology as well as professors (three of them over two decades, while one over one decade). Their experience with teaching pathology and practicing it as a medical discipline was invaluable to understand the medical dimension of the virtual microscope.

The tutors interviewed were actively involved in selecting the samples, digitizing them, and embedding the text for the explanatory feature during the implementation phase. They were in constant interaction with teachers and eLearning team. Moreover, they are teaching assistants in the courses involving VM 2.1, where they explain the histo-morphological structures to the students in the VM. Their experience and involvement is one of the main reasons why I chose to interview them, but also to better understand the organization of teaching around VM, the interaction with students, and the collaboration with the eLearning team.

[29] I could have probed to elaborate more on how are they virtualized, but instead I jumped to the next question unrelated with the previous.

6.3 Technical Features

6.3.1 The Technology behind the Virtual Microscope

The new version (2.1[30]) of the virtual microscope is a commercial software based on the product Zoomify [see: http://www.zoomify.com/] capable of handling very high-resolution images based on HTML5 technology at the front end (student interface) and a standalone application as a backend (administrator side) for image processing and preparation. The front end is programmed in HTML5 and JavaScript, which both construct a meaningful mainframe of digital imaging (JavaScript) and panning the image, implemented in a webpage (HTML5) (informal conversation with VMC/eLearning Team). Zoomify offers also a backend to render the images in an image resolution pyramid in order to make them efficiently accessible in webpages.

The older version, VM 2.0, used Flash Macromedia technologies that required plug-ins to operate. Moreover, this was not adaptable for mobile devices and smartphones. This change, as with the initial implementation of 2.0, was done with Zoomify source code provided by this company. This radically facilitates working on VM, as you don't have to go back and forth with the IT specialists of this company, but the eLearning team can work directly with the implementation. Even when they needed support from Zoomify, their response was quite quick and adequate (informal conversation with VMC/eLearning Team).

The main reasons for choosing Zoomify is the experience of the company in medical microscopy area, the technical features to operate VM (supports HTML5, source code is provided for free, and C++ is used as the programming language for the visual objects), and to reduce costs by replacing expensive physical microscopes with the virtual one (Rehatschek and Hye 2011; informal conversation with VMC/eLearning Team).

The slides from the normal microscopes are scanned and migrated in VM and are accessible through Virtual Medical Campus (VMC)/Moodle. Currently, there are 150 virtual slides for the topics of histopathology and dermatology in the modules that use VM (informal conversation with VMC/eLearning Team). This is a further step toward digital pathology[31], as an expensive scanner is needed to scan the glass slides and transfer them as a digital image in a computer, where it can be stored, consulted, and shared with other pathologists in other locations (Mikula et al. 2007; Hamilton, Wang and McCullough 2012).

On the left upper side is the mini map (thumbnail overview, see Hamilton et al. 2012) that serves as an orientation tool when a student pans or selects a structure; while on the right upper side are

[30] After the last discussions with the eLearning team (29.05.2018) they explained me how the version is defined. Thus, after each change in technical features, for instance changing the position of POIs, or the way of selecting a POI, was considered as an improvement but not as a new version. Fundamental technical changes constitute a new version, for example the change from Flash technologies to HTML5, or adding the explanatory feature.

[31] Later discussed as how can VM be used as a diagnostic tool in the future.

the points of interests (POI) defined as structures (Figure 1). The user can select within these different structures to study the sample and focus on a certain area of interest (Figure 2). And with just a click or simply passing with the mouse over, the annotation shows up that explains the structure and its pathology as shown in Figure 3 (Int-Professor 001).

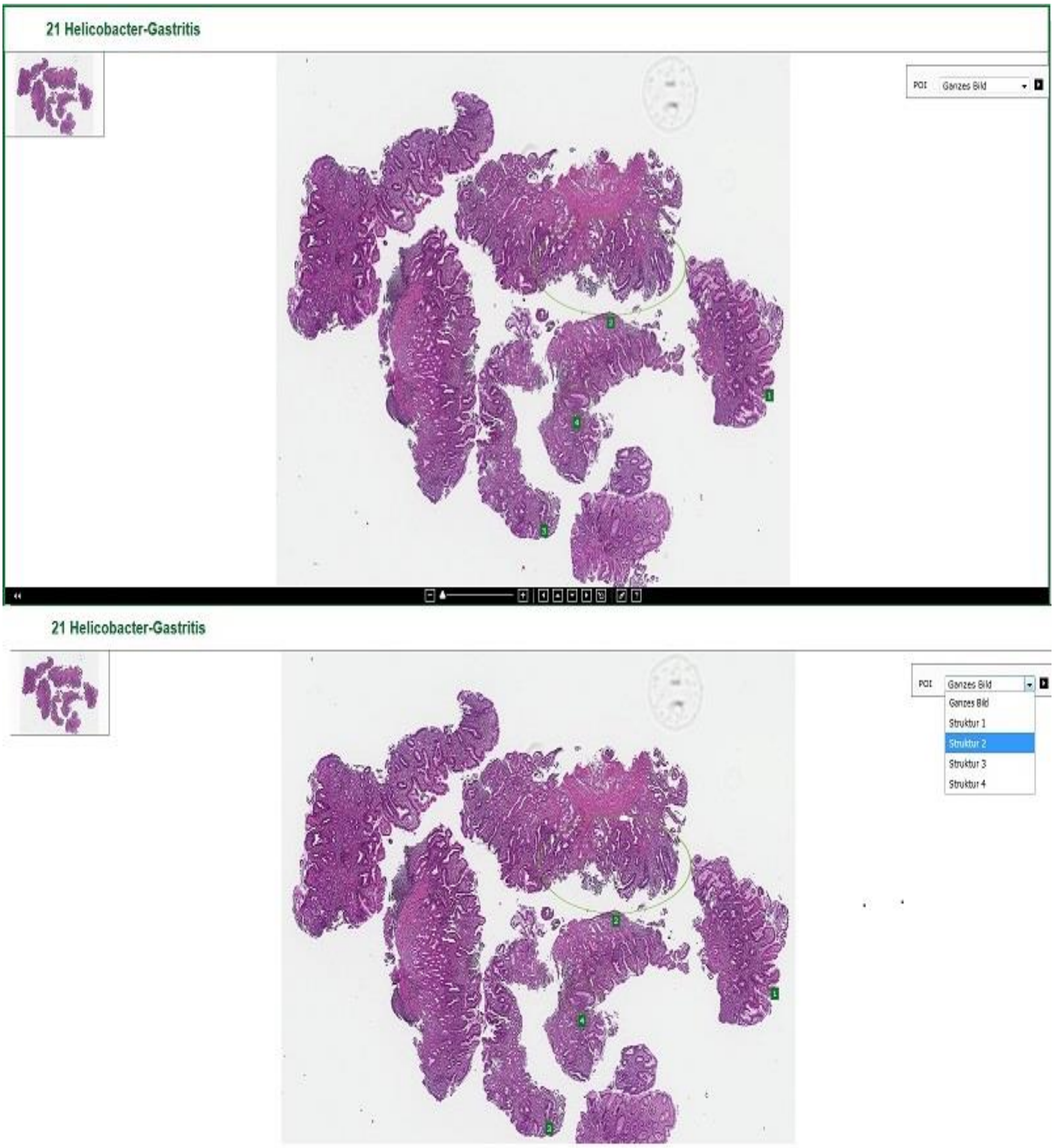

Figure 1. The virtual microscope 2.1 with the sample slide, minimap, and points of interests (POI).

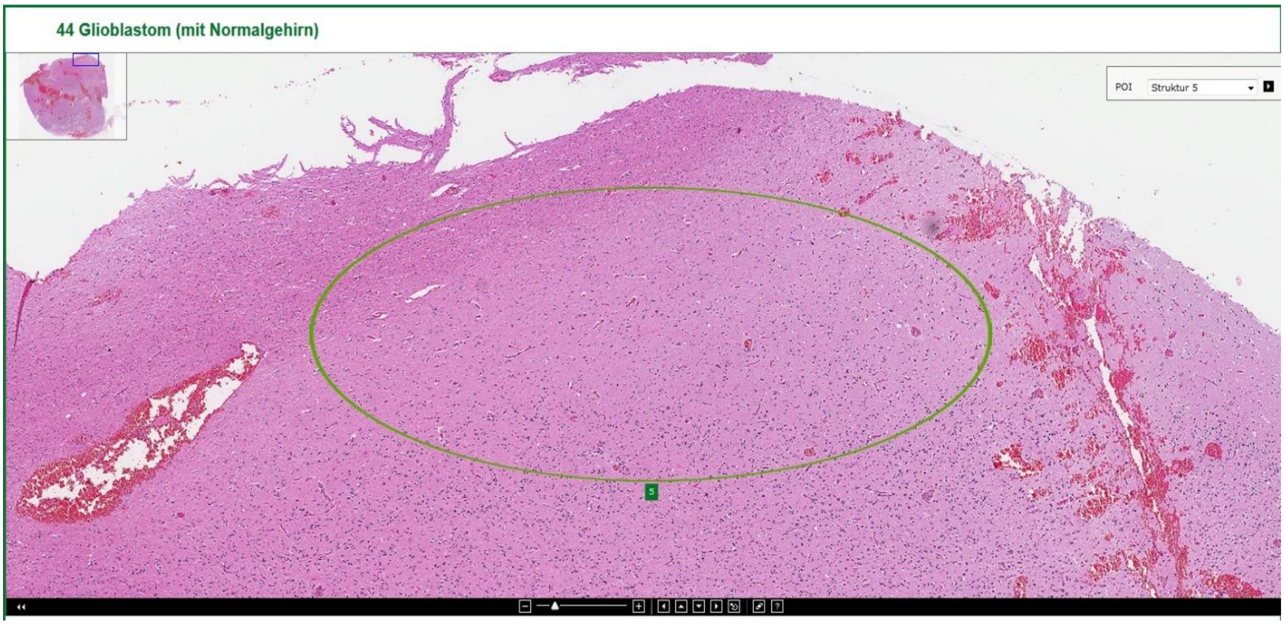

Figure 2. Focusing on a POI inside the whole sample.

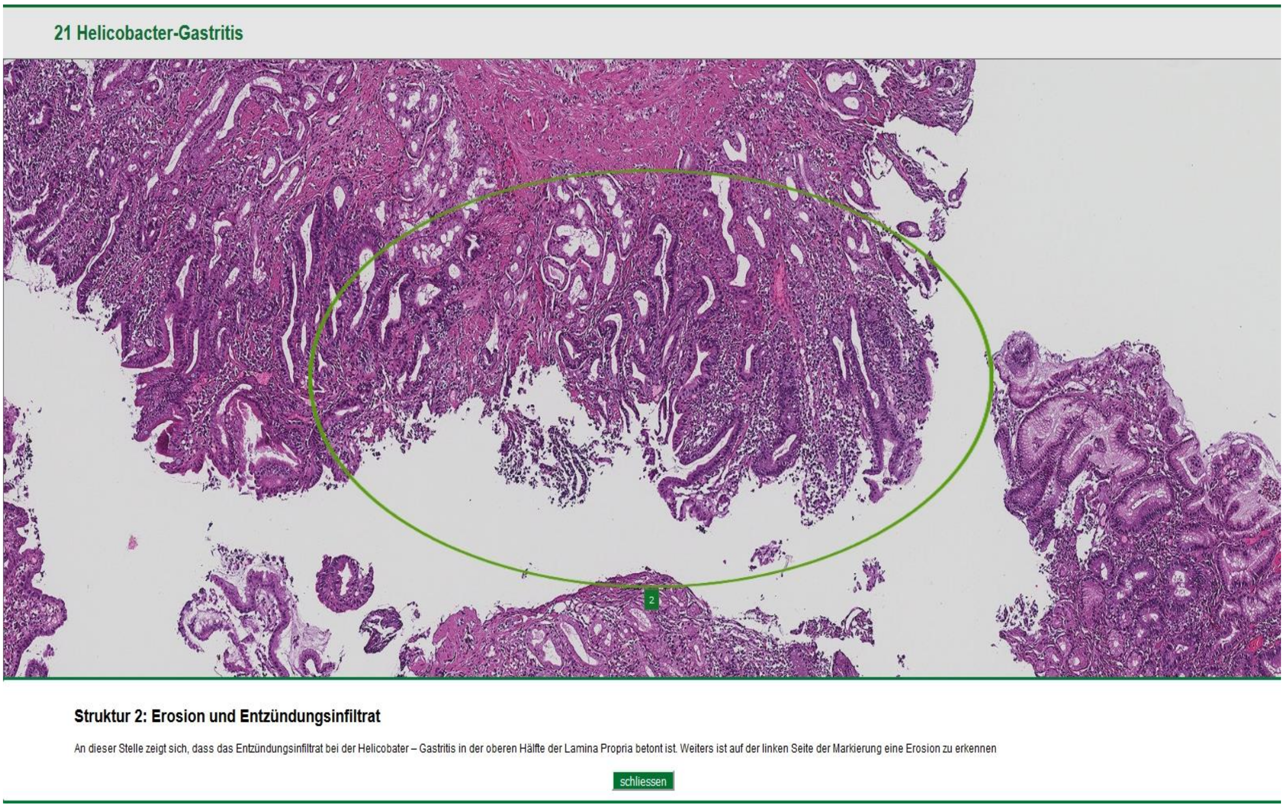

Figure 3. The explanation of the POI via the annotation[32].

6.3.2 Abstaining to Discuss Technicalities

The interviews conducted with teachers and tutors in the department of pathology weren't supposed to provide details regarding the technical background of the virtual microscope, but rather how has

[32] The four screenshots that are displayed in the respective Figures 1, 2, and 3 are a courtesy of the Virtual Medical Campus (VMC)/eLearning team.

technology impacted their everyday job. Thus, the interviewees provided insights mainly about the user-related features of the VM (Int-Professor 003 and 005). When they had the impression that the question was inquiring deeply into the technical aspects of VM they suggested to ask the eLearning team.

Interviewer: [S]ince you also told me that you were one of the first ones to […] [have] started with technology, can you briefly describe me the eLearning platform Moodle, which you use in here?

Int-Professor 003: I'm from the side of the user and not from the inventor or producer of Moodle or…

***

Int-Tutor 005: So, we would rather use it by, by virtually microscoping and […] looking at it and then we would take screenshots and send him[33]*, so than he would apply the point of interests. So, we didn't actually program anything, we just worked as an end-user, […] but we defined the point [of] views first case then, also the texts.*

***

Interviewer: Ok, so the difference is just this one or maybe also the configuration?/

Int-Professor 001: /Yeah, the technic is much better, but […] you can ask ***the eLearning team***[34] *[…] for technical details, so it's a better version as well but for technicalities, I'm sorry I cannot really tell you.*

6.4 Adopting Technology for Teaching Purposes: A Brief Retrospective Account

6.4.1 Predecessors

The adoption of the virtual microscope (VM) at the Med Uni Graz has a long tradition which has started with other predecessors in the field of microscopy. It has begun with an analog video microscope connected to a beamer, passing through a video microscope, then a digital microscope (no oculars just a camera inside), and finally the first version (1.0) of the actual virtual microscope (Int-Professor 003). Even though these technologies were considered as achievements in teaching microscopy at the

[33] Referring to the eLearning team.

[34] The interviewee refers in first name to a member of the eLearning team, thus the change in quote for the sake of anonymity. These are subject of confidentiality that is why I refer to "informal conversation with VMC/eLearning team".

department of pathology, they had some limitations deriving from the overall technical achievements in the period they were implemented (Int-Professor 003 and Int-Professor 002). Since then digital imaging technology has improved with a tremendous pace. Some of these improvements are reflected in the VM 2.0 and the new version 2.1.

Int-Professor 003: Hm, the virtual microscope made teaching easier for us. […] In previous years at the beginning we had a video microscope showing an analog image from the microscope to a camera to a beamer, […] very old school! Then we had the video microscope and later on we had a digital microscope […] like a microscope which has no oculars, but only a camera inside, which is really specified to beam the images on the wall. And that was an achievement already, but you always had to change, uhm and it's was a mechanism dia-objective, so from 4 to 10X, to 40X or 400X about that. So, this […] cost some time and it interrupts the image.

6.4.2 eLearning Platform

The virtual microscope is accessed through the eLearning platform Moodle, introduced at the Medical University of Graz in 2010 (Rehatschek and Hye 2011). Moodle is the primary Learning Management System (LMS) at Med Uni Graz. Departing from this premise, I inquired the teachers' adoption of educational technology starting with Moodle or other technologies used in their teaching practices. Int-Professor 002 and Int-Professor 004 didn't use eLearning systems for teaching.

Interviewer: Ok! So, can you describe me the Moodle, do you use Moodle for teaching, the eLearning platform?

Int-Professor 004: Hm, just eLearning *platform or...? We don't, anyway, I don't use any eLearning platform […] I'm teaching just on the teaching room with the students together, and […] I discuss with them shortly the slides the main points […]and after that they have to […] microscope by themselves*[35]

***

Interviewer: Ok. So, any other eLearning elements that you know based on Moodle or that you have used previously?

Int-Professor 002: [coughs] Uhm, we have some lectures in […] form of virtual lecture, but that's basically a power-point narrative, so that's not very fancy.

[35] Part of this quote is also used subsequently in another subsection.

Int-Professor 001 addresses Moodle as “one of the key actors” that is complementary to the traditional teaching. Moreover, this interviewee regarded as a development the two totally virtualized courses with specific pathological topics, especially freeing the professors from extra engagement in preparing a seminar or lecture. The virtual courses are based on eLectures and the virtual microscope. eLectures are recorded lectures in a video format with a PowerPoint presentation. VM is used to explain the structures and the microscopy topics by simultaneously displaying the image and explaining it. In the end, there is a test with multiple alternatives which should be completed by the student in order to get five points (informal conversation with VMC/eLearning Team; Int-Professor 001, Int-Tutor 005, and Int-Tutor 006).

Int-Professor 003 thinks that Moodle is user-friendly though his teaching content (learning objects) are uploaded by a teaching assistant. Besides, he discusses the possibility to record lectures and upload them in this eLearning platform. VM is also accessible through this platform.

> *Int-Professor 003: Hm, so, Moodle […] is, user friendly, I think, yeah, it's ok. I […] do not put the content inside of Moodle by myself. We have an assistant, study assistant. She gets the PDF files of my lectures and put them on Moodle, […] now in the new Med Campus we have also the possibility to record all our lectures […], and […] put then afterwards in the VMC (Virtual Medical Campus) on Moodle. Hmm, and also, under this platform easily accessible for the students is also the virtual microscope.*

6.4.3 Origins of the Virtual Microscope

Initially, VM was used from pathologists in teaching postgraduation programs (Int-Professor 001). As a field working closely with microscopic images (Int-Professor 002), professors thought it could be used to teach the undergraduate students as well (Int-Professor 001). Alongside the teaching purposes in this department, VM was used to prepare difficult cases (not seen routinely in clinical practice) in pathology, especially for congresses and conferences. Through this technology pathologists were able to interactively present these cases not only to the students and other professors, but to all medical practitioners participating in these conferences. Because many cases are presented in conferences, virtual microscopy is an effective tool to assemble them all together, so any participant will have a saved copy to consult whenever and wherever they want (Int-Professor 001).

> *Int-Professor 001: [T]he microscope and the virtual microscope was used from pathologists for teaching purposes in post-graduation education for many years, yeah. So, it's a very good thing to exchange, uhm, difficult cases and make case conferences and present cases on congresses, yeah, so that's why it was used, uhm, basically by us pathologists in the first place and then we, we thought about this technology and said ok, would also be good to teach the students that way. So,*

it comes from our, our education, postgraduate education where it was used, and successfully used, because pathologists themselves, they see on congresses a different case, very difficult and seldomly seen cases, ok? […] That's why the scanning of the slides and the virtualization was introduced so everybody could get a CD of the records with these difficult cases, let's say interstitial lung diseases but you can look at it again and this nice system, we thought, would be for students as well very applicable and useful, so that's is probably why we did it, uhm I guess!

6.4.4 Functionality: Comparing the New Version with the Old One

There are three stages concerning the development of the virtual microscope after the initial implementation in 2001. Initially, VM 1.0 was implemented for undergraduate students after the successful use in postgraduate teaching, as mentioned above (Int-Professor 001). After a decade with VM 1.0, the transition to VM 2.0 together with the change of the Learning Management System marked the second stage (Rehatschek and Hye 2011). The final stage took place in March 2018 with the new version 2.1, which started in the summer term with histopathology courses (Int-Professor 001 and Int-Tutor 005). This stage is marked with several technical improvements of the VM, the most important among them being the explanatory feature.

The term functionality refers to the main features used to operate the virtual microscope. Thus, Figures 1 to 3 represent the basic (main) functionalities such as the main image, the mini map, the POI, and annotations (see pages 77-78). The basic functionalities since the first version haven’t changed that much (Int-Professor 001 and Int-Professor 003). The newer version (2.1) doesn’t have the navigation panel that was needed when VM was operating with Flash technologies. Now it can be fully operated with all the mouse functions, including zooming with the mouse wheel, which previously wasn’t possible as it was not supported by Flash technologies (informal conversation with the eLearning team).

Int-Professor 003: [T]he basic functionality making uhm the magnification or going into the slide deep enough […] stood approximately the same.

The previous version was already an improvement in terms of virtual technology to teach microscopy (Int-Professor 001). Although, it was limited to a single structure like a cell, it was similar in terminology. The main change in the 2.1 version is the explanatory feature.

Int-Professor 001: [T]he previous version it was also quite nice, it was similar, but now we have a new feature that is more explanatory, so in the old version it was just one structure, a structure like a cell or something like that, which was named cell XY, ok, like, this is a tumor cell or whatever, and in this new type we still have this explanatory. We have this uhm, terminology, like this is a tumor cell, *this an arrow, but also when the student went with the mouse over it, then comes an explanation. This is a tumor cell and it does this and this and that, the specifics of the tumor and this and this and that, so it has some characteristic […] of a lecture.*

The first version was much slower, while the upcoming versions have greatly improved in speed, which is one of the main reasons for adopting this digital imaging technology (Int-Professor 001, Int-Professor 002 and Int-Professor 003). Int-Professor 003 thinks that maybe the reasons behind the increase in speed lie in the improved internet infrastructure and also the image compression. The improvements have impacted the resolution of the images in VM, as well as moving with the mouse and panning the images within the slide (Int-Professor 001, Int-Professor 002, and Int-Professor 003). Nonetheless, since the first version was new in terms of virtual technology everybody was using it in this department (Int-Professor 002).

Int-Professor 003: So, the main thing is, it has to be quick and the second generation now the third is much quicker compared to the first. That's the main thing, so the compression of the images seems to be, has maybe changed or maybe the internet structure, infrastructure, I'm not absolutely sure, but the speed is important, and this changed.

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Int-Professor 002: Well, [coughs] I think the previous version and, there had been a version, like a long time ago. […] I mean, at that time, you know it was much slower. [T]he resolution was, if you wanna a high resolution, it was very [pause] slow. It was too slow to, really for my taste, to use it. But, you know, since it was new, everybody also used it and tried it, but if you compare it to nowadays it’s much smoother, it's almost as good as a normal microscope.

6.5 Implementation, Collaboration, and Organization of Teaching around VM

6.5.1 The Implementation Phase

The implementation of the virtual microscope engaged in a collaboration the teachers, tutors, and the eLearning team. The two tutors interviewed provided relevant information about the implementation phase regarding VM 2.1. It started in 2016 with tutors scanning the normal slides in a digital format (Int-Tutor 006). The two tutors weren’t quite sure initially during the interview when did exactly the implementation phase begin, but afterwards they asserted that it was the winter semester of 2017. They started by preparing the slides, marking the POI, inserting the texts (annotations), and then double checking them together with the professors (Int-Tutor 005, Int-Tutor 006, and Int-Professor 002).

Int-Tutor 005: Well, we started last year, in summer; no actually we started in the winter. I'm sorry! Last year, in winter semester and there our chef[36], she told us we have to work up some basic structures, which we think are necessary for each lesson and anyway I had to talk to the IT guy and he would [pause] draw points of views in the virtual microscope. So, we would rather use it by, by virtually microscoping […] and looking at it, and then we would take screenshots and send him, so than he would apply the point of interests. So, we didn't actually program anything, we just work as an end-user, and, but we defined the point of views first case than, also the texts. And then we went to the professors and ask if it was ok with the point of views or correct, if they wanted to change the texts or if they wanted to have more points of views of some structures we didn't find or if would be necessary, or if we had too much and they would scale down or the basics.

As also hinted in the above quote, the tutors were the ones that actually worked upon the slides in defining what samples to choose, where to focus, and what to explain (Int-Tutor 005 and Int-Tutor 006). They were the main mediators and coordinators between the teachers and the eLearning team (Int-Tutor 005). They took screenshots of the digitized samples and named the markers (POI[37]) and shortly described them. Afterwards, the teachers responsible for the specific lecture, for example the brain pathologies or bone marrow, were consulted about the POIs and the respective explanations. Then, the eLearning team prepared and implemented the learning objects by fitting the images in the format displayed in the VM and correcting the errors that were spotted afterwards by tutors or professors. For a better workload distribution, the tutors divided the themes equally between each other (Int-Tutor 006).

Int-Tutor 006: [M]y colleague digitalized all the histological samples, in cooperation with the IT in the Med Uni Graz. [A]nd then we had to set markers and describe the markers with the name, what the students can find there for example […] and the description like two sentences for each marker.

…

Int-Tutor 006: So, the colleague and I separated by themes, so I did 50% and he, and afterwards we cooperated with the teachers who had the lectures for example uhm, brain or the other has uhm bone marrow. […] And then we had appointments […] to correct the sentences which we wrote uhm… And yeah that's it. And then afterwards again with the IT to make the new POI, also [german] points of interests, someone was not correct, […] we made a contact and if the

[36] Referring to their boss.
[37] Both terms markers and POI (points of interests) can and will be used interchangeably to describe or refer to the region highlighted in the sample and explained with an annotation.

teacher […] wished we have an appointment with them to discuss the points of interests which we marked…

6.5.2 Collaboration with VMC/eLearning Team

VMC/eLearning Team had a very strong impact in implementing this technology at Med Uni Graz. Their technical expertise was pivotal in setting up the virtual microscope and providing technical support during and after the implementation phase (Int-Professor 001, Int-Professor 003, Int-Tutor 005, and Int-Tutor 006). Nevertheless, this implementation phase had also its problems. Due to the different expertise of the medical students (tutors) and professors on one side and the eLearning team on the other, several times the process of implementation was hindered because of technical errors in setting the markers or where the text should be embedded (Int-Professor 003 and Int-Tutor 006).

Interviewer: Ok, ok. So, what is the role of VMC supporting, VMC/Moodle support team[38]?

Int-Professor 003: That's really important, they do everything what we want to change in the, in the virtual microscope. So, if you want to change some explanation or put some markers on a new position, they have to do it nowadays, and in my opinion, this is a big disadvantage, because they are not sitting side by side with me. That was just an experience we had, I think one or two weeks ago we changed one of our specimens, one slide and brought the new scan to the VMC team. […] [A]nd then they had to […] incorporate the new markers […] from screenshots. And also, I sent a list of this marker should be this, and that, and that text should appear there and, of course, I had to check it once again afterwards and there was a mistake, yeah! Two times the same explanation for two different markers.

Nonetheless, the role that the eLearning team played is quite crucial in supporting and dealing with the technical aspects, as asserted in the first part of the quote. This example emphasizes the different areas of expertise, in this way legitimizing the necessity of the collaboration. Int-Professor 003 goes on to elaborate more on this issue by stressing the drawbacks of the different fields of expertise and how can they manage to tackle these issues. But he still doesn't know how to overcome the practical difficulties of inserting markers and annotations by the teachers or tutors.

Int-Professor 003: [T]he problem is they are technicians and it's hard for them to understand what do you want. So, there is always a little bit a lack of quality. And […] that's not the fault of the VMC, they are engaged, […] but that's the same if, I would be asked to implement some script or so. [starts laughing]. How to make a

[38] VMC/eLearning Team.

script or so? I have no idea! And […] that's a little bit of disadvantage. So, […] there are practical issues incorporating markers, setting markers, putting text in, into the VMC. That's not perfectly available, nowadays. I don't know why!

Int-Professor 001 also makes the case that medical doctors aren't supposed to know the explicit technical details of the VM, as in turn the eLearning team shouldn't know the medical area of expertise. They were there since the first version and they have done a remarkable job in setting up the 2.1 version as well as working for its support (Int-Professor 001 and Int-Professor 003).

Interviewer: So, uhm, what is the role of the virtual medical campus support team in this?

Int-Professor 001: Yeah this is a very big role, they do all the technical support, yeah, and they are in, in interaction with us. Uhm, they are very helpful actually because [laughs] as medical doctors don't have much clue about how to… you know=

Interviewer: =or even much time in a sense huh…=

Int-Professor 001: No, even if I had time, I couldn't do it what they do so... [laughs]. They have been a big help…

Int-Professor 003 thinks that a flexible collaboration could avoid some minor technical details, such as setting markers for instance, that could be done by the teachers, their assistants, and tutors, without having to disturb the eLearning team. This initially supported by an IT working side by side with them. Thus, an effective operational collaboration would tackle minor issues that are time and resource consuming.

Interviewer: Do you have any kind of suggestion for that, in a sense, or do you think there is another solution?

Int-Professor 003: It should be possible […] for the responsible or the teachers themselves to set markers very easily. And to put the text inside very easily and not, via the technician. So, the direct way for me would be much better than some persons and they are normally two or three in between and that's […] a loss of quality. Causes a lack of, causes [short pause] some quality issues,

Interviewer: Ehe, so you think that teachers can set the markers […] by themselves?

Int-Professor 003: I don't think so, but if they have the support sitting side by side on one screen. That could be fine. For me it would be fine, if I could do it by myself.

6.5.3 The Possible Game-changer

Teachers of pathology have another software that they use as a virtual microscope, which is different (better) in terms of functionalities to that of the students (VM 2.1 from Zoomify) (Int-Tutor 005). This software, 3DHistech, is a panoramic viewer used for digital pathology where scanned slides are embedded, and the user can easily manipulate the sample by marking the regions; moving around the slide; changing the contrast or brightness of the sample, and uploading or downloading the file for remote consultations (https://www.3dhistech.com/pannoramic_viewer; informal conversation with eLearning team).

> *Interviewer: Ok! So, how are the professors interacting with this technology in terms of teaching. This is just, like your opinion as a tutor?*

> *Int-Tutor 005: Uhm, it depends because […] this semester we got a new set up for our actual lessons because they can use also virtual microscope, which is different to the virtual microscope the students can look at, so it's a bit better because you can, the magnification is higher and the resolution is better and they use it very good during the lessons because, I think it [is a] very good way to show because you can show very precisely what you want to show, plus you can point on it with the mouse so it can draw on the microscope and you can also scale it a lot better than the analog one. And so, I think you can also for instance compare two slides side [by side], so, for instance similar structures which [are] different in some […] aspects, but not in all of them, and you can show them side by side. I think this is a very good way […] to work the virtual microscope during the lessons.*

This solution (3DHistech) seems very suitable considering also that this department has invested in an expensive digital scanner, which is the first step toward digital pathology and the digitization of microscope slides (Int-Professor 003; Mikula et al. 2007). That may also be the reason behind Int-Professor's 003 claim that it could be possible for teachers or their assistants to make the changes in the virtual slide without the help of the eLearning team (the previous subsection). The main problem highlighted by the eLearning team and also by Int-Professor 003 is that 3DHistech is not supported by VMC/Moodle. There are also technical shortcomings such as lack of storage capabilities for the digitized samples that hinder the implementation of this software for teaching purposes.

> *Int-Professor 003: That's some kicks and putting the markers here and there, like […] we have […] for the new or also the old virtual microscopy. The slides scanner I mean, we had a soft package and we could enter anything we wanted to do. Yeah! And that was very easy! And they, yeah, and that's should be possible for the teaching purposes. There must be some technical issues related between the slide's scanner, slides scanning software and Moodle on the other side. Or the*

presentation in Moodle, yeah, and that, there are technical issues I don't understand completely.

6.5.4 The Organization of Teaching around VM

After the initial collaboration for the implementation of the VM, the teaching structure was organized around this supplementary tool for the histopathology classes. I am not going to explain here the module of pathology-related topics or courses, as in the interviews that I conducted this was not my aim. I wanted to place VM in its proper context, which concerns the department of pathology and the courses that are currently taught with its help. Thus, the accounts in this subsection will follow faithfully what was said about the organization of teaching in this setting, and the different roles of each actor.

The organization of teaching around the VM involves two modules of histopathology, started since the summer term of 2018 (Int-Professor 003). Moreover, two out of ten pathology-related courses are fully virtualized in terms of teaching and learning (Int-Professor 001). VM 2.1 is used for in-class presentation of cases by the teachers with the same slides available in VMC/Moodle for students to consult it before or after the seminar (Int-Professor 003, Int-Tutor 005, and Int-Tutor 006).

Int-Professor 003: Currently we are teaching histology, pato-histology in two modules of the study for medical students and we're now in this term we started to use the virtual microscope also for presentation to the students in the direct, hm yeah, lecture…

VM is complementary to the physical microscopes. This means that students engage with physical microscopes as well in order to properly understand microscopy and how to approach the patients' samples. After the lecture from the professor about specific pathologies of an organ (liver diseases for example, Int-Professor 001), the students use the physical microscope to consolidate the theoretical knowledge. Since many topics are time-restricted with specific time-slots, like half an hour, VM is a good tool to recall what was previously done in the seminar. The same samples that they see in the physical microscope are in the VM too (Int-Professor 003, Int-Tutor 005, and Int-Professor 001).

Int-Professor 003: So, nowadays we can, we conduct all these things, so we have the lecture about the specimens and teach about the pathology in these specimens. The students can then look by themselves in real microscopes and on real glass slides, so they get the idea what they see and how it is to use a microscope, but afterwards they have also and that's a great advantage now, time independent, the possibility to look at the same images or, or the same slides afterwards yeah.

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Int-Tutor 005: So, basically, it's a supplementary concept, because we have […] normal lessons […] where the students apply, and they have to microscope using the normal analog microscope. And they have a box of different tissues slides there which they have to microscope and the same slides they can microscope here in those lessons [are] digitalized and can be looked before and after the lessons.

For about 50 students there are at least two professors and four tutors to answer their questions (Int-Professor 001). Thus, the workload is fairly divided for teachers to interact with tutors and students, and vice versa (Int-Professor 001 and Int-Professor 003). Interaction is crucial as many topics are difficult and complex, which means that only VM is not enough to learn the pathologies and structures.

Int-Professor 001: Because they have one and a half hours for a topic like liver disease or whatever, yeah, uhm and they need to use that time. They get a short presentation and then the microscope themselves and there are two professors and four tutors for […] let's say 50 students. So, it is plenty of opportunity to ask, yeah.

Interviewer: It's, it seems like, like [a] fair distribution of/

Int-Professor 001: /yeah, it's a good distribution, so/

Interviewer: /of the work or the workload/

Int-Professor 001: They could ask and interact as much as they like…

***

Int-Professor 003: Uhm, [pause] when we do lectures for the histology, pato-histology, [short pause] the people are in the room with, equipped with the virtual microscope for the presentation but for the students themselves they have a microscope and they have also tutors that can be asked, the lecturer can be asked. So, this is very interactively done.

Professors teach different organ systems regarding basic histopathology topics. The students have to look on the physical microscope the different structures for these organs. As already explained, the same content is on VM for re-consultation. In the classroom, teachers are mainly responsible for the theoretical part of the current lesson (Int-Tutor 005).

Int-Tutor 005: And during the lessons there are professors who teach some basic knowledge about pathology […].[I]t's getting more into detail with different organ *systems and professors, they hmm, teach basic histopathology, which the students have to look in microscope and the same structures which the professors teach during their lessons can be seen in the virtual microscope. Also, sometimes, the professors also teach more obviously, but there's certain minimum structure provided via the virtual microscope, which the students can look beforehand, they can prepare themselves, for when they go to the lessons. […] Hmm, tutors are there to help students find structures […] since they have questions regarding the structures, if it's a right structure or not.*

There are 12 tutors regularly employed that are helping currently in the department of pathology. They are in their final years of study and their aim is to become pathologists (Int-Professor 001). During the seminar tutors are responsible for helping the students identify the histo-morphological structures of the sample, they can also answer basic questions from histopathology. In the end of each lecture students have an oral test supervised by the tutors about these structures (Int-Tutor 005 and Int-Tutor 006).

Int-Professor 001: We have a good feedback from the tutors, yeah. […] I think now there are 12 tutors. Uhm, which are peer teaching from their older semesters and they kind of want to become pathologists. That's why they are hanging around here, they get a little salary and […] they register the students in the course…

***

Int-Tutor 005: Hmm, tutors are there to help students find structures […] since they have questions regarding the structures, if it's a right structure or not, and then they can ask us. And they can also ask us basic questions about, theoretical questions, but it's rather more about the histopathology, not so much about the theoretical background, is rather more about histo-morphology. […] In the end of each lesson, we have to test them, so, they get five points, for tested by us [a]nd the stuff they were doing in class.

Each year or semester new tutors start in this department. The older peers should introduce them the structures that they will explain afterwards to the students (Int-Tutor 005). The dynamic of teaching regarding VM-related classes is modelled after blended learning rationales. First, the teachers present the basic notions concerning a specific organ or system and their pathologies with the help of VM. Then, the tutors take over and show them in the selected sample the POIs and the relevant explanation of the histo-morphological structures. Afterwards, the students must use the physical microscopes to learn how and what to see, as well as handling the sample (Int-Professor 003, Int-Tutor 005, Int-Tutor 006, and Int-Professor 001). At the end of each class students have an oral exam that is based on the lesson they had, and they get five points if they answer correctly (Int-Tutor 005 and Int-Tutor 006). Due to the curriculum change, they now have two big exams instead of three in the pathology-related courses, and they are based on what the students have seen in the VM (Int-Tutor 006).

Int-Tutor 005: [W]e have new tutors every year and semester, and when they start there, they need to uhm [pause, slight] be taught what structures they should look for and what's the right structure, strong structure.

***

Int-Tutor 006: [S]o we showed them the POI and then they have to say to us what we showed them in the microscope, and uhm theoretical questions are also asked, yeah […] and uhm so they can prepare themselves because we have an exam, an oral exam.

…

Int-Tutor 006: [W]e had no oral exams, it's all a new curriculum. I am from a curriculum 210 version 14B and they have version 17, so it is a new curriculum and therefore the system of pathology semester is different. […] I had three exams to write, and they have two big ones in one semester.

6.6 The Role, Purposes, and Advantages of the Virtual Microscope

6.6.1 The Role of VM in Teaching

The students are the main users of this technology. The main role of VM, as was stated by the majority of the interviews, is to engage students more intensively with histopathology courses in microscopy (Int-Professor 001, Int-Professor 002, and Int-Professor 003). Int-Professor 002 elaborates on the idea that VM encourages the independence of students from the physical microscopes, which makes it more comfortable to study microscopy in their own terms. This auxiliary tool promotes self-study, but nevertheless it will not replace the traditional teaching. The interaction with their peers and teachers is still very important for the medical students.

Int-Professor 002: I think it's a very important auxiliary tool for the students. Uhm, students have a course in microscopy pathology. And they can use that tool, in addition to look up things whenever they have time to study, so they are independent of the slides and the microscope and the availability of this microscope. So, first of all, it gives them the comfort of beginning what they are studying wherever they like […]. Uhm, so, I think is an important tool of self-

study. It does not replace in my mind the real teaching, uhm, because personal interaction is always something different but is a good auxiliary tool.

Similarly, another role of the VM is the possibility to reiterate the same learning content of the seminar. This can be done comfortably at home whenever they want by selecting the POI, visualizing the sample, and reading the explanations attached (Int-Professor 003). Here they can see different variations of the same cell and can better study its characteristics through the VM (Int-Tutor 005). Another complementary aspect was highlighted by Int-Tutor 006 who asserted that students can consult the material beforehand as it is already available in VMC/Moodle and come better prepared for classroom as well as for the oral exams in the end of each class.

Int-Professor 003: [T]he same slides can be used for all students in the virtual medical campus afterwards to see again the slides and there are different areas which are of interest and some small explanations of the areas. That's the main thing for us now.

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Int-Tutor 005: [R]egarding the virtual microscope you can see a lot different variation of the same cells, so you can get a better feeling of what it is about, and you can also, when you, for instance, uhm, the lesson ended, you can go home, look at the slides again, with lots of more time, and get a better feeling what is, what is it about you just learned.

***

Int-Tutor 006: I think it is really good for the students because before they have the seminar, which we separate in histology 1, part 2, part 3 and so on, […] they can look at home already what are they going to be shown next day in the seminar with the professor.

Tutors also briefly elaborated on the role of VM for them personally, as teaching assistants and as students, too. Int-Tutor 005, for instance, benefited much from it because it was easier to explain the structures to the new tutors (see also the previous subsection). Also, this tutor used it to prepare for his materials as an assistant of the professor. For the other tutor VM was useful to repeat the knowledge of the topics in pathology, courses she did almost three years before (Int-Tutor 006).

Int-Tutor 005: And we can show them[39] on the virtual microscope, so I use that for this. I also, like to, to look at it myself and to prepare for the lessons I am assisting and also to just look.

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Int-Tutor 006: Uhm, for me it's was just a training [laughs] […] to wiederholen [german] to uhm, what does it mean [checks the dictionary] [longer pause], ah to repeat [laughs]. To repeat the content of the pathology lectures which I had in 2015.

To conclude with the role of VM in teaching, Int-Professor 001 gives a detailed account starting with the practical use of it to come prepared for the course and the exam. Ideally, the students should engage with it before the class, to optimize the self-studying time and be prepared for the next seminar. Finally, re-studying the same slides in home after the class, solidifies their knowledge about the slides, which will be used also for the final exam.

Int-Professor 001: It has a very big role, because it's for the students to prepare […] not only [for] the exam but for the […] let's say, histopathology course, so which is entitled to start with the virtual microscope at home and then come to the actual teaching unit. […] So, it's an optimal combination of self-study explanatory courses and self-study again. In the sense, like […] they learn it themselves firstly with the aid [of the] virtual microscope and then they get a teaching session with the professors and with tutors even, and afterwards it's a small […] questionnaire of […] this kind of slides that I've presented. And in the end, they can go home and if they want and they should, uhm, re-prepare the same […] slides again, which then are asked in the final exam, in a written form.

6.6.2 The Purposes of VM

According to Int-Professor 003, one of main purposes of VM is to alleviate the limited capacities of the microscopy room in the department of pathology. Understandably, there is a restricted number of physical microscopes (which are also very expensive) and glass slides, comparing to students per year following the pathology-related courses.

Int-Professor 003: I think, the main purpose and advantage is compare to previous years. In previous years, the students came physically to our microscopy room. It was also a lecture hall, quite large area and they had the possibility to microscope their slides by themselves, on real microscopes. So, hm, there was a

[39] The new tutors

disadvantage, they had to come at a specific time. They had to use the glass slides, the glass slides broke then sometimes. They had to be reproduced or they are not available anymore. Hm, yeah, and the microscopes, of course, cost a lot of money.

A general purpose for adopting VM is to help the students study the samples themselves comfortably and in an optimal timeframe to come prepared for the seminars and the exams (Int-Professor 001, see also previous subsection). A less general purpose of using VM is to enable students better identify healthy and diseased structures. Since in pathology visual learning is more useful than abstract text learning, this technology is the appropriate instrument to understand what is going on in the sample (Int-Professor 002).

Int-Professor 001: [T]he purposes is to help the students to understand the microscopic, uhm, topics by themselves, yeah, with the help of the virtual microscope and to ensure that they ask in the present course direct questions, so than they are not unprepared and, like, sitting for the first time with this, because is overwhelming, so they can prepare each in their own, hm, timeframe to have the optimal benefit from it.

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Int-Professor 002: The main purpose is for the students to distinguish normal and diseased tissues structures, and I think, since most of us are learn easier by visual learning than just per text-learning I think is [a] very good way to understand for example, how, what's different in the tumor and the cells.

6.6.3 The Advantages of VM

Later in this empirical analysis chapter I will also elaborate on a comparison between the physical microscope and the virtual one. The advantages of the VM discussed here, either emerged naturally like in the case of the interviews with the tutors, or were asked explicitly without the intention to invite the interviewee for a comparison. Thus, the subsequent comparison (subsection 6.8.2) will be devised in a different light to see how virtual technology is performing against an established visual technology (physical microscope) in terms of learning pathology. Whilst, the advantages discussed in this subsection are a way to evaluate how this technology is affecting teaching and learning.

A main advantage of VM, also discussed previously, is the fact that the students can access it from their homes and overcome the difficulties of learning pathology just with the textbook and the limited use of physical microscopes. This is a way to engage more with microscopy in practice and "have fun with it" (Int-Professor 001). Similarly, it is more practical to study for the exams with VM as students can 'dive' into the pictures and have a broader view of the sample, the structures, and the pathologies (Int-Tutor 006 and Int-Professor 003). Unfortunately, the textbook has but a limited set of pictures and explanations regarding the pathologies of a certain organ explained in the seminar (Int-Professor 002, Int-Tutor 005, and Int-Tutor 006).

> *Int-Tutor 006: And so, they can prepare themselves at home, and look up in the book if they don't get something because the virtual microscope should not be like a book of pathology, should be just a little assistance to guide them what is the content.*
>
> ...
>
> *Int-Tutor 006: I think it is practical for the students because if they just started with the pathology book for the big exam, which is at the end of all the lectures and seminars they have in a semester, they can look up in the virtual microscope pictures, and scroll into and make it bigger and smaller […] and look after the special cells and regions of interests which they cannot on the book because there are just a few pictures of the topic.*
>
> ***
>
> *Int-Professor 001: It's a big difference because the physical microscope they can only use in a short period of time, but they have the courses, then they can use the virtual microscope and one of them have it at home of course. But the main question pop up after the courses, when they come home and then they re-value and think about what they have learned and now it would be good that they could look again at these slides and they could so, with the help of the microscope now they can. And it's also supposed to be more fun for them. Yeah, they can use it like, on a tablet, or just play around, and as long as they want. […] I hope is much fun, more fun than with the book, actually.*

Int-Tutor 005 elaborates on the idea that if he had had VM during his pathology course, it could have been easier and more beneficial to see a variety of cells, structures, and pathologies. The textbook or PowerPoint presentations don't have the same variation of cells and structures as in VM. Adding to this, another advantage with the 2.1 version, are the annotations that help the students to learn more efficiently (Int-Professor 002 and Int-Professor 003). Int-Professor 001 makes a strong case about the abstractness of pathology and how VM is very helpful for students because it gives them the opportunity to work their way around the structures. Moreover, they can work alone or in groups with the VM.

> *Int-Tutor 005: I wished I could [have] had that when I was a student, because the problem for me was that when you look to the slides, for instance in the textbook or at the power-points of the professors you just see […] one particular cell and*

regarding the virtual microscope you can see a lot different variation of the same cells…

***

Int-Professor 001: I think principally for the students it's a big help, because the microscopy is always a difficult thing to learn for the students. So just to learn the structure from the book is kind of too abstract for them. But when you teach in this interactive setting when they point at cells and ask which cell it is, yeah, and the microscope gives them the answer, so it's like they can reexam over and over again, as much as they want, or together or in groups or alone with the laptop or whatever and they can optimally prepare the book learning experience with the interaction of it.

6.6.4 Why Pathology

A strong motive to adopt VM in pathology is the extensive use of images regarding the diagnostic aspect, and also in teaching this medical topic (Int-Professor 002). Other departments that focus on images can benefit from using this technology, too. Int-Professor 001 argues that VM was introduced for undergraduate students because of the successful use in postgraduation education, and also to present cases in pathology conferences and congresses (see also subsection 6.4.2, Int-Professor 001 quote). Int-Professor 003 is not sure if pathology is the only department using it at Med Uni Graz, but he doesn't explain clearly why this department is more prone to use virtual technology. Instead, he elaborates on the benefits that virtual microscopy could bring in this setting not only in terms of teaching, but also regarding the diagnostic aspect like in other medical disciplines such as radiology. However, they should overcome a set of technical difficulties regarding its use in diagnostics (Int-Professor 003).

Interviewer: So why do you think is pathology the main user of this technology, in this university?

Int-Professor 002: Well, […] we work a lot with images. Having said that, there are also other specialties that work a lot with images and […] I don't know, I mean, radiology would be a good candidate. I could also think of, let's say, dermatology…

***

Interviewer: Why do you think that pathology is the main user of this technology in Medical University of Graz?

Int-Professor 003: I'm not sure if we are, the only or the main users. Is it the histology department using it also? I think so yeah. So, comparing this two, I think, they are both using virtual microscopy. In general, virtual microscopy increases in the field of pathology. That could be reason, yeah. […] Virtual microscopy is also in use nowadays, and some departments not here, we want to, yeah. That's […] should be in the near future that you scan all the slides but that means 1500-2000 glass slides per day. How much storage you have […] to have? […] It's an incredible large amount of data and maybe the step towards integrated microscopy, not only looking at the image but if you have also in the background an analysis software […] like in CT or MRI the radiologists use already, that could improve our diagnoses too. So, technology achievement in the last years go to what's the diagnostic root, But, of course the benefit for the students, is also in parallel.

6.7 The Impact on Teaching

In this section I will discuss more in detail the part of the interview guideline that reflects the research questions of this thesis. First, I will give an account of how has VM affected teaching in the department of pathology according to the teachers and tutors. Has the virtual microscope effectively reshaped teaching, or the impact is minor and insignificant? This is one of the issues that I will address in the last chapter of the conclusions. Second, I will briefly discuss how are teachers adapting with this technology, is it challenging, or consonant with them? Third, an important aspect to focus upon is how has VM affected the relationship teacher-student and did it have any effect on the latter performance and engagement. Finally, I will address the impact of VM in the pedagogical approach regarding microscopy (if any), or if there are other factors that have had a major effect.

6.7.1 Affecting Teaching

VM has made microscopy less abstract, by giving the students the possibility to visually check the structures and read the annotations. In this way, teachers are 'exempted' from preparing lengthy lectures and can focus on matters that are still difficult for the students to apprehend (Int-Professor 002). Thus, one practical outcome is that teachers have more time to address the other problematic issues concerning teaching and learning. However, the teachers interviewed are not so sure that the majority of students actually engages with VM before class to come better prepared for the seminar or the exams.

Int-Professor 002: Uhm, well, I think it has affected my teaching in a sense that I can maybe focus more on whatever is not well understood by the students of the things that you can easily find out you can learn by yourself and I can focus more on the question, and the things that are harder understandable for whatever reason.

Interviewer: [Th]e idea is that you have more time probably to focus on?

Int-Professor 002: Yeah, there's more time to focus on specific questions of the students, because they are more knowledgeable to start with.

Interviewer: Uhm, and they are more knowledgeable because they have, like, the normal images of the virtual microscope?

Int-Professor 002: Uhm, […] that's one thing I'm not so sure of, whether all students already looked at the virtual microscope before they go to lecture or not. Some of them probably do, most of them probably don't.

Nevertheless, it is relatively early to assess the impact that the new version of VM has had on teaching as it was implemented in the summer term 2018. Int-Professor 001 refers to it as promoting a "new teaching style". Especially if we consider the comparison between the older version 2.0 and the newer one 2.1. The main features that could also impact teaching is the idea that the annotations, the improved visualization, and handling capabilities will help students to efficiently study for the exams. Nonetheless, the fact that VM was implemented quite recently[40] prompted the indirect answer (about the impact on teaching) of Int-Professor 001.

Interviewer: So basically, how has this virtual microscope affected your teaching?

Int-Professor 001: Well, actually we are going to start through this semester with it, yeah in the old semester there was the old time virtual microscope, which was also very nice, but this new is supposed to help the students prepare […] for the ongoing exams […] in the courses. So, we're going to experience from the beginning of March, with this very new idea […] explanatory microscope.

The virtual microscope has made teaching easier, comparing it with its predecessors (discussed in subsection 6.4.1). It is technically superior and allows teachers to deliver the teaching materials faster, explain them better, and in a more comfortable fashion (Int-Professor 003). The improved handling of VM 2.1 makes it an easy-to-use tool for teachers and students.

Int-Professor 003: Hm, the virtual microscope made teaching easier for us […] [with] the virtual microscope you can move outside, inside, […] continuously. And that's really, really nice! So, we look […] on the screen, use only the mouse to move, do not have to move very often, because we know exactly where we want to go and that's very comfortable. So, it got more comfortable for us and I think it

[40] Referring to the time when I was working upon the thesis, starting from November 2017 and at the end of the fieldwork in May 2018.

got, uhm, the realization what we are talking about and explaining it better for the students.

Int-Tutor 006 claims that teachers like VM because it is technically more comfortable and practical to present the slides this way, than beam the images of a normal slide from a physical microscope. Moreover, the structural details are better presented through VM 2.1. Teachers don't have to worry from now on about the set of slides that they use for teaching microscopy. Thus, there is less material (claimed by one of the professors) to take care for, and you can teach about specimens with just few clicks.

Int-Tutor 006: [T]hey like it because they don't need to put in the preparates of the tissue in the microscope and then beam it over the microscope with the cover to the… yeah it is complicated.

…

Int-Tutor 006: I just once heard that they like it that they don't have to look after the teachers set, they have their own teacher set with the […] slides, yeah, from the microscope, so they just take the mouse and [laughs] click it on, easy, yeah, less material…

Int-Tutor 005 claims that teachers' use of VM was confined to the implementation process, as they don't usually engage with it in their everyday practice. Although, he has heard that some of the professors use it additionally in their lectures or seminars (not only those about or closely-related to microscopy), it is hard to properly assess the impact (so far) in teaching. He personally thinks "that the quality of teaching is increased by this", but doesn't elaborate more regarding this claim. On the other hand, Int-Professor 004, states that this technology has not affected his teaching. He prefers more the traditional way of teaching microscopy topics (in pathology), using the physical microscopes and discussing in the classroom, rather than using new technologies such as VM.

Int-Tutor 005: But in means of the virtual microscope which the students can see, I think the professors […] they mostly interact with the virtual microscope […] at the application process[41] *when they*[42] *came to them and show them the structures. So, I'm not sure how much they do use it in their own purposes. I've heard that some of the professors during the lectures in the normal teaching and lectures,*

[41] Referring to the implementation process of the VM. I had a follow up email with the Int-Tutor 005 to clarify this part, as it is ambiguous in his answer.

[42] Referring to the tutors.

they use it as supplementary thing as well, but I don't know what they do beside the application process…

***

Interviewer: Has it, kind of, impacted your teaching, in the sense of, has it contributed in your teaching?

Int-Professor 004: Not really. I'm not a friend of that, because I'm a friend of, let's say […] this, the teaching together. Face to face teaching, teaching together because, if you make that, you realize that the students understand quite a lot of things, not if you show it to them, they look at it and they don't realize […] what they have to see…

6.7.2 Adapting to Technology

Generally, all the interviewees state that there was no problem of adaptation with this technology. Nonetheless, there are different reasons and factors for it. Int-Professor 001, interestingly, argues that there is a generational 'ruler' which defines the interaction with digital technologies. Older pathologists have some difficulties in using the new technologies, even user-friendly ones. In this case there are tutors that help them with the pure technical activities (Int-Professor 001, but also Int-Tutor 006). For younger pathologists there was no problem of adaptation with this technology as they use digital tools in their everyday work (Int-Professor 001).

Int-Professor 001: Well, for the younger pathologists is quite easy to understand because they use, […] programs and things like that on the regular basis, but older pathologists it was, uhm, probably not so easy but they, uhm, they put the information in the microscope with the help of tutors…

…

Int-Professor 001: I mean [VM] it's quite simple to use and now it's a good system and how […] can you help the older pathologists [sneezes] to adapt, it's a question probably, uhm, yeah, for the development of easy, if not even easier towards I don't know, something like that…

***

Int-Tutor 006: They really like it[43], for them it is easy to use and if they have questions, we are next to them and we can answer if some, for example the system

[43] Referring to the teachers.

is now frozen, and they don’t know what to do, because the connection is gone, to the internet, and for example some professors are not so into technical […], nowadays internet and so on, yeah. We are always there to help them but normally they really like it and it is easier to handle.

Being exempted from the technical aspects during the implementation phase, which were done by the tutors, is also another motive for not having problems of adaptation. The teachers basically checked the structures presented by the tutors, and it doesn’t require any profound technical expertise (Int-Professor 002). Similarly, Int-Professor 004 emphasized his minimal involvement, in which he just checked the structures and markers, and provided a short text for the annotations.

Interviewer: Ok, ok, so, did you have any difficulties in adapting with this technology?

Int-Professor 002: I did not have to do much on a technical side of work, you know. The annotation was done by tutors and I just checked the data, marking, set up…

***

Interviewer: Hm, have you seen any sort of difficulty to, with this technology with the virtual microscope, in the sense of, preparing the slides, or annotations?

Int-Professor 004: No, not really problems there, because I didn't make that. No, not really! […] So, once the students came to me, about half year ago, showed the slides "Are these correct slides?" Yes, uhm. It was one of the tutors from the students. He came to me, showing the slides […] from my basics and we discussed it and he said, "give me a short text to that, […] and the main points, […] where's the tumor cell, […] where's that, what's that”. And that's it! I was not really involved in that.

Finally, there is also the sense of curiosity or the predisposition to technology that facilitates the adoption of digital imaging tools (Int-Professor 003). One of the tutors claims that the teachers use VM very well during the lessons, because the technology itself is quite user-friendly (Int-Tutor 005). The virtual microscope that teachers use (3DHistech, see subsection 6.5.3) was a big help in adapting to VM, as this software is updated and upgraded for digital visualization in pathology.

Int-Professor 003: [M]y affinity to technology is quite high, so, I like things to, to try and look for new things and so... [starts laughing]. […] So, I don't have really a problem with technology.

***

Int-Tutor 005: [T]hey use it very good during the lessons because, I think is a very good way to show because you can show very precisely what you want to show, plus you can point on it with the mouse, so it can draw on the microscope and you can also scale it a lot better than the analog one.

6.7.3 Evaluating Teacher-Student Interaction

VM is additional (supplementary) to the physical microscope in teaching microscopy, and is a comfortable solution for both students and teachers (Int-Professor 003). In terms of interaction it has not changed so much the rapport between teachers and students, but it has certainly impacted the self-studying time for students. Nevertheless, Int-Professor 003 thinks that VM has isolated students and maybe has impaired the communication between them and professors, as well as among their peer group. Regarding their engagement or performance, he thinks that it has remained approximately the same, but since the curricula has changed by and large, it is difficult to be sure about this claim (Int-Tutor 006 also elaborated on the curriculum change).

Interviewer: [D]o you think that learning through this technology promotes a new interaction between teachers and students, in this department?

Int-Professor 003: Hm, for this question, I'm a little bit skeptic, I think, uhm, that kind of teaching we've tried several things already during the last year, but we came back […] to the teaching methodology that we show the slides at first and make some explanations to this, and this is now done virtually, […] so that's easier. It's not so time consuming, you have not this change of objectives in between and you find your areas [of] interest[44] very quickly. So, that improved, but the kind of interaction, uhm, in my opinion didn't change a lot, yeah. And maybe only, the only thing is that for the self-teaching time, the students use. [short pause] Maybe here they are more isolated. So, the discussion about the topic, or about the, if they have a question is not so easy to… Previously you ask your neighbor, also maybe a student that you ask and what was this now, and now there is, maybe, sitting alone in the evening at home, [starts laughing] looking at the virtual microscope and do not have the possibility to ask something.

…

[44] Referring to the POI – points of interests.

Interviewer: So, do you notice […] anything regarding […] performance or engagement in the classroom, because of virtual microscope? Like, students can be more engaged…

Int-Professor 003: I don't think so! That's approximately the same! I would assume, I'm not absolutely sure. The problem for this question is also that, the kind of study changed a lot.

Int-Professor 002 reiterates the same response (as in the subsection 6.7.1 when discussing the impact on teaching) regarding the interaction teacher-student by reemphasizing that he has more time to focus on matters that are not so well understood by the students. Thus, it facilitates teaching and gives more liberty to the professors to engage with other issues. However, according to him, the interaction doesn't change so much in general. Similarly, Int-Professor 001 states that VM optimizes the teacher-student time, by assuming that the students engage with it before the class in order to come up with interesting questions or issues about the slides. Nonetheless, she is not sure about this, as it is not mandatory to use VM before the seminar.

Interviewer: So, […] is virtual microscope changing the interaction between teachers and students?

Int-Professor 002: Uhm, as I said, I think I can focus more on specific questions, uhm, assuming that the students already have acquired some knowledge using the digital microscope and then we can focus on whatever it was difficult to understand, so by itself it does not change that so much but the content of maybe of what you are talking about.

***

Interviewer: [D]o you think that […] VM promotes kind of a new interaction between teachers and students?

Int-Professor 001: I hope so because uhm, I am not quite sure that the students when they really do it and you cannot force them, [laughs] but when they really do it, uhm, new questions arise, yeah. And then, when they have the extra course with this topic, they pre-prepared, they did in advance, [pause] they can ask the right questions, not uhm anything show me something, but I prepared this slide and I have this specific question about it. So that is a thing to optimize […] the teacher-student time.

Int-Professor 001 claims that VM has contributed in the engagement and performance of students. They use it increasingly more as they know from their professors that the same slides will be used for the exam, in this way giving them a big advantage. In terms of performance, she draws on the tutors' feedback that the students recognize more structures than before (Int-Tutor 005 also claims this). Int-Professor 002 gives an interesting motivation for a possible increased engagement by referring to the VM as a 'toy that you can play with' (see also Int-Professor 001 in subsection 6.6.3). One of the professors that didn't agreed to get interviewed (he had contributed to gastro-entero-hepatology topics in VM) thinks that only a minority of students (5% according to him, from my notes) really engage with VM.

Int-Professor 001: I think, they do, and they use it more and more, last year they learned that it was possible to look at the VM and this year we want to introduce it by saying them in advance that the questions that are asked after the course will be taken from the structures from the virtual microscope. So, this way, the student that prepares for this, uhm, has a big advantage for his exam. Because these are the questions that are asked at them.

…

Interviewer: Do you have any idea of […] has it like enhanced their performance or engagement?

Int-Professor 001: Yeah, I guess so, I guess so. We have a good feedback from the tutors. I think they say they have a positive, they see a positive effect from the students that they recognize more structures, yeah, they are actually better.

***

Int-Professor 002: I think it, uhm it's all of, you know, you can play with it. And if you can play with something, you'd spent more time with it, right? [laughs]. So, I think students might spend more time with it as opposed to if they would not have it, so by that, they acquire a knowledge which otherwise they would have to study more…

The engagement of the students with this technology is surely facilitated by accessibility and the possibility to use VM in their own timeframe (Int-Professor 004). But to increase their knowledge and understanding of microscopy requires much more than that. Int-Professor 004 makes strongly the case that the students don't quite understand what they are learning, and VM can hardly improve this trend. Initially, students should reflect on what is important to learn regarding pathology and microscopy. According to him the best way is the traditional approach in which they learn via the textbook and practice with the physical microscope.

Int-Professor 004: [F]or the students is much easier. Yes, because they can do it at home. They can do it in the airplane or wherever they want. That's, […] really good for the students. I understand that, it's much easier for them. But, uhm, one of the main points, I really, I told you, is to understand […] they are reading something, they are learning something, but they don't understand it. That's a really big problem for them.

…

Int-Professor 004: You cannot discuss it, because […] for example a couple of years I studied in Austria, I studied in Graz, and we had to study books and all, and we had to work out the main points for us. With this working out we had to understand it and then, afterwards we had to go by ourselves to the microscope. And to the microscope with the slides. We had the courses and all and so we were able to work the main points out. And, uhm, the students, probably for pathology is very big […] part of medicine. The students don't understand what's important, what's not important, what's very important, and they are just learning absolutely blind now.

The opinions of the two tutors are also a very valuable and reliable source of information about the students' uptake of the different topics in pathology and microscopy, because they interact with them in everyday basis. Int-Tutor 005 claims that students do really use VM as they come prepared in class with printed structures, and can easily identify them. However, it is still quite early to make certain claims due to the recent implementation of VM 2.1. Int-Tutor 006 elaborates on the idea of using VM before class, by pointing out that coming prepared increases the chances to get more points in the oral exam in the end of the seminar. These points are calculated and included in the final grade of course. Similarly, VM makes the study for the final exam easier and interactive as it allows the students 'to dive deeper' into the slide and learn the structures, which is impossible just with the pathology textbook (see also subsection 6.6.3, Int-Tutor 006 quote). Nonetheless, these claims are personal opinions and not statements from the students.

Int-Tutor 005: So far, I think, the students [pause] do use it, because when […] we observe that, for instance in this semester a lot of students, they come prepared and they print out structures on paper […] when they came to the lessons, which *indicates they can use it and they even make they own scripts*[45] *[…] with the virtual microscope and I have the feeling that, because […] the new course just started […], so we just got very little information so far. But I personally have the feeling, which could be biased, uhm that the students find […] the structures which we ask them easier. So, I think it's an improvement for them and we also, […] when I study in the library, I see the students use the microscope. I'm not sure if it's before, or after because I don't ask them, but so far is used by students…*

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Interviewer: Uhm, what is the students' feedback about the use of the virtual microscope?

Int-Tutor 006: I have never asked them, but I think they like it because they can look at home before they attend the seminar because they know they have to get the [exam], gain the 5 points for it, which they need for the note[46]*, yeah. And so, they can look at home what they should study for tomorrow.*

The opinions and claims in this subsection about the interaction between teachers and students, are undermined by the fact that there is little if no feedback from the students. This is backed up one way or another from almost all the interviewees. Int-Professor 002, for instance, is curious to know how the students perceive this technology, is it worthy to spend more time in improving it? Int-Professor 004 is also interested if VM has helped students to understand better pathology. Although he is skeptic about this, claiming that half of them don't really do. Both tutors don't have any feedback from the students, although I initially thought they would, as they interact more closely with them (Int-Tutor 005 and Int-Tutor 006).

Int-Professor 002: I would be, just, interested to find out how students really see it, and […] how they perceive the effects of the changes […] because, uhm, to be quiet honest, I have not really, [pause] I sometimes ask do you like it or not, but I have not, let's say, formal feedback on how well is perceived, how much it is used. Is it worthwhile to spend even more time on annotating things and things like that, so that, I would be interested to hear that.

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[45] The detailed histo-morphological structures viewed in VM.
[46] Meaning grade.

Interviewer: So, you are, kind of, interested in knowing, like, how much the students use this application or has this application helped them to understand pathology better?

Int-Professor 004: Yes, it could be, it could be more interesting for us or for me, and the […] difficult point is, we don't get any feedback from them. The only feedback we get is, […] if we're going […] to this short answered-questions and to read a lot of them, […] and in the writing, in the answers we can see, or I can see that, I would say that 50% don't understand what they are learning.

6.7.4 The Impact on Pedagogy

In comparison to previous years, computers and digital technology are increasingly adopted in medical education. Nevertheless, the type of teaching hasn't changed so much from technology, and it has been affected more by the curriculum change than the virtual microscope (Int-Professor 003; see also Fried and Feldman 2008; Satava 2008). For instance, some specialties in medicine have been put aside and others have emerged and grown into prominent disciplines. Microscopy was part of the new specialties that saw an increasing presence in the medical education curricula. Int-Tutor 006 states that the new version of the VM took place along with the change in the curriculum of pathology at Med Uni Graz.

Int-Professor 003: I think it's […] a kind of evolution and, and it's the same we use nowadays computers much more than we used it 15 or 20 years ago. […] [B]ut it's more the type of vehicle we use and not, it didn't change a lot our type of teaching, I think. [Pause] It's like, if you compare cars, old cars 30 years ago, had maybe less comfort compare to newer cars. […] The comfort of teaching increased, but the type of how we teach it's more condensed now, but that's correlated to the new curriculum and not to the virtual microscope.

…

Int-Professor 003: As I studied, already I think 24-25 years ago, approximately, we had a different kind of study, a different kind of teaching plan, yeah. The curriculum was completely, completely, completely different. […] Some specialties were more, uhm, taught and were more important and nowadays they are shrink to a minimum. So, it's a little bit difficult to compare because the virtual microscopy started already with the change of the studies. The curricula changed and then soon, after that, the virtual microscopy was also introduced and was used for the students.

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Int-Tutor 006: [It] is a new curriculum and therefore the system of pathology semester is different. I had three exams to write, and they have two big one in one semester, and histology is also part of pathology of course and so they have oral exams. […] [W]e had just a script with some pictures, no virtual microscope.

Moreover, there are certain expectations regarding how can VM influence pedagogy in the future. Teachers expect students to come prepared in the class and this presupposition could be probably one of the factors for change. It is hard to evaluate the broader effects of VM in the pedagogic approach, as professors teach pathology in a certain system that involves blended learning, making it quasi impossible to assess separately technology-enhanced and face to face teaching (Int-Professor 001). Although VM has not had a fundamental impact on pedagogy, it could give teachers an incentive to focus on other issues concerning students. This technology is additional to the normal teaching (traditional) and will not replace it (Int-Professor 002). Int-Professor 004 affirms that this technology has had no effect on his teaching or the pedagogic approach toward microscopy.

Interviewer: How has this technology-enhanced learning affected or changed your […] pedagogic approach to teaching?

Int-Professor 001: That is a tough question. I mean we are supposed to teach […] like in a system. So, […] we have to re-teach the things that they do at the VM, so we cannot leave out, yeah. But uhm, I think uhm, the hope or the aspect of presenting these titles is that you ask more of the students as you very well know or as you saw in the microscope, this and these structures. So, I think […] we have a certain expectation that your […] message is received […] you can say "as you very well know from the microscope, or you have seen it already […]". I think this is the difference, so you can relate to something.

***

Interviewer: [H]as this technology, kind of, changed your pedagogy approach towards teaching?

Int-Professor 002: [pause] Not fundamentally, but maybe, as I said, in terms of, where my focus could be. No, is not a disruptive technology, as one what would in modern terms say. It's additional, auxiliary, and enhancing, but not replacing.

6.8 Blended Learning in the Department of Pathology

Blended learning is a reality in the today's educational system (Selwyn 2011, 2013). Although, the implementation of technology into education systems hasn't been easy, but in many cases a stark challenge. Many digital technologies have been increasingly introduced and used in education, but they haven't fundamentally changed the pedagogic approaches. The problem is not how to implement the technologies in educational systems, but how to reflexively consider the needs of students and teachers in higher education (Schober and Keller 2012; Pernsteiner et al. 2009; Frankl and Bitter 2011; Bitter and Frankl 2012). Medical University of Graz, and particularly the department of pathology, have constantly promoted new technologies for teaching microscopy (Int-Professor 003, see also quote in subsection 6.4.1). In this section I will elaborate on the interviewees' arguments about traditional (face to face) and technology-enhanced teaching. How has technology affected medical education, how can it improve different aspects of teaching and learning, as well as what is still obdurate and hard to change?

6.8.1 Face to Face and Technology-enhanced Teaching

Medical education has been increasingly permeated from different sets of innovative technologies, such as virtual bodies for anatomy and simulators for surgery (Prentice 2013, 2005; Satava 2006, 2008). Nevertheless, Int-Professor 003 states that the hands-on approach in teaching pathology is still crucial for the students. By training the tactile senses they can acquire a set of skills that could make a big difference in diagnosing diseases (see also Prentice 2013).

> *Int-Professor 003: [I]f you do not have this experience by feeling a tumor in your hands, you really [do] not know how it feels […], if you are looking for a breast tumor and if you want to differentiate. It is only an example, but either if you want to differentiate between a benign and a malignant. The feeling […] if it is very hard or soft, that helps a lot.*

Increasing virtualization for the students guarantees a 'safe investment' in medical education (Int-Professor 001 and Int-Professor 003). The VM beside its economic convenience (reducing costs, having reusable learning objects, and avoiding the excessive use of resources), promotes an interactive way to learn microscopy and pathology that will have an impact on students. This impact is already manifested in that students recognize more structures learned through VM than they used to do when they had just the textbook (Int-Professor 001 and Int-Tutor 005). VM is a practical solution that can be harnessed furthermore to include comparison between slides with cross-specimen images (Int-Professor 003). Technology-enhanced teaching can cover a wide range of topics and pedagogical methodologies, but the hands-on approach in pathology as a crucial aspect of diagnostics cannot be taught only through digital technology (Int-Professor 001). Although virtual diagnostics in pathology is a reality in many institutes around the world, medical practitioners still prefer the traditional approach in microscopy and the use of physical microscopes. Probably a good combination of the two approaches could be more beneficial for the students, who nevertheless should learn how to 'find their way around' the physical microscope (Int-Professor 001, Int-Professor 002, Int-Professor 003, and Int-Tutor 005).

Int-Professor 003: Maybe, maybe two things or two points I realize for me personally. So, the one thing is, it's great that we increase virtualization for the students. So, for the microscope, also maybe we will do it for later on for cross specimen like in anatomy. Or only for pathologies specimen or showing them on video or whatever. Also, the record of lectures, I think is important! And that's relates to comfort. The comfort for the students, they can recapitulate or repeat the lecture or, and, and see once more and learn it better, I think.

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Int-Professor 001: [T]here are two groups of pathology's hardcore microscope's fans. All around the world it's the same, and there are pathologist even using the virtual diagnostics in their routine diagnostics. So, there are some institutes that totally stopped using microscope and they are doing everything with scanned slides, yeah. Uhm, and there are advantages and disadvantages [laughs] for it, but I think a good mixture, is probably the answer to it, because uhm, the classical handling of a microscope should be learned by a medical doctor. So, I would never put all the courses in purely virtual experience. […] You can teach everything computer-based, but this is still for the students maybe not such, uhm, such a good experience, to see how the actual work of pathology and diagnostic finding […] occurs.

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Int-Tutor 005: I also think that it's very important that the […] analog histologic courses are maintained. So, the students do get [the] feeling on working on a microscope and […] this is not replaced by, for instance tablets or PCs and they just have the lessons in their PC. So, this is also very important.

Instilling more technology in teaching pathology could have unpredicted drawbacks such as isolating students (Int-Professor 003). This can be a big disadvantage because it can impair the communication student-teacher, but even more importantly the communication of students with each-other. Int-Professor 003 goes on with rather pessimistic predictions regarding the technologies implemented in this educational setting. For example, recording the lectures and virtual classrooms could 'backfire', for instance, in less students participating in lectures. This possibility and the lack of communication could affect how these students will behave in the future as medical professionals. And he is not sure if the students realize the 'magnitude' of these issues.

Int-Professor 003: But the big disadvantage on the other side is the isolation of the students, in a kind of, as we said already, the decrease of communication. And not so much between the teacher and the students, but I think the students among the students. And that could be an interest in point also to, to hear, maybe from you[47], what do you think that the people get more and more into isolation, yeah! And do not communicate any more so much as we did in the, yeah, 20 years ago!

...

Int-Professor 003: I'm a little bit afraid also for the experiment of recording lectures, that the students will not come anymore to the live presentation and live lectures. […] Students appear at the lectures, at a high level. And later on, they disappear more and more. […] I don't know exactly but, the communication among the students […], it relates also to how they will behave later on in the profession. I believe, yeah […] medicine has a lot to do with the communication among each other. […] And I'm not, I, absolutely, have no idea how we can, yeah, make it, make this weakness a little bit better. I'm not sure if they realize the disadvantages. Yeah! They are, let's say, kind of "blind" area!

Int-Professor 004 elaborates more regarding students' uptake of microscopy in the histopathology courses. Previously, I elaborated on how could the improvement of slides visualization and the explanatory feature of VM 2.1 'dissolve' the abstractness of pathology (Int-Professor 001 and Int-Professor 002). Int-Professor 004, on the other hand, claims that the only way to tackle this abstractness is with face to face teaching and discussing together with the students what they have learned during a seminar.

Int-Professor 004: Face to face teaching, teaching together because, if you make that, you realize that the students understand quite a lot of things, not if you show it to them, they look at it and they don't realize what they, what they have to see, and they need the background, because the pathology [..] for the medical students is something abstract and many of the students think they don't need that. A lot, not all, but a lot think they don't need it, and […] if you are teaching face to face, you can show them why they need that, and you can discuss the short questions they have.

[47] Invited by Int-Professor 003 to give an opinion about the isolation of students and the lack of communication, I elaborated on the idea of assuring yourself that you learned something (facilitated by technology) and refrain from asking for a second opinion or open up a debate about it with your peers. Nevertheless, discussing it could shed light upon the aspects that are less clear to you, and is also a pool of further opinions that could improve your knowledge about the topic.

Engaging with the physical microscopes and then discussing the findings or issues with their professors is crucial for a student of medicine. They would understand more about pathology and benefit further from their experience with the hands-on approach, rather than focusing only on virtual microscopy. Communication or contact is very important but students don't understand that, and they are more inclined toward novel technological solutions (Int-Professor 004). Students sometimes display a lack of quality in understanding and reproducing the knowledge about microscopy. This probably happens also with the VM, they don't fully comprehend it and its use. Ultimately, resonating also with the above claims of Int-Professor 003, Int-Professor 004 points out that problems of understanding and the lack of communication could be carried further in the students' professional life as medical doctors. He backs this statement up with the observation that students are often not able to read their (professors) diagnoses.

Int-Professor 004: If you are teaching together with the students, uhm, the students have their slides by themselves, and I think it's very important for the students to work out the difficulties by themselves, yeah, and if they have questions they can talk, contact you, contact the teacher and, I think this small talk is very important. And if you're talking, […] if they just have this virtual microscope, they don't have the opportunity for that. Yeah, I think, that's […] one of the main points, the whole studying of medicine, everybody wants to make virtual microscopy, virtual teaching and so on. And the students, they take […] your pages or whatever you give them, they are just learning that without using their brain.

…

Int-Professor 004: That's the main point with the young in the university, to have contact. So, I would say, I have seen quite a lot in my life, I have seen a lot of mistakes and I can show the students the mistakes and can show and declare them what they need, […] what's the problem, and what they don't need, but you cannot do that with the virtual teaching or probably with the virtual microscopy.

…

Int-Professor 004: That's a […] a very important thing, […] I can see that if we're correcting the short-answered questions, I see that they have some special words they throw in and they don't realize what this means, and I think that's the same problem [with] the virtual microscopy. They found something, they read it, but they don't understand it.

...

Int-Professor 004: Later on, if they are, probably I don't know, a surgeon or something like that, but it should help them to understand the problems, and we see that this new generation of students now, they are medical doctors and they are coming, and they are not even able to read our diagnoses, they don't understand the diagnoses and that's very dangerous for […] the working out, […] for the patients and for all. Ok, because […] they are not able to, to understand the main points, for them, for their patients, […] for their future...

6.8.2 Physical Microscope VS Virtual Microscope

Following on the different aspects of blended learning are the questions of what is achievable with VM in terms of learning, and why students still need a physical microscope? Although, I discussed some aspects in the subsection dedicated to the advantages of the VM, in this part the physical microscope advantages will be emphasized to compare both of them. This comparison will, hopefully, give a clear dimension of what can VM do for the students. On the other hand, I will lay down the arguments about the reasons why the physical microscopes are still needed to learn microscopy and pathology.

Handling the specimen and manipulating it to determine its pathologies is a very crucial skill for future pathologists to make the diagnoses. This hands-on practice starts initially by pulling out the tissue, cutting the specimen, putting it on the slide, then staining it to make it ready for the microscope. Afterwards, the pathologists observes in the microscope the different structures to define what is going on with the sample. These are the basic skills that students have to learn which is not possible with the VM (Int-Professor 001). Nevertheless, Int-Tutor 006 thinks that it is not so hard to acquire and develop these practical skills, as you just need to learn how to operate and observe with a physical microscope. But this statement is clearly very 'reductionist' if we consider all the skill-set described by Int-Professor 001. Obviously, the visualization offered by VM is very handy for the reasons already mentioned, but vision is not the most important thing, especially considering the handling of the specimen. That can be the reason why both microscopes are needed for a better learning experience (Int-Professor 001).

Int-Professor 001: It's not really the vision, it's the handling of the specimen, so things you really see on a slide, ok. This is the tissue, it's the actual tissue, which was cut and put on the slide and then stained with certain stain and now I have it and I put it in the microscope. And I look […] at the low magnification, and then I see the overview of the tissue which I have in the hand, and then I can switch it to higher magnification, and then I see the same [pause] specimen, actual specimen here. And then I change it, and can I look at, you know, it's just having more of the patient in your hands. So that's for the students I think a good experience because in the end they are going to pull out the tissue of the patient and they experience *what is gonna happen with the tissue and the pathologies also. Of course, the visualization is also very nice on the screen and you can see the same thing, but you don't have the handling and the feeling of the real thing, […] and then you can connect, yeah, if have a few courses like we do then the other courses on the virtual and that's fine. But I would not have never used the microscope themselves and get the experience […], a good combination is the key, I think…*

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Int-Tutor 006: Uhm, you mean how to how to, to handle the microscope itself? Oh, that's not a harder technique, you just have to [laughs] uhm use one or two how to say rotors yeah, that's not hard, yeah.

Int-Professor 002 argues that the explanatory feature of VM 2.1 makes somehow the difference between them, especially considering the handling of information about the slide. Nevertheless, the physical microscope brings the pathologist more closely to the "real life" and they can deliberate independently of the annotations about what is going on in a certain specimen. The slides observed with the physical microscope could give an important additional information about the pathologies and the structures. Although VM has many advantages, the 'actual body' (Prentice 2013), or the physical world is important for the diagnostic aspect (Int-Professor 002). In the department of pathology they have even considered the transition to digital pathology considering the advantages of the VM, but most of the medical practitioners still prefer the physical ones.

Int-Professor 002: [O]n the virtual microscope you have annotation which you do not have them on the real thing. On the other hand, I think is also good to look at the slide, or a specimen and find your own way around. So, [coughs] it's both ways, because if you have annotations, automatically only look at the annotating things, uhm, everybody does, I guess! [laughs]. So [coughs] I think, both things have something and, and I also think, uhm, like having something in the hand, you can also look at it just with the eye, right! […] You can look at it just with the eye and see a tumor and I think that is needed to get the connection between real life and the different magnifications. Which you will not get at the virtual microscope because, for me at least, […] I think it's you know, the real thing gives you […] an additional information.

…

Int-Professor 002: I think there is still a place for the physical world, but lots of things can be done, just by the virtual microscope, and has a lot of advantages, *and as we in pathology also we are contemplating the […] transition for daily diagnostic work that we have. And at this point, most, I would say, 95% still prefer the real microscope. Because, at best virtual microscope is equal in terms of handling information of that. So, at this point there is no real useful transition for diagnostic work.*

6.9 The Future Regarding the Virtual Microscope

Besides what was already discussed, an important facet emerged from some interviews, are the future projects regarding the virtual microscope in this setting. Virtual technology is taking over in many medical institutes in the developed countries (Prentice 2013; Int-Professor 001 and Int-Professor 003; Lenoir 2002; Satava 2008). Teaching is often the main target, but in the future, it is no surprise that virtual microscopy will extend in the 'realm of diagnostics' (Int-Professor 003, see subsection 6.6.4). The accounts given by Int-Professor 001 and Int-Professor 003 (subsection 6.4.1) suggest that the department of pathology is prone to adopt novel technologies in teaching.

The tradition continues with the department of histology at Med Uni Graz pushing for the implementation of VM, too. Since the modules taught with VM are histopathology (see subsection 6.5.4), the further implementation and adoption by the department of histology seems consequent and well-grounded (Int-Professor 001, Int-Professor 003, and Int-Tutor 005). It will be in the benefit of both departments to have a proper comparison between healthy and unhealthy tissues through VM, thus learning histopathology in a more interactive way (Int-Tutor 005). It can also be a bridge toward understanding some clinical aspects of microscopy which are not clear yet. Since histo-anatomy is taught before pathology it is better to have the overview of healthy tissues and then apprehend the pathology of the unhealthy ones (Int-Professor 001). This project could extend even further, as normally there will be more digital slides with a bigger database concerning VM, creating in this way a kind of medical atlas of samples and images fully digitized (Int-Professor 001 and Int-Professor 003).

Int-Professor 001: [T]he histology department asked us if they can virtualize their normal histology slides, you know like the normal histo-anatomy of the body, the whole body, which is […], let's say […] [a] topic that is taught before pathology, because before you know what is a disease you need to know how it really looks like. So, in this department they ask us to use our slides scanner and they will do it now. So, it will be even more specimens.

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Int-Tutor 005: [H]istology department asked if they could have the same virtual microscope and make it possible to compare the healthy and the unhealthy tissues, so you can really see and measure things and compare them directly. So, I think *that this is a very good way to learn histopathology in a more active way, which I think, helps a lot in understanding the clinical aspects later, when you also can, because it's all, for all the students, and also come back later, and when you learn it […] maybe then understand it better…*

Another project that will be carried on in the near future, will be the one concerning cross pictures of specimen integrated in the VM (Int-Professor 001 and Int-Professor 003). From the same sample, images will be focused on different sections, considering the pathological aspects as well as the healthy tissues in the same region (marked within a POI). This will be explained in a histopathological correlation through the explanatory feature. Thus, the student will have the cross pictures and the respective explanation that will help them make sound judgements about the sample (Int-Professor 001). According to Int-Professor 001 and Int-Professor 003, VM or virtual technology in general, has a good potential to make teaching more effective and influence also the diagnostics in the future.

Int-Professor 001: [O]ur plan is to add to the virtual microscope some cross pictures. So, you have a cut surface of a heart with a heart attack with fresh necrosis, […] like, which is yellow on the cut and then you have the slides, where you see streets of granulocytes, this area where the necrosis took place. So, we want to combine these two things as well, so that's the […] project which should add additional information like that the student has the specimen as a picture, as a cross picture and additionally the histo-correlation in the microscope. So, that will be very nice, but this is in the future, yeah [laughs], so there are many things that can be done.

7. Conclusions

“Education is on the brink of being transformed through learning technologies; however, it has been on that brink for some decades now.” (Laurillard 2008, p. 1) Like this quote suggests, it is not an easy task to assess the success of digital technologies in education, especially when many educationalists engage with instrumentalist and overoptimistic accounts. Educational researchers within social sciences and working with qualitative methods have tried to open up the debates regarding the influence of digital technology in education (Selwyn 2011, 2013; Selwyn and Facer 2013). Claiming that technology has really changed teaching, learning and pedagogical approaches is very problematic, despite the increased presence of digital technologies in schools. There are successful adoptions of educational technologies such as the Hole in the Wall project or One Laptop per Child in the developing countries, but this doesn’t mean that digital technology is reshaping education or radically improving it (Selwyn 2011). On the other hand, the department of pathology (Medical University of Graz) through the years have tried different technologies to teach microscopy, but each of them failed to make an impact mainly because they were not practical to use for teaching purposes (Int-Professor 003).

In the context of this research, emerged two clashing philosophies about how much technology (and what type) could be beneficial in learning pathology and microscopy? Two professors were very enthusiastic about the VM 2.1 (Int-Professor 001 and Int-Professor 003), and the possibilities that it opens up for the students to cognitively learn the visual aspects of the sample by forming mental models (Prentice 2005, 2013). On the other hand, two other professors claimed that students have difficulties understanding pathology and microscopy, that is why the best way to tackle this problematic is the combination of textbook, face to face explanation, and then using the physical microscope (Int-Professor 002 and Int-Professor 004). The questions that arise are: What type of skills does virtual technology teaches? What kind of skills are taught better only through the traditional methods?

It is quite hard to quantify medical skills. As there is abstract and theoretical knowledge about anatomy and pathologies (Hirschauer 1991), there is also tacit knowledge or practical skills that are acquired through years of practice and experience (Myers 2007; Prentice 2013). The students should learn the histo-morphological structures, which is the cognitive part based mostly in visualization (Satava 2008; Prentice 2005, 2013). As argued by most of the interviewees, VM 2.1 is the perfect tool for this. The digitized samples have a clear image, the movement within the sample is fluid, magnification is as good as the physical microscope, and the explanatory features explains what is going on with the selected section.

The physical microscope, on the other hand, is unreplaceable because students learn the handling of the microscope and the sample through it. For many professors this is an embodied skill, because of their experience and the constant practice (Prentice 2013; Csordas 1993). This is the reason that students should engage with the physical microscope, they should learn how to handle it, but also get the "feeling for the real thing" (Int-Professor 001; see also Int-Tutor 005 quote in subsection 6.8.1). As also Int-Professor 003 argues, a medical student should learn the different clinical skills (touch, smell, seeing) as it gives more diagnostic information than that provided by a screening or imaging device. Discourses about how much digital technology should be implemented in medical education and for what purposes must consider the different elements of medical training. Undoubtedly, simulation and virtual technologies are 'handy tools' in clinical practice (Satava 2006, 2008), but we should also consider that perception, skills, and medical judgement are vital in healthcare settings, and it is rather impossible to train them through technology (Prentice 2013).

Why this technology? As with any medical specialty, the tools are important in many aspects, but they also contribute to more confusion if the trainee or the medical practitioner cannot use them properly (Collins et al. 1997). The availability of physical microscopes is problematic because of a limited number of devices and a growing number of students, which hinders the proper practice sessions necessary to develop the skill of handling the specimen and the microscope. VM besides improving the cognitive skills, has the potential to help students to have a better studying experience concerning the seminars and exams, as the material is available before and after the actual courses (Int-Tutor 005 and Int-Tutor 006). This is in line also with the emphasis in today medical education of criterion-based training aiming to boost performance and proficiency by promoting measurable cognitive skills (Fried and Feldman 2008).

The adoption of virtual technologies in this department can also derive from the fact that digital pathology, telepathology, or remote pathology are experiencing a big growth in western countries (Hamilton et al. 2012). Digital technology is increasingly being adopted in healthcare settings and education is also one of the main beneficiaries of this trend (Prentice 2013). VM from its first version to the current one has improved in all the technical features, but the main functionalities have remained the same. 3DHistech[48] has other functionalities and products that could really be useful not only in education, but in digital pathology as well (https://www.3dhistech.com/pannoramic_viewer). The future projects based on virtual microscopy are another reason for its implementation (see subsection 6.9).

The beneficial nature of this technology is clearly dependent on the students' engagement. Despite the fact that it favors more learning, teaching is also influenced by this virtual technology. Interviews with professors and tutors proved to be the right methodology to inquire about the virtual microscope and how it has influenced teaching practices in the department of pathology at Med Uni Graz. Four professors and

[48] The virtual microscope that teachers use for their own purposes, see subsection 6.5.3.

two tutors accepted to be interviewed. Other teachers in this department have also contributed for specific topics in the VM, but they refused to participate[49].

The professors interviewed here were teaching in this department since a long time, they helped with the implementation of VM 2.1, and also held pivotal positions within Med Uni Graz. Their expertise and experience in various fields of pathology and microscopy helped me to understand better the scientific profile of this discipline, matters of teaching and learning concerning microscopy, how has technology impacted their teaching, and its expected impact in the future. Moreover, the two tutors interviewed were also for a long time working in this department. Both had a crucial role in the implementation of VM and also assisting teachers during the seminars in explaining the histopathological structures (with the help of VM) to the students.

This virtual technology is designed to tackle the problems in learning microscopy. The main problem that emerged during all the interviews was the fact that both teachers and tutors had no feedback from students about this technology. Thus, the discussion here is solely based on their perception and experience. However, the main focus of this research is on teaching practices and the influence that VM has had on them. How will teachers cope or adapt with educational technologies in terms of delivering an efficient teaching within an acceptable time-frame? How have teachers benefited so far from it? How is the interaction with students regarding the classes based on VM 2.1? How can we (as researchers) make sense of the actual benefits of digital technology for teaching and learning?

The technologies implemented during the 20th century, such as radio, television, and microelectronics failed principally because teachers either were reluctant to use them, or they lacked training and skills to engage with technologies in a classroom setting (Selwyn 2011). Nonetheless, the professors of pathology didn't had any problem of adaptation, and tutors were there to help in case of difficulties. VM 2.1 has made teaching easier and comfortable for them as they can deliver the materials for the histopathologic courses in a more structured way (Int-Professor 003), without having to prepare long lectures, or worry about the microscopy teaching set of glass slides (Int-Tutor 006). The presentation of the topic is more comfortable with VM 2.1, while at the same time teaching in general is better organized - teachers explain the theoretical part and the tutors the histo-morphological structures (Int-Professor 003). They have more time to focus on other issues regarding teaching that need a solution (Int-Professor 002), and also more time for the other tasks that their profession entails, such as the clinical practice and research activities.

[49] One of the professors that declined to get interviewed wasn't using VM in the courses that he was teaching. The other professor that didn't accepted stated that he had contributed in some topics but didn't liked this technology.

Most of the professors were skeptic about any change in their rapport with the students regarding the classes in which they use VM 2.1. Nevertheless, they have higher expectations of an increased engagement by the students, as they have the right incentives to come better prepared in seminars as well as exams. Professors give also differing accounts about the impact that this technology has had on their relationship with students. While Int-Professor 003 and Int-Professor 004 are afraid that this technology will impair communication with students, but also students among each other; Int-Professor 001 believes the opposite, VM 2.1 can incite a better communication and stronger engagement from students, where they can work in groups or alone. Together with Int-Tutor 005, they think that this technology has already helped students to better recognize the structures and come better prepared in the classroom with printed slides from the VM.

There is no doubt that the implementation of VM 2.1 has benefits for teaching and learning. But, is this a sign that it has affected, changed, or reshaped them? Selwyn and Facer (2013) warn about the "means-end thinking" (p. 7), which takes for granted that the implementation of more technology will bring positive outcomes. Educational technology and VM in particular are complex devices shaped by different actors (Latour 2005), and beside the expected benefits there could also be unexpected consequences, like the possibility discussed previously of isolating students and impairing communication. Another problem in evaluating the proper effect that this technology has had on teaching (also learning) is the relatively recent implementation of it (Int-Tutor 005). The missing feedback from students adds to the complexity of assessing the impact that VM has had so far. Further research is needed to inquire about the students' perception and experience with this technology to have a clearer idea of how learning has benefiting from it.

So, is it premature to speak about a change in the pedagogical approach or teaching practices in microscopy? Int-Professor 001 talks about "a new teaching style" in the histopathology courses due to the VM 2.1 and especially the explanatory feature. Again, this is an expectation more than a reality in the department of pathology. One thing which is evident is that the structure of teaching has been changed in relation to VM-related classes. This doesn't mean that the pedagogical approach in teaching microscopy has changed too. The curriculum of histopathology has changed (Int-Professor 003 and Int-Tutor 006), maybe also towards what Fried and Feldman (2008) have called "reproducible curricula" (p. 156), which is medical training directed towards performance and proficiency. This evolution in the curriculum has coincided also with the implementation of virtual technologies in pathology. Moreover, as most of the interviewees state, VM 2.1 is a supplementary tool in learning microscopy, thus any effect on teaching and pedagogy should also take in account the traditional aspects of teaching microscopy.

The collaboration between teachers, tutors, and the eLearning team made possible the implementation of this technology for students of histopathology courses. Although there were minor delays because the delegation of tasks passed to and from the main actors (Latour 1992, 2005), the virtual technology is ‘up and running’ with no problems so far. The future is promissory, as elaborated by Int-Professor 001, Int-Professor 003, and Int-Tutor 005, because there are projects that will extend the application of virtual technology for students towards digital pathology rationales. How and who is deciding for the technology implementation at this department? Is it a top-down chain or is it a bottom-up movement from professors and students? Unfortunately, I haven’t inquired about these general rationales, at least these weren’t reflected in the interview guidelines. Although, researchers of educational technology should consider the economic and political rationales behind the implementation and adoption of digital technologies (Selwyn 2011, 2013; Selwyn and Facer 2013), my focus here was to inquire about teachers’ experiences with VM. This, somehow, directed the research more towards scientific and practical reasons of adoption, rather than the economic strategies or political rationales behind it.

Nevertheless, future research beside inquiring about students, should also focus on the decision-making practices regarding educational technologies at the department of pathology, economic incentives, and political rationales. As argued by Rehatschek and Hye (2011), the cost-effectivity of the operation for the implementation of VM at Med Uni Graz is quite clear: the physical microscopes are quite expensive and VM is a cheaper alternative; the reusability of the learning content; and the affordable costs of the Zoomify software and application. Teachers used this technology in postgraduation courses, so probably they were the initiators regarding the decision to implement VM also for graduate students. Finally, there are proponents inside medical education that favor more digital technology (Satava 1997, 2006, 2008), while on the other hand there are more cautious researchers that believe perception, practical skills, and medical judgement need a different approach (Prentice 2005, 2013; Hirschauer 1991). This means that digital technologies should be used diligently along with traditional approaches to cultivate a prepared and skilled medical practitioner.

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Annex A

Questionnaire Teachers

Introduction phase

1. Can you please briefly present yourself and your academic background?
2. How many years have you been teaching at Med Uni Graz?
3. What role does the virtual microscope play in your teaching?

Describing usage of Moodle/VM 2.0

4. Can you describe the eLearning platform VMC/Moodle? Other eLearning elements worth noting?
5. What are the main purposes of the VM?
6. How can you describe the functionality of VM 2.0? In case you had the chance to know the old version (before May 2011 in use): which are the advantages of the new VM?

Research question and first sub-question

7. How has VM affected your teaching in this setting? What are the advantages of the VM in comparison to the usage of physical (practice) microscopes?
8. Do you think physical microscopes are still necessary for education? If yes, why?
9. Did you had any sort of difficulties in adapting with this technology? If yes do you have any ideas for improvement?
10. Why do you think is pathology the main user of this technology at Med Uni Graz?

Second sub-question and Third sub-question

11. Do you think learning through technology-enhanced learning (VM) promotes a new interaction between teachers and students? What about their performance or engagement?
12. How has technology-enhanced learning affected or changed your pedagogic approach toward teaching?
13. What is the role of the Virtual Medical Campus support team?

Ending point

14. Final thoughts or remarks. Is there anything you want to ask me?

Annex B

Questionnaire Tutors

1. Can you please briefly present yourself and your (studies) background?

2. How long have you been a tutor in this department (pathology)?

3. Can you describe/explain the teaching structure regarding classes where VM 2.0 is part of it?

4. Can you describe the practical role that each of these actors have concerning VM 2.0?

5. Let's talk about your own experiences using it…

6. How are the professors interacting with this technology in terms of teaching?

7. What is the students' feedback about the use of VM?

8. Final thoughts or remarks. Is there anything you want to ask me?

Annex C

INFORMED CONSENT

THE RESEARCH PROJECT

Title: Assessing the Virtual Microscope 2.0 in Medical University of Graz – The impact of educational technology in teaching practices in the Department of Pathology

Project Manager: Olsi Kusta

Affiliated institutions: University of Vienna, Faculty of Social Sciences, Department of Science and Technology Studies

Short description of research project: This is a Master Thesis for the Program: Master of Arts 'Science-Technology-Society'. This thesis main aim is to inquire about the impact that educational technologies have had on medical higher education, regarding teaching practices. Teaching is increasingly targeted by digital technology, and teachers are always facing challenges as these innovations improve with a tremendous pace. How do teachers perceive and experience technology in their everyday job, how do they adapt to these changes and the interaction with their students, are some of the main questions that this study aims to answer.

Project benefits: Expand knowledge in the field of science and technology studies regarding educational technology. This applies also for Sociology of Education. Contributing in Medical University of Graz research studies about teaching practices through innovative technology and eLearning.

Contact person (name, email, phone number): Olsi Kusta, olsi.kusta@gmail.com, mobile: +436606792360

PARTICIPATION IN THE PROJECT

An interview of about 60-90 minutes that is audio-recorded and later transcribed for data analysis purposes.

VOLUNTARY PARTICIPATION

Participation is voluntary, you can withdraw from the interview at any time, without giving any reason. Furthermore, you can choose to not be recorded and the researcher will have to comply with this request.

CONFIDENTIALITY AND ANONYMITY

The data collected in this interview will be strictly kept confidential and only the researcher will have access to them. No personal information will be disclosed, and you will be represented in an anonymous form in this research to avoid any risk of being identified.

FURTHER USE OF THE DATA

This research project has benefited from the collaboration with Virtual Medical Campus support team, represented by Dipl.-Ing. Dr. techn Herwig Rehatschek, and Professor Josef Smolle (New Media, Medical Knowledge Transfer and Processing). They have promoted and actively participated on this project by providing materials, explaining the technological background, and further contacts to realize the interviews.

Further collaboration will ensue with Professor Smolle concerning his research study. We have decided to collaborate due to the similar focus of both researches, and I will share with him the final anonymous analysis results of the interviews. Anonymity of the respondents will be assured, and this analysis will be the general product derived by the transcription of the interviews and multiple coding processes.

CONSENT

I hereby confirm with my signature that my questions have been satisfactorily answered, that I have read, understood, and agree to the terms of this consent, and participate voluntarily in this project.

Participant name**:**

Place, date, signature**:**

PROJECT MANAGER/CONTACT PERSON

Name:

Place, date, signature:

The participants will receive a copy of the signed consent.