REDISTRIBUTING THE TEACHER: AN ANALYSIS OF TECHNOLOGY ENABLED TEACHING IN MEDICAL EDUCATION

by

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B.A., The University of British Columbia, 2013

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

THE DEGREE OF

MASTER OF ARTS

in

The Faculty of Graduate and Postdoctoral Studies

(Science and Technology Studies)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

October 2018

The following individuals certify that they have read, and recommend to the Faculty of Graduate and Postdoctoral Studies for acceptance, a thesis/dissertation entitled:

Redistributing the Teacher: An analysis of technology enabled teaching in medical education

submitted by Sharon Doucet in partial fulfillment of the requirements for

the degree of Masters of Arts

in Science in Technology Studies

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Abstract

Educational technologies (ETs) are increasingly used in undergraduate medical education to train the next generation of doctors. However, once introduced to a learning environment, ETs can have intended and unintended consequences. Current research in medical education frequently renders these ETs as simple tools to be used by teachers, and ignores their unintended effects on the learning environment. This thesis employs actor-network theory (ANT) to chart the distribution of teaching from human to ETs to determine: 1) In what ways are the properties or roles of the teacher distributed across advanced learning technologies (ALTs) in medical education? 2) In what way is this distribution acknowledged among teachers within medical education discourses? Discourse analysis methods were used to analyze a selection of twenty-five medical education research and practice articles drawn from the PubMed database (2007-present). The distribution of teaching to ETs, specifically ALTs, in these articles is extended through time and space, teaching context, and content, and modifies human teaching. Acknowledgement of this distribution was evident in faculty members' or teachers' concerns of being displaced or overshadowed by ALTs. Human teachers and nonhuman ET teachers ought to be considered partners. Once introduced, the nonhuman ETs become socially embedded and their participation requires continued attention and critique. Finally, when examining the effectiveness of ETs' role in a learning environment, scholars should consider the ways in which their inclusion was deliberate, transparent, and accepted by other actors within the network.

Lay Summary

The goal of this thesis is to chart how human teachers distribute parts of their roles to educational technologies when they are utilized in undergraduate medical education. Current medical education research treats educational technologies as simple tools to be utilized for effective teaching. Through charting the distribution of teaching roles from human to technology, this thesis demonstrates that these technologies are best understood as partners, as nonhuman teachers. Educational technologies have intended and unintended effects on learning environments and those within. By considering educational technologies as co-teachers instead of tools, the distribution of teaching becomes intentional and deliberate and allows for a more symbiotic teaching relationship between humans and nonhumans.

Preface

This thesis contains the original, unpublished, independent work by the author, S. Doucet.

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List of Abbreviations

ALT	advanced learning technology
ANT	Actor-Network Theory
ARS	audience response system
CDA	critical discourse analysis
DA	discourse analysis
ET	educational technology
STS	science and technology studies
UBC	University of British Columbia
UGME	Undergraduate Medical Education

Acknowledgements

This work was made possible by the support and guidance of several UBC faculty and staff. Most notably is my thesis supervisor, Dr. Stephen Petrina, who provided constant guidance, encouragement, and unbridled excitement regarding my research that was essential in every step of my (slow) progress from the conception of this thesis, to the research, and finally, its completion. I thank Dr. Petrina for his unwavering support that made this thesis possible. I'd also like to give a special thanks to Dr. Robert Brain and Dr. Barry Mason for their incredible insights and feedback in the course of the thesis defence. From the STS program, I'd like to thank Drs. Adam Frank, Alan Richardson, Ian Hill, and John Beatty for their engaging and informative discussions that were instrumental in guiding my work. Next, thank you to my colleagues and friends in Faculty Development for their unwavering enthusiasm and appreciation for my research, and also for their patience when I was a bit slower on Monday mornings after researching and writing all weekend. I'd like to acknowledge Dr. Rachel Ellaway for her work that inspired this thesis and further for being so gracious when I accosted her at a medical education conference in Halifax to thank her in person. Thank you to Jenn Clark for being my Virgil, providing direction whenever I got lost. Thanks to my family for their love and support: my wonderful Mom and Dad, Gram, Matt, and my especially my husband, Cam, who always picked me up from the office with a smile, no matter how late it was, and to our beloved dogs, Simon and Abbi for their eternal adoration and reminder that walks in the woods are an excellent place to ponder teaching with technology. Finally, I'd like to thank my dear friends Marie and Nick, who actively listened to me pontificate for hours on educational technology research without previously having any discernable interest in the topic.

Dedication

This thesis is dedicated to all the passionate, brilliant faculty and students within the Science and Technology Studies program at UBC for being a constant source of inspiration and motivation.

Chapter 1: Introduction

As an Instructional Designer in the Office of Faculty Development and Educational Support at the University of British Columbia's (UBC) Faculty of Medicine, part of my work involves building online learning modules to support physicians and foundational scientists who teach within undergraduate and postgraduate medical education programs. As an Instructional Designer, the affordances provided by technology when teaching are very apparent in my work. For example, broadcasting and online technologies allow me to extend my teaching across space and time, which is essential for supporting a medical school distributed across the province. Within my work, it is easy to take various technologies for granted, assuming they are stable and dependable tools for teaching. However, when technologies do not work, or there are unintended consequences impacting learning, I have to troubleshoot and examine these technologies' relationships with other actors to find a solution. For example, hospitals frequently have firewalls that block faculty from viewing teaching videos. This creates a challenge for faculty trying to access videos on effective clinical teaching strategies embedded within a learning module. Or when the institution, in this case UBC, chooses to focus their technology infrastructure on protected and secure platforms, quick and easy access to the modules in distributed medical education system becomes challenging. It is through these challenges that complexities of the teaching network, including me, the educational technologies (ETs), learners, institution, technological infrastructure, faculty's requirements, and IT developers, become apparent.

A habit of the medical education field is to borrow and adapt pedagogies or methods of training from other disciplines and put them to work. A few brief examples include: a simulation-based training approach from aviation, gross anatomy lessons from biological sciences, and investing in technological innovations from computer science and the broader culture of medicine to solve problems. Some of these adaptations transfer more easily than others, becoming so embedded it would be difficult to imagine medical education without them. This is the case in simulation-based training; early documentation of the use of simulation devices to support learning in medical education is traced back to 1737 (Castilano, Haller, Goliath, & Lecat, 2009; Moran, 2007). Simulations in undergraduate medical school provide an opportunity for students to practice their skills and techniques on non-living patients, to demonstrate their diagnostic reasoning, or counselling abilities to preceptors with paid actors playing patients. These simulations provide a low-risk environment for medical students to make mistakes and learn without impacting a patient's health. Other adaptations, such as investing in advanced learning technologies (ALTs) to solve education delivery problems are not always successful despite the commitment of institutions to integrate them (*Building the Future,* 2013 p. 20).

While education scholarship is robust with debates regarding the role of technology within learning environments and its pedagogical integration, medical education discourse includes a narrower evaluation of ETs. The current research on technologies in medical education often consists of focused studies on implementing technology (X) to improve student learning in comparison to a 'traditional' method (Y). For example, Owston, Lupshenyuk, and Wideman (2011) looked at whether or not the introduction of lecture capture and students accessing the recorded videos improved learning over attending the lectures in person. This common approach in medical education literature effectively renders ALTs or ETs as simple tools that can be applied in specific contexts and impact student learning.[1] But this approach to

[1] ETs and ALTs are used somewhat interchangeably in the Thesis when referring to contemporary media and technologies.

viewing ALTs or ETs creates varying results across contexts. A different lens for reviewing the roles and impacts of learning technologies within medical education discourses is required to see the whole picture.

The complexities of teaching with technologies begin before attempting to disseminate them across the teaching network. Applying technology recommendations from the literature in one context does not always guarantee success in another. The variable contexts, technologies, teachers, students, institutions, and IT infrastructure continues to impact whether teaching with technology is a success or failure. This complex network makes it difficult to discern if ALTs are truly effective or what factors along the network need to be examined to ensure consistent success.

While how to use ETs effectively in teaching is debated within medical education discourses, there is a consensus that their use is increasing, and that integration has made a significant impact on reshaping the landscape. George et al. (2013) argued that “Medical educators are rapidly integrating technology into medical education curricula as a necessary intervention” (p. 522). Similarly, for McGee and Kanter (2011), “the use of information technology to support the educational mission of academic medical centers is nearly universal” (p. 279). Guze (2015) concluded the same: “The use of technology in medical education has been developing over many years. The trend in the use of technology has primarily developed in response to challenges facing medical education” (p. 260). Here, technology is consistently expanding within medical education and its integration is intended to solve problems. The idea that technology solves problems is a pervasive rhetoric of ETs within medical education. When ETs fail in solving a problem, or create unintended problems, the literature within medical education discourse does not provide a solution.

An example of ETs impacting the learning environment and creating a problem is UBC's Undergraduate Medical Education (UGME) program's decision to shift to a paperless curriculum. This shift introduced ALTs to previously low-tech environments such as Case-Based Learning (CBL) small group sessions. CBL within the UGME involves six to eight students and one medical educator, referred to as a CBL tutor, who facilitates the group of students through the progression of a clinical case with a pre-designated patient. Through the introduction of the paperless curriculum, students were required to bring a device, i.e. a laptop or tablet, to their small group sessions. Through the introduction of devices to these small group sessions, CBL tutors had varying degrees of difficulty managing the addition of the nonhuman 'technology teachers' in the room. While their inclusion meant students could quickly access videos and other media relevant to the topic of the week, they also provided a distraction from learning among students who used them inappropriately or obsessively. Another unintended consequence involved students now spending more time staring at the screen or devices than interacting with each other, effectively shifting the focus of the learning environment from peer- or student-centered to technology-centered. Students now had the case information at their fingertips instead of the CBL tutor unveiling the case step-by-step. The simple shift from analog to digital required CBL teachers to also shift how they taught students and re-think their role as teachers to make room for the nonhuman teachers in the learning environment. Integrating technologies requires role adjustments for many actors within the medical education network. UBC's sudden shift to a paperless curriculum is an example of introducing new actors to a complex learning network without fully understanding or considering the current actors, their role, and the changes to those roles required.

As a Science and Technology Studies (STS) scholar, I have studied different approaches and bodies of thought to critically examine complex networks and the actors within them. Looking at medical education discourses with an STS lens allows me to unpack some unquestioned ‘truths’ regarding media and technologies within the medical education network. The first approach will dispel the notion that ETs are simply tools. STS scholar Bruno Latour (2005), interpreted technologies as actors along with humans within a social network and flattened the human/non-human hierarchies prevalent in technology discourses. The work of Latour (1987) and Callon, Rip, and Law (1986) provided an approach to examine the significant and insignificant ways in which ALTs work within the learning environment and their impacts on other actors in the network. Latour’s (2005) lens, Actor-Network Theory (ANT), when applied to medical education discourse provide an effective view of complex medical education teaching actors and networks. STS scholars Woolgar (1991) and Pinch (1992) also provide a lens through which to explore the biases and rhetoric within medical education discourses that proffer ETs as tools to solve a problem. Medical education discourses feature a tension between proffering ALTs as revolutionary and unstoppable, while at the same time rendering them as simple, obedient tools used by human teachers. Critical STS approaches or methodologies illuminate how ETs are “black boxed” (Pinch 1992) by their perceived use and function. By identifying how ETs are black boxed and opening them, unquestioned beliefs or unrecognized actors driving their function can be compared to functions and roles when integrated into medical education learning environments and operating smoothly.

Rachel Ellaway, Assistant Dean and Associate Professor Education Informatics at the Northern Ontario School of Medicine, is a leading scholar in the field of ETs and their role in medical education. Ellaway’s (2012) work in uncovering the complex relationship between ETs, the medical teacher, and their subsequent teaching goals provides a foundation for the construction of this thesis. In the passage below, Ellaway (2012) analyzes the role of ETs in medical education in terms of replacement of the teacher:

> Educational technologies can be odd partners. Having invested so much effort in making, acquiring and/or customising them we often then tend to ignore them as no longer needing or deserving our attention. The underlying assumption often being that because our learners have access to technology X then learning Y will naturally follow and we need not worry about the matter any more. As such, many of these technologies stand in for the various aspects of a teacher's role. Technologies that act in this way are performing *in loco docentis* [in the place of the teacher]. However, we tend not to think in this way. We often disregard what it is a teacher does, focusing instead on learning outcomes. As a result the connection between the teacher, teaching and the role of educational technologies can become dysfunctional and disappointing. (p. 871)

Ellaway (2012) outlines some of the core principles that will be built on and argued throughout this thesis:

1) ETs should be considered partners in teaching.
2) Once introduced into the learning environment, ETs become socially embedded and their participation impacts the teaching network, requiring our continued attention and critique.
3) When examining the effectiveness of ETs' roles in the learning environment, researchers should consider ways in which integration was deliberate, transparent, and accepted by other actors within the teaching network.

For ETs to truly be 'partners', the teacher must distribute parts of their teaching roles that are compatible with both the technologies' abilities and their teaching goals. Optimization of learning requires this partnership to be a deliberate distribution of aspects of the human teacher's role to the nonhuman teacher. I argue that in an effective partnership, the ETs will not simply be standing in "place of the teacher", but rather working *alongside* the teacher. Ellaway (2012) uses a principle of replacement to see where the human teacher ends and the nonhuman teacher begins. Approaching technology in terms of replacement of human action allows for the autonomy of both human and technology teachers. However, focusing on replacement results in examples of the ways in which technology stands in the place of a human teacher, as though the action of teaching is a like a relay race hand-over, configuration of proxies, or delegation of tasks. While it is important to consider when the human teaching ends and the technology teaching begins, by reframing the focus to how teaching is distributed we can examine the collaboration, or partnership, of teaching, as well as the independent teaching of humans and nonhumans.

This thesis investigates the role of ETs in learning environments to demonstrate that ETs are not merely tools for human teachers to use; rather they are actors playing multifaceted roles alongside other medical educators. I use Latour's (1996) ANT to flatten the human/ET, hierarchies within relevant medical education literature to determine in what ways the properties or roles of the teacher are distributed across ETs in medical education. To better understand the role of ETs within a medical education network, I then examine the ways this distribution of teaching role to ET is acknowledged among teachers within relevant medical education literature. To effectively achieve this, the thesis first introduces the complex historical and social relationship between teachers and ETs. I unpack the history of the pervasive rhetoric of technologies as signifiers of progress, which effectively black boxes them as neutral, 'taken for granted' objects within medical education.

Reviewing education scholarship, I first present a key historical debate to highlight two schools of thought regarding the pedagogy of ETs in student learning. Second, I introduce STS theories of how technologies are laden with rhetorical positioning of being synonymous with innovation and progress. Third, I outline a STS perspective of how ETs are 'black boxed', which helps them to be integrated uncritically into learning environments. The first half of the thesis establishes a conceptual framework while the balance provides an analysis of literature addressing the research questions: 1) In what ways are the properties or roles of the teacher distributed across learning technologies in medical education? 2) In what ways is this distribution acknowledged among teachers within medical education discourses?

Chapter 2: Literature Review and Methodologies

2.1 Education's Kozma vs Clark debate: What's the point of technology?

While the research shows universities around the world have increasingly utilized technology to support teaching and learning in all departments, the rate of which these technologies enable learning is consistently debated among scholars. One of the most influential and lasting of these debates occurred between education scholars Clark and Kozma. Clark (1983) infamously proffered that "the best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 445). Clark's position was firm: technologies, by themselves, do not increase or decrease student learning. The technological medium is irrelevant to student's learning; the content or teaching present in the material or resource is what matters for learning. Technologies are a vehicle to deliver learning to students. On the other side of the debate is Kozma who argued for call to action on the part of educators to increase the use of technologies for the purposes of educational reform. Kozma believed that ETs were the answer to improving student learning and revolutionizing education (1994). It was simply a case of finding the right technology for the job at hand. Kozma (1994) argues that some media "possess particular characteristics that make them both more and less suitable for the accomplishment of certain kinds of learning tasks" (para. 6). In other words, each medium can be broken down into attributes that can either impede or aid achieving a particular task. The role of educators is to first determine which attributes are required for a certain learning goal, and second match-make the right technology to facilitate student learning with those attributes. Kozma (1994) reframes

Clark's argument by suggesting educators re-focus their research to not inquire as Clark did, *if* technologies enable learning, but *how* they do it (p. 18).

Clark's (1983) philosophy provides a 'uses' determinant, where technology is approached as a simple tool to be called upon to achieve a goal. This position treats ETs as neutral objects that humans can engage to extend their teaching abilities. The assumption is that users of the technology control the effect the technology has on the learning environment. While Clark does not fall into the most common pitfall of uses determinism, which is assuming there is a technological fix for every problem, his treatment of technologies disregards their social influence in education that can lead to varying results from different actors. Kanuka (2008) argued that the problem with reducing technologies to simple instruments is:

> There is an inclination to place emphasis upon the intentionality of agents, with an unbalanced focus on the interactions between the actors and the technologies. As a result, educators tend to narrowly focus on the role of agents and disregard the broader social structures and/or technological artefacts' effects on the learning outcomes, leading to explanations that overemphasize the power and autonomy of actors. (pp. 4-5)

By focusing solely on the interactions between the human actors and the technology actors, the supporting social and technological network enabling teaching is ignored. Overemphasizing the autonomy of actors can lead to inconsistent success integrating ETs into learning environments. Human control over technologies is undermined the minute they do not 'work', behave as they were expected to, or the server hosting the ET is offline for maintenance. Teachers who assume ETs are passive agents or perhaps were told by IT staff that they are simple and easy-to-use-tools will be disappointed and exasperated when ETs perform otherwise. The variability of performance and successful integration of ETs requires a closer look at the role of ETs within education. In order to mediate ALTs' impacts on a learning environment, we first must recognize and examine their social role as actors within the teaching network instead of simple tools.

Kozma (1994) proffered a technological determinist approach and stresses the importance of considering the type of technology used to create the best learning outcome. A determinist approach can either be negative or positive due to the positionality of ETs. A negative deterministic approach is demonstrated through the following beliefs: 1) that ETs are designed or used to oppress students in universities; 2) ETs are designed or used to commercialize academic institutions and shift the focus from faculty to ALTs (Kanuka, 2008). Kozma's (1994) philosophy demonstrates a positive example of technological determinism, one that believes that ETs can transform a learning environment in unique ways for the benefit student learning. ETs serve, as Kanuka (2008) called it, a "catalyst for change" (p. 6) and institutions must reorganize to accommodate them. A common pitfall of determinism lies in the assumption that technologies are somehow outside of society, independent of it, as if they are constructed by alien developers, brought into human society where they create change in it (Woolgar, 1991, p. 26). Within medical education, many ETs are imported from external disciplines, which can create challenges that will be addressed later in more depth. However, the ideology driving technological change and innovation within medical education is not external from its culture. A second pitfall of technological determinism is the assumption that any change when technologies are integrated subsequently changes the society the technology was integrated in (Woolgar 1991 p. 26). However, this view ignores the other possible causes for changes within society and does not account for the times when changes in technology had no impact on the society it was integrated into. With those possible pitfalls of both the use determinism and the technological determinism briefly discussed, a common failing is that they effectively treat ETs as objects.

This assumption that ETs are neutral tools to be used or acted upon, ignores the intended and unintended ways in which they impact teachers and students in learning environments. This omission creates a significant gap in understanding the various relationships among teachers, ETs, and the learning environment explored in this thesis.

As well as trying to influence educators' approaches to teaching with ETs, Clark and Kozma also critiqued or encouraged certain types of ET research. Clark (1983) claimed that academic publishers demonstrate biased editorial decisions by favouring publications that show significant influences of ETs in learning rather than publishing the plethora of studies showing little to no difference with their use (p. 446). Kozma's (1994) call for researchers to pursue a determinist approach by looking at *how* technologies support learning encourages the very publishing bias by focusing on studies that demonstrate differences in learning after the introduction of an ET. In medical education, Clark's concern is not as apparent since many of the controlled studies results comparing student learning using technology vs. no-technology in the reviewed literature ultimately demonstrate little to no difference in student learning (Jenkins, Goel, & Morrell 2008; Stoddard & Piquette, 2010). Medical education journals do not shy away from publishing those types of articles. However, Kozma's (1994) lens of technology as the solution is found to be the dominant perspective in the literature. Despite showing no differences in student learning via employing technology or without technology in the articles by Stoddard and Piquette (2010) and Jenkins et al. (2008), authors argued for the continued use of the ETs.

When it comes to research documenting student learning gains, Clark (1983) also dismissed studies demonstrating increased student learning gains from ETs by arguing that the time, funding, and knowledge that go into designing a learning activity far exceeds what is invested into teacher training (p. 449). Thus, if provided the same opportunities, human teachers would be able to show their students' increase in learning from their supported efforts as well as their ET counterparts. What influenced learning according to Clark was the actual teaching done by the teacher (1983, p. 456). Clark's argument here introduces a key area of exploration in this thesis. Medical educators and ETs cannot do their job effectively without being appropriately supported by the institutions that employ them. A medical educator is employed by a medical school due to their clinical or foundational science experience and their teaching is embedded within a longitudinal medical curriculum. A single teacher does not provide medical students with all the knowledge necessary to graduate. Rather, there is a network of teachers, supported by staff, faculty developers, instructional designers, and IT professionals all embedded within an institution that receives regular accreditation reviews from national bodies that allow them to issue medical degrees. Although the network of human teachers is often described in the salient medical education literature cited in this thesis, the network of ETs is often neglected with the exception of IT professionals. ETs come laden with marketing, software developers, user experience designers, or at the very least, infrastructure support services to enable them to operate. When medical educators employ ETs, the network of actors and influences in the learning environment grows by more than just a device.

2.2 STS theories on the socialization of technology and opening black boxes

2.2.1 The culture of technology

STS theories provide a way of thinking about technologies in medical education and can be used to construct understanding of visible and latent roles. The first concept briefly discussed as a pitfall of technological determinism is Woolgar's (1991) argument that technologies are part of the social world of humans and not separate from it (p. 31). However, their role within societies is socially mediated (Woolgar, 1985, p. 565). In other words, since most ALTs cannot speak for themselves, our understanding of their possibilities, functions, and roles are marketed by people. Toscano (2012) argued that “technologies are products of the societies from which they come. By reading the technologies a culture creates, we can understand the ideologies of a culture” (p. 31). Technologies are reflections of cultures that bring them into existence. The type of technologies valued by specific cultures or social groups provide a glimpse of their principles, beliefs, and practices. When a social group accepts a technology or perceives a value in its abilities, they stabilize its role (Toscano, 2012, p. 30). Also, as social groups stabilize individual technologies, they also maintain the ideologies backing technologies. For example, the belief that technologies will always advance and that that advancement will have positive impacts on society is an ideology generally accepted within Eastern and Western cultures (Toscano, 2012, p. 30). In medicine, the ideology that technology *is* the future is culturally embedded. New machines that aid physicians in the diagnosis or treatment of patients are constantly being developed and medical breakthroughs are newsworthy stories. For example, in 2017 neurosurgeons in Calgary were able to experience first-hand the benefits of technological innovations within medicine as they performed brain surgery on a patient without even cutting into the patient’s skin using a “magnetic resonance guided focused ultrasound (MRGFUS)” (Johnston, 2017 parra. 1). The MRGFUS technology allows doctors to target areas of the brain responsible for a patient’s tremor and treat them using a high intensity ultrasound beam (Johnston, 2017). When technological advancements are praised and idolized within the medical social group, and physicians can directly see how they benefit the care and treatment of their patients, the rhetoric of technological advancement as progress becomes further stabilized within medicine.

Medicine's ideology that technology is the future is also present within medical education. The Royal College of Physicians and Surgeons of Canada (RCPC) recently made the integration of ETs into the medical curriculum a priority (Cenkner, Sonnenberg, von Hauff, & Wong, 2017). The RCPC framework of seven core competencies that all physicians must acquire by the end of their medical training, named CanMEDS, includes: medical expert, communicator, collaborator, leader, health advocate, scholar, and professional. The priority now is to integrate technology-based competencies within each of these roles (Cenkner et al., 2017, parra 2). Yet, as this thesis outlines, within medical education the adoption of ETs is not always accepted or successful within the learning environment. Decisions made at an institution-level regarding technologies is not always aligned with the values and goals of front-line teaching faculty. This disconnect becomes even more probable when ETs are driven by the rhetoric and sales pitches of technology developers. Bijker (1995) argued:

> Technology is created by engineers working alone or in groups, marketing people who make the world aware of new products and processes, and consumers who decide to buy or not to buy and who modify what they have bought in directions no engineer has imagined. (cited in Toscano, 2012, p. 36)

There is frequently a disconnect between the software developer and the technology end-user. This is especially true in large institutions where each university's curriculum is organized differently and has different requirements and expectations of the technologies they invest in. Many new ETs implemented within medical education like mobile apps, virtual/augmented reality simulations, and online module software tools are frequently created externally by software companies and marked for a wide variety of uses. Thus, their integration into a medical education learning environment can lead to unexpected problems for the actors.

Toscano (2012) advanced Latour's work to examine why a technology succeeds or fails. In *Aramis*, Latour (1996) tried to "show technicians that they cannot even conceive of a technological object without taking into account the mass of human beings with all their passions and politics and pitiful calculations"; so that then "they can become better engineers and better-informed decisionmakers" (p. viii). Latour (1996) suggests that investigators follow the actions of all actors, the technology, and the humans the technology interacts with in order to understand why or how it fails or succeeds within a network (Toscano 2012 p. 19). By applying such a perspective, Latour's methodology lets the individuals' interactions with the technology supply meaning(s) for why a technology fails or succeeds. Or as Latour (1996) argues: "sociology prefers a local history whose framework is defined by the actors and not the investigator" (p. 33). Investigating the local history of how the technology and humans interact in an environment allows researchers to look at what actions occurred and how those actions differed from was expected. Woolgar (1991) completes this argument by stating that while it is difficult to determine the effects of technology, to have an attempt at success, "one requires a good theory of how society works, an understanding of the overall dynamics of society, before being able to specify the effects of a technology" (p. 30). In order to understand why a technology succeeds or fails in an environment, researchers must first look at all the actors at play, their interactions, and their expectations.

2.2.2 Back to the Roots: From blue to black boxes[2]

To understand their role, researchers must open technology's 'black boxes' by critically examining their 'truths,' including their rhetorically mediated role as signifiers of progress. Layton (1977) argued that technologies are frequently rendered as black boxes in that their contents and their behaviours are assumed to be common knowledge, when in fact expectations may not be consistent across social groups (cited in Pinch & Bijker, 1984, p. 404). Black box theory is an important metaphor in relation to ETs within this thesis. Pinch (1992) claimed he first heard the use of the black box metaphor from his supervisor Richard Whitely in regards to the stopping the 'Black Boxism' of the sociology of science (p. 488). Pinch (1992) claimed that Whitely advised that sociologists study the processes by which scientific knowledge was formed instead of focusing just on its inputs and outputs. This process would allow for the opaque study of scientific research to be made transparent, effectively, opening a black box. This metaphor in STS can apply to anything that is accepted in an environment and its inner workings hidden from discourse. When something is 'black boxed' a boundary is created around that object, creating a closure in the network (Kaghan & Bowker, 2011, p.258). These network boundaries are culturally maintained, making black boxes seem neutral, passive, or even natural in the environments they exist in. Black boxes are reduced to their inputs and outputs, i.e. how they are used and the purpose they serve. Their history and the process of their integration into the social world is either forgotten or ignored. ETs are frequently black boxed in the environments they exist in through the belief that input, ET, leads to output, improved student learning. When this

[2] The first flight simulator invented by Edwin Albert Link in 1929 was named "Blue Box" and though it initially only gained traction in amusement parks, after several plane crashes were deemed due to bad weather conditions, renewed interest in the Blue Box by the United States Army Corps commissioned the simulator to be a mandatory part of pilot training (Jones, Passos-Neto & Braghiroli, 2015, p. 57).

belief is challenged by research demonstrating that ET is not successful in improving student learning or its integration was not functional or cumbersome for teachers within the learning environment, opening the black box illuminates the technical workings of the technology and the rhetoric driving its deployment or integration.

2.3 Examining networks using Actor-Network Theory (ANT)

2.3.1 About ANT

ANT is a lens through which to view and think about actors and networks. Kaghan and Bowker (2001) defined an actor-network as “any collection of human, non-human, and ‘hybrid’ human/non-human actors who jointly participate in some organized (and identifiable) collective activity in some fashion for some period of time” (p. 258). Because the boundaries are socially mediated, almost anything can be considered an actor-network if one is thinking about actions occurring, and follows the actors performing those actions that impact the collective over a period of time. While this tracking can be messy, ANT’s hierarchy-flattening perspective and action-focused lens provides a framing for the disjunctions that occur with the ideology and investment backing technologies and their on-the-ground roles in medical education. Cressman (2009) stated that ANT is a “theory that is best understood as something that is *performed* rather than something that is *summarized*” (p. 1). The performance of ANT involves identifying the actors who form a network, and then tracking the interactions of those actors to stabilize the network.

2.3.1.1 Actors

Actors in ANT refer to all humans or nonhumans within a given network who possess agency and act within that network. By treating material objects, like technologies, with the same status of human actors, ANT allows us to examine all action that builds and maintains a network. Latour argued: "An actor in ANT is a semiotic definition—an actant—that is something that acts or which activity is granted by another… an actant can literally be anything provided it is granted to be the source of action" (1996, p. 373). Actors are defined by their action and their actions impact on other actors to form or exist within a given network. Actors in ANT are the humans, objects, symbols, or machines who possess the ability to act. By placing all of these things on the same level, and simply observing how the actors act and impact a network, we can learn about how their roles work together. ANT does not assume actors will act or behave in any presupposed or predetermined way. Rather, ANT insists actors have freedom to act (1996). Latour (2005) clarified that "[b]y definition, action is *dislocated.* Action is borrowed, distributed, suggested, influenced, dominated, betrayed, translated" (p. 46). Rather than being a theory of action, or why action occurs, ANT is a method of mapping action.

In medical education, there are multiple actors who build and maintain a learning environment for future doctors. Some of these actors are humans, like foundational scientists or practicing clinicians who perform specific roles in the medical curriculum. Other actors include the medical institution itself, governing the curriculum and hiring the medical educators. There are also nonhuman, technology actors that are consistently embedded into the learning environment, though these actors are made up of different types or forms and act in varying ways. Latour (Johnson [pseudonym], 1988) described the actions performed by technologies in the place of humans as delegation. An example he outlined is that of a traffic light in a city. The traffic light is a technological replacement of a human traffic cop. The directing of traffic to either stop or go is delegated from the human traffic cop to the traffic light. Drivers are then trained to follow the traffic light in the same way they are trained to follow the instructions from police. As police are also drivers on the road, on and off duty, they also follow the instructions of the traffic light (Latour, 1988, p. 305). Latour used the term delegation to describe the passing of action or skill from either human or technology to the other. In this thesis, I track distribution instead of delegation. An important distinction, since the terms are similar, the term delegation implies there is an authority, or decision made either by technology or human, to delegate a task or part of it from one actor to another. Distribution allows for the simultaneous teaching by both the human and ET actors. It also unearths the potential of unintentional teaching distributed to technologies or human actors.

2.3.1.2 Networks

Latour (2011) described a network as observable "whenever action is to be redistributed" (p. 797). Networks are as pliable as the actors that act within them. Actors themselves can be made up of networks. ANT brings to light the hidden or assumed actions of an actor within a network. Often, technologies are black boxed in a social context, and their role in the network is only demonstrated when they are not working as expected. For example, when a YouTube video will not play in a distributed lecture theater, a previously contained object, the YouTube video, actually contains an entire other network of the internet, software developers at YouTube, and even the institution's own IT professionals and the firewall the institution decided to buy that can block videos. At the moment of malfunction, other actors in the learning environment are made discernable or visible. The ways in which actors relate so that associations are formed develop the network.

Actors within a network can act as mediators or intermediaries – a crucial distinction in ANT. To Latour (2005), an intermediary is a vehicle of meaning or force that does not transform or alter the meaning or force in the process. Latour (2005) stated: “For all practical purposes, an intermediary can be taken not only as a black box, but also as a black box counting for one, even if it is internally made of many parts” (p. 39). Latour distinguishes mediators from intermediaries, noting that mediators change or warp the meaning of whatever it is they are moving. Or as Latour (2005) argued: mediators “transform, translate, distort, and modify the meaning or the elements they are supposed to carry” (p.39). Intermediaries can become mediators and mediators can become intermediaries. Latour (2004) wrote: “As we will slowly discover, it is this constant uncertainty over the intimate nature of entities—are they behaving as intermediaries or as mediators?—that is the source of all the other uncertainties we have decided to follow” (p. 39). In medical education, by tracing the distributed role of the medical educator from human to technology to student, we can see if the technology teachers are being positioned as intermediaries when they are really performing as mediators or vise-versa. Ultimately, juxtapositioning the roles in which the technology teachers are acting in the learning network in the human teacher’s role will show if the distribution of roles is aligned effectively.

2.3.1.3 Theory

ANT, when applied, more accurately resembles a method than a theory since it cannot be empirically tested (Bleakley, 2012). However, theories informing ANT include illuminating ‘black boxed’ concepts like ‘social’ by treating them as constructs requiring performed actions, understandings, and rules that form a network. ANT, rather than an analytical approach, as Fenwick and Edwards (2010) argue, is “more like a sensibility, an interruption or intervention, a way to sense and draw nearer to a phenomenon” (p. ix). ANT can provide a lens from which to map the “actions” of both human and nonhuman actors in learning environments. The most relevant action in this thesis is teaching, how it is discussed in the literature, and what parts are performed by the ETs and the human teachers.

2.3.2 ANT lens on the affordances of technology

Within medical education, a way ANT has been employed relevant to this thesis is the examination of how ETs affordances have driven their investment and expansion within medical education networks. Wright and Parchoma (2011) called for a mobilization of ANT to critically examine the ways in which mobile technologies are articulated and positioned within medical education research as ALTs. The rhetorical positioning of affordances of technology is a common approach in the literature reviewed in this thesis. A brief overview of the goal of Wright and Parchoma’s work supports a subsequent analysis of the rhetoric that technology is, potentially, more advanced and useful teachers than their human counterparts.

Mobile learning is significantly represented in medical education discourses (Wright & Parchoma, 2011, p. 249). Medical students’ undergraduate curricula consist of overwhelmingly full schedules and mobile learning is positioned as a solution to adding flexibility in students’ learning. However, Wright and Parchoma (2011) found that even in the term mobile-learning, the focus is on the technology rather than the learner. The ability of a device to be mobile is through the motion of the human user. For the most part, without a human, a mobile device simply has the ability to be moved and maintain internet or network connections. Mobile learning implies a learner is mobile, but also that learning will occur. While interrogating the term ‘mobile learning’ may be considered nitpicking or engaging in semantics, I agree with Wright and Parchoma (2011) that the analysis is worth a closer examination because the concept mobile learning assumes an outcome of using a device. In fact, the concept is made up of affordances offered to learners, mobility, and a device in which to procure information, potentially for learning. Wright and Parchoma (2011) argued that mobile learning is coined as “anytime, anywhere learning” in medical education discourse (p. 252). ‘Anytime anywhere learning’

> Becomes shorthand, casually ‘afforded’ by the technologies and presented as obvious and inherent. Rendering something as complex as the idea of *anytime anyplace learning* in this way closes it to investigation; it simply becomes a *black box* with an input of access, which occurs anytime or anywhere, and an output of learning. (Wright & Parchoma, 2011, p.252)

By black boxing the affordances of mobile technologies, it creates a boundary that is maintained by actors within the network, that the ‘can’ of anytime anyplace learning leads to students ‘will’ learn. Wright and Parchoma (2011) discerned that mobile learning technologies promise results when, in actuality, further engagement from the user is required for learning to occur. What technologies afford or offer in a learning environment has become a commonplace way of positioning technologies in medical education discourses (Wright & Parchoma, 2011). Wright and Parchoma, (2011) found that mobile devices were originally developed and designed for selling products via corporate markets and retail and that the co-opting of mobile devices in medical education follows the same trends of co-opting desktop computers from their role in the corporate world to individual users (p. 256). Most educators and students use personal computers for their work or studies, but people also use their computers for non-academic pursuits. Simply having access to a computer does not ensure learning will occur. Wright and Parchoma's (2011) research demonstrates that much of the literature regarding mobile learning consists of experimental, pilot-projects where researchers pre-selected a technology and documented student use (p. 254). This pursuit misses the mark by focusing on students' use of a certain technology instead of asking what technologies students learn from and how. The problem with positioning the affordances of technologies is that they may overpromise a learning outcome without qualifying other necessary actions required by students or by educators to produce knowledge. Herrington and Herrington (2007) called current use of mobile technologies "pedagogically regressive" (p. 4). When adopting new ALTs, in this case devices such as smartphones, educators often "revert to old pedagogies as they come to terms with the capabilities of new technologies" (Herrington & Herrington, 2007, p. 4). While the affordances of technologies as tools for learning are consistently proffered, without deliberate integration as teachers in the learning environment, educators may in fact stunt the technology teacher's ability to teach by employing it regressively. This thesis argues that the role technology teachers play in a learning environment must be deliberate and explicit to students. The affordances offered by technologies alone are not enough to warrant their place in a learning environment. Further, by focusing on the affordances offered by technologies, instead of how and what students are currently learning from technologies, we miss an opportunity to strengthen the current relationship between technology teachers and human teachers in medical education.

Black boxing the affordances of technologies in medical education is prevalent and ignores the required action of both medical educators and the learners to engage in an activity. Kaghan and Bowker (2001) stated:

> How the actors inside the black-boxes transform or translate inputs into outputs becomes unimportant unless the connections to the larger network come to be challenged in some fashion. The black-box can simply be treated as another actor in the network. Crucially, black-boxes are always the outcome of socio-technical negotiations — it takes continuing work both to create them and to hold them in place. Closure is neither complete nor final. (p. 258)

Thus, in order for the 'truth' driving the affordances of technologies, the actors within the network have to challenge them. Like Wright and Parchoma's (2011) use of ANT to trace the essentialist positioning of mobile technologies to their roots, this thesis uses ANT to trace the distribution of teaching to technologies and how this distribution is challenged and maintained by actors within the medical education network.

2.4 ANT in this thesis

When ALTs, like online learning modules, simulated learning environments, or video-conferenced lectures, are introduced, the social network of teaching and learning becomes increasingly complex. The role of the teacher utilizing the ETs is distributed further and the variables that determine if learning is effective are more difficult to identify. ANT is an effective way to map the distribution of a teacher's role. Latour (1996) calls for us to redefine 'the social,' normally defining groups of humans within a society, to include nonhumans, since to the extent in which humans interact with, rely on, and are acted upon by nonhumans makes extracting them impossible (p. 372). By employing ANT, the complexity of the combined role of the teacher and the ET to improve student learning can be brought to light, as well as the variables that determine an effective outcome.

Medical education discourses also frequently contain varying human-technology hierarchies that influence our understanding of technologies' role in a learning environment. Using Latour's lens, we can briefly ignore the differences between humans and ETs and focus on the actions they perform in a medical education learning environment. This will allow us to: 1) bypass the potential pitfalls Wright and Parchoma (2011) outlined in the rhetorical positioning of technology use as synonymous with learning due its affordances; 2) bring to light the ways in which teaching is distributed between human and technology teachers in medical education, both deliberately and accidently; 3) see how the distribution of teaching is acknowledged among human teachers to highlight human teachers' understanding of their role alongside technology teachers. Ultimately, the goal of this thesis is to provide a closer look at the roles of the human teacher and the roles of the ET teacher(s).

This focus on the distributed role of the teacher has largely been absent in the ET discourses. Failing to consider how an ET actor is utilized to share the role of teaching causes the actors to be treated as 'black boxes', a process Latour (1999) defined as one that "makes the joint production of actors and artifacts entirely opaque" (p. 183). When ETs are black boxed, and not considered actors in their own right, a significant gap in understanding how learning occurs on-the-ground in a learning environment with human and technology actors at play. I argue that medical education scholars should consider all the actors and their distribution of roles within the medical education network to support learning environments when determining if ETs are effective teachers. When ETs are utilized to teach students, the role of the teacher is distributed to the technology actors. To fully understand how ETs teach effectively, we must first analyze the way in which the teaching is currently distributed from teacher to ET, and see if that distribution is deliberately intended or driven by the ETs affordances. When ALTs are used, the network of teaching and learning becomes increasingly complex. Through ANT, the complexity of the role of the teacher and the ET teacher to improve student learning can be brought to light, as well as the variables that determine an effective outcome.

ANT also enables me to bypass the varying human-technology hierarchies that can be prevalent in education research. Latour (1988) stated,“I do not hold this bias [“between the human and the inhuman”] but see only actors—some human, some nonhuman, some skilled, some unskilled—that exchange their properties” (Johnson [pseudonym], 1988, p. 303). Latour flattens human-technology hierarchies and considers all actors basically equal. Actors exchange their properties.

2.4.1 The Methodologies

Addressing the research questions, I searched the Medical Teacher and PubMed databases. Within Medical Teacher, I searched for “undergraduate medical education” anywhere within the publication and “technology” in the title and limited the search from 2007 to the present. Within PubMed, I searched for both terms: “undergraduate medical education” and “technology” within the publication title or abstract and limited the search from 2007 to the present. The result of these two searches was a combined 177 articles. I filtered the articles on the basis of their content removing 152 articles. Exclusion criteria included: articles that were from authors outside of Canada and the United States, duplicate articles from both searches, articles focused on health professions outside of the Faculty of Medicine (i.e., nursing, dentistry, midwifery, or veterinary medicine), articles that were focused on selling or marketing commercial technologies and lacking an education perspective, and articles that focused on the use of technology in medical practice, not in teaching. Articles were also eliminated based on applicability to the research questions in that they did not discuss or demonstrate any interaction between teachers and ETs or did not include any reference to teaching with technology. Lastly, I excluded articles that did not involve lecture, online module, or simulation ETs in order to limit and focus the analysis. This excluded articles on teaching with ultrasound imaging, mobile applications, video-conference, and video games. Of the 25 articles remaining, 8 articles focus on simulation training, 8 on lecture-based teaching, 6 on online teaching, and 3 articles on technology in general. See Appendix 1 for a flowchart of this process.

In addition to drawing on ANT as a methodological framework for analyzing these 25 articles, I relied on techniques drawn from discourse analysis (DA) and somewhat from critical discourse analysis (CDA). For the research, the selected articles represent a body or system of discourse constructing how ETs and ALTs are understood and used in undergraduate medical education. DA is a systematic analysis of texts that represent the discourse in the field. Phillips, Lawrence, & Hardy (2004) defined DA as "the systematic study of texts— including their production, dissemination, and consumption— in order to explore the relationship between discourse and social reality" (p. 636). The method focuses on an "analysis of collections of texts" and "the ways they are made meaningful through their links to other texts" (p. 636). Critical techniques, or CDA, draw links between micro scales of discourse with macro scales of politics and identity norms, such as gender or professional affiliation (Phillips, Sewell & Jaynes, 2008). CDA helped me shift between these articles and trends within medical education.

Chapter 3: Results

Within the selected literature, there are three ways in which the role or properties of the human teachers are distributed to ET supported lectures, simulations, or modules: teaching through time and space, teaching contexts, and teaching content. This section describes these three areas.

3.1 Teaching through time and space

One of the most common ways in which a human teacher's role was found to be distributed through ETs is by extending their teaching through time and space (Billings-Gagliardi & Mazor, 2007; Cardall, Krupat, & Ulrich, 2008; Craig, McGee, Mahoney & Roth, 2014; Ellaway, Pusic, Yavner, & Kalet, 2014; Jenkins et al., 2008; Martin et al., 2013; McNulty et al., 2009; Mi & Gould, 2014; Owston et al., 2011; Premkumar et al., 2010; Rasmussen, Lewis & White, 2013; Tully, Dameff, Kaib & Moffitt, 2015; Zureick, Burk-Rafel, Purkiss, & Hortsch, 2017). The ETs extend human educators' teaching beyond the time of the original learning event. This distribution of teaching was demonstrated by ETs for lectures, online modules, and online simulations. These ETs were designed to be available to learners at anytime from anywhere with a device and the ability to connect to the internet by way of infrastructure and staff from the medical schools. There is an important difference in this distribution for lecture ETs, and ET simulations and online modules. The difference is found in the goal of the faculty and the ET. In lectures, there is a face-to-face component so recorded lectures are intended by faculty and institutions to be supplementary resources to the live lecture (Billings-Gagliardi & Mazor, 2007; Martin et al., 2013; Owston et al., 2011; Zureick et al., 2017). Additionally, some lecture ETs modified teaching by enabling students to adjust the lecture recording speed during viewing via acceleration or deceleration capabilities for the recorded lectures (Billings-Gagliardi & Mazor, 2007; Cardall et al., 2008; Zureick et al., 2017). Students on average watched the lectures at 1.67X the original speed of the lecture (Cardall et al., 2008). This allowed the teacher's sixty-minute lecture to be distributed in thirty-six minutes. The ETs increased speed of the video modifies the educator's teaching with the student's pacing preference. With distribution using online modules and simulation, the goal of faculty and ETs is for students to learn via self-directed study (Cardall et al., 2008; Craig et al., 2014; Ellaway et al., 2014; Jenkins et al., 2008; McNulty et al., 2009; Mi & Gould, 2014; Premkumar et al., 2010; Rasmussen et al., 2013; Tully et al., 2015). These online modules and simulations are designed by multiple teachers with deliberate pacing and curated information for students (Ellaway et al., 2014; Mi & Gould, 2014).

3.2 Teaching context

Lecture-based ETs in the literature were not shown to extend teaching contexts; online modules and simulation ETs enable medical educators to extend their teaching contexts to integrate the clinical context, specifically due to its team-based working environment and the patient.

ETs simulated or created a clinical environment for students to apply their foundational science and early diagnostic techniques (Castilano et al., 2009; Dolev, Sullivan, & Berger, 2010; Ellaway et al., 2014; Gorden et al., 2010; Jenkins et al., 2008). Online modules bring the clinic to the classroom, library, or students' home, etc. through videos of surgical procedures or interactive lessons that present knowledge within a clinical setting (Ellaway et al., 2014; Jenkins et al., 2008). These ETs work in tandem with clinical teachers by frontloading necessary information, materials and images, and vocabulary surrounding specialties before students enter the clinic. Some simulations and online modules also extended the team-based element of the clinical context. This extension was achieved by creating online spaces for collaborative sharing and building of information for learning (Mi & Gould, 2014; Rasmussen et al., 2013). Another simulation extended the flow by working alongside multiple healthcare providers with different roles in patient care. This was simulated by ET and human teachers for students to experience the clinical context while collectively ‘treating’ a mannequin ET (Gorden et al., 2010).

3.3 Teaching Content

The extension of content is also prominent in the distribution of human teaching to ET teachers in medical education literature. This extension includes patient content, dynamic information content, and reinforced content. This section describes the content extension of those groups.

3.3.1 Patient content

ETs extend the teaching of the human patients students will be tasked to care for later in their careers. This is through an ET filling-in the role of a human patient where students can practice diagnosing a specific illness, or interacting with the patient for interviews (i.e., history taking). In these simulations the human educator can assess the student’s bedside manner, ensuring the patient is treated with respect, and assess their organization of questions to ask the patient and assist their diagnosis (Castilano et al., 2009; Cook & Triola, 2009; Craig et al., 2014; Dolev et al., 2010; Ellaway et al., 2014; Gordon et al., 2010; Jenkins et al., 2008; Rochlen et al., 2017; Tully et al., 2015). These ETs generate anytime, anywhere patients suffering from various illnesses. This extension allowed medical educators to replicate doctor-patient interactions without a real patient. This extension of the patient teaching was a way for medical educators to ensure that students all ‘saw’ the same patient, thus all students were considered to have a standard learning experience with patients who had a specific illness (Craig et al., 2014; Gordon et al., 2010; Ellaway et al. 2014). Since human teachers cannot replicate the physiological vitals of a patient in severe medical distress, ETs were enabled to extend teaching of consistent patient representations (Ellaway et al., 2014, Gordon et al., 2010). These re-presented or virtual patients were always ready to become ill, on demand, allowing medical educators to teach care of specific patient problems. In one case, the human and ET teachers created a simulation of a doctor-patient experience with the human teacher’s dynamic and emotional responses, and the technology teacher responding with the accurate vitals and symptoms of distress that humans cannot physically reproduce for the purposes of teaching (Gordon et al., 2010). In this case, medical educators distributed emotional elements through the ET, to create simulations that are dynamic and more authentic to the environments students may later face as medical practitioners. Through this distribution of teaching, the human and ET teacher simulated a doctor-patient encounter in which the patient presents in medical distress within a clinical context. In another simulation, the ET facilitated the learning of medical students in performing the technical aspects of a patient interview (i.e., organization of questions, patient answers that require follow-up) (Cook & Triola, 2009).

3.3.2 Dynamic informational Content

The second notable way in which ETs extend human teaching is through providing organized, dynamic content for each student via online discussion boards called wikis, online modules, or simulations (Cook & Triola, 2009; Craig et al., 2014; Mi & Gould, 2014;

Premkumar et al., 2010; Rasmussen et al., 2013). In module and simulation ET distribution, teachers created branching stories using questions and the outcome within the module was dictated by responses by the individual students (Craig et al., 2014; Cook & Triola, 2009). Another way to describe this type of learning is a 'choose-your-own-adventure' style lesson. This type of distribution required teachers to input questions or scenarios with multiple options for students to select from. The feedback provided to the student after they answer a question is based upon the option they selected. This allowed educators to test student's clinical reasoning and other forms of knowledge, while simultaneously providing specific corrections for incorrect answers. Teachers also designed simulations that allowed medical students to provide primary care to a patient and select questions to ask during a history interview before then choosing what types of tests they would like to order for diagnostic purposes (Cook & Triola, 2009; Jenkins et al., 2008). These ETs provided an opportunity for students to learn diagnostic reasoning skills in a safe environment for patient care. They also provide an opportunity for medical students to engage in clinical learning, with specific, expert feedback based on their decisions, outside of a busy clinic where patient care is prioritized. Through wikis, teachers worked with ET to create an online place for students to collaborate on building a shared repository of information (Mi & Gould, 2014; Rasmussen et al., 2013).

Online modules, simulations, and lecture ETs helped teachers reinforce content (Craig et al., 2014; McNulty et al. 2009; Owston et al., 2011; Stoddard & Piquette, 2010). These ETs enabled human teachers to revisit previously learned material to further consolidate student knowledge for long-term learning. This was achieved through the ETs distributing teacher's questions for the students, either through built-in quizzes in modules, or building questions into lecture ETs. Through ET questioning, material can be reinforced.

3.4 Modifies Teaching

While extending teaching from human to ETs is common within the salient literature, the modification of the teaching or properties of the teaching is also prevalent (Craig et al., 2014; Gorden et al., 2010; Mi & Gould, 2014; Premkumar et al., 2010; Tully et al., 2015). The way in which the distribution of teaching modifies the teacher's role is relevant to examining what parts are distributed, requiring the teacher to alter their teaching. The modification of teaching within the human and ET teaching network that this section addresses involves two scenarios: 1) where human teachers modify their teaching when ETs are enabled and 2) when, after teaching is distributed to ET, the ET then provides student learning information back to the human teacher, identifying areas that could be improved. The quality of teaching is important here, as educational technologists have claimed for years that ET can in some ways teach better or more efficiently than humans (Petrina, 2004, p. 312). Data distributed from ETs back to the human teacher informs the human teaching through modification.

The first modification of teaching involves human teachers modifying their teaching while enabling ETs. This is demonstrated in a several ways through online modules and simulations. The first example involves teachers who took on the role as content experts, which led to an identification of content to include in the module or simulation and identified the learning objectives (Craig et al., 2014; Premkumar et al., 2010). The human teachers acted as content editors, while the module and simulation were developed by other people. The second example involves human teachers who modified their teaching from content experts to facilitators when teaching with a simulation ET where novice students are first-point-of-care for a patient (Tully et al., 2015). Usually when patient care is involved, medical educators intervene if there is possible harm that might come to the patient. In this simulation, educators modified their teaching to take a back seat and facilitated the ET teaching. Educators allowed students to make mistakes, including those that ended the patient's life, if the patient dying was part of the simulation. In this modification teachers decided how much simulated patient death was acceptable as they did not want their students to develop a false sense of security in regard to making patient care decisions and there being no serious repercussions if they make a mistake and the patient dies. The third modification of teaching involves students using ET to record a simulation with a standardized patient. The teacher in this simulation did not need to be present, in the room, with the standardized patient and the student. Instead the teachers watched the recording of the simulation later to provide feedback to their students. The fourth modification of teaching involves the inclusion of audience response system (ARS) ETs in a lecture (Stoddard & Piquette, 2010). The ARS requires human teachers to embed questions into their lectures, effectively modifying their teaching.

3.5 In what ways is this distribution acknowledged among teachers?

Within the relevant literature, only two studies include qualitative teacher data along with student data on their thoughts, feelings, and experiences with ET teachers (Ellaway et al., 2014; Premkumar et al., 2010). Within those interviews, the teachers do not explicitly acknowledge that they distributed their teaching roles to ETs. Rather, they speak of the utility of the ETs, the time they take to design, and way in which the ETs are integrated into the institution. The utility of the ETs was discussed by teachers: how successful the ET teachers were in teaching material, and how the ETs made the subject matter interesting. The time component is demonstrated as an investment on behalf of the human teacher to ensure the success of the ET teacher. Integration is expressed by teachers who wanted deliberate curriculum integration of the ETs, and further wanted the ETs to align with exam questions and accreditation requirements (Ellaway et al., 2014; Premkumar et al., 2010).

The other way in which faculty are shown to acknowledge their teaching has been distributed to ETs is through paraphrasing by researchers. Researchers paraphrased faculty fears and concerns regarding the integration of ET teachers. Within articles containing lecture ETs, this was demonstrated through faculty frequently cited as concerned that through the inclusion of lecture recording ETs, their role as lecturers was diminished (Billings-Gaglardi & Mazor, 2007; Cardall et al., 2008; Martin et al., 2013; Owston et al., 2011; Zureick et al., 2017). The perceived diminishment of role is demonstrated through concern that students would prefer the teachings of the ET via lecture recording instead of attending face-to-face lectures to engage with the human and class discussion. These lecturers were concerned that teaching to empty lecture halls would ultimately impact the effectiveness of their teaching and students' learning and questioned the pedagogical evidence of student learning via video lecture (Cardall et al., 2008).

Faculty were also paraphrased to as being concerned that the growing emphasis on the integration of patient simulations consisting of mannequins or virtual patients would eventually replaces student interaction with real patients (Gorden et al., 2010). Faculty expressed concern that the plastic mannequins and pre-designed simulated scenarios ultimately create reliance on technology while the complexity of real-life patient learning of clinical practice gets lost for students (Gordon et al., 2010). Two articles include scenarios where ETs taught duplicated content so effectively via an online module that, eventually, the ETs took the place of the human teacher's lectures or workshops (Dolev et al., 2010; Ellaway et al., 2014 Jenkins et al., 2008).

Chapter 4: Discussion and Conclusion

For Clark, ETs are simple tools while, for Kozma, ETs are useful tools to solve problems. Both education scholars render ETs as tools. This lens is also found, as expected, to be prominent in medical education discourses. Using an ANT lens to the relevant medical education literature allowed me to flatten the hierarchy of human teacher as actor and technology as tool, and institution as employer and teacher as employee. When integrating ETs into the medical education learning environment, there is an assumption within most of the relevant literature examined in this thesis that ETs function as intermediaries. Intermediary actors are those that work as simple vehicles of meaning and do not transform, alter, or distort the meaning in the process of moving meaning along a network. A lecture recording might simply be a record of a lecture and distribute the teaching; students might learn the same, both in and outside of the lecture hall. An online module might simply hold curated and organized information, questions to test student's knowledge and understanding. Simulations, online and in-person might provide an accurate representation of a clinical process or procedure without risk to a patient. At the same time, ETs are also supposed to function as cutting-edge gadgets that will invigorate medical curricula and improve student learning. Through the ANT lens, I flattened the hierarchies of human and non-human and tracked what roles or parts of teaching are distributed to ET teachers to better understand the role of ETs within the medical education network. When ETs are assumed to be intermediaries, simply vehicles to deliver content, the complex social network of teaching is reduced to content delivery methods. This is contradictory to one of the problems ETs are intended to solve within medical education, which is invigorate old, didactic-learning styles (Cardall et al., 2008; Martin et al., 2013; McNulty et al., 2009). ETs are simultaneously rendered simple tools and innovations that will force institutions to move away from traditional, didactic lectures to authentic, flexible, personalized, student-centered learning experiences for medical students (Cardall et al., 2008; Martin et al., 2013; McNulty et al., 2009; Owston et al., 2011; Zhao & Potter, 2015). I also described the impact of that distribution based on what human teachers said or were suggestively saying about their experiences with ETs. ETs were shown to significantly extend the teaching of humans through time and space, contexts, and content as well as modifying their teaching role demonstrating that ETs are not simple tools. ETs were shown to play a significant role alongside human teachers within medical education. At times, ETs were even designed to enable students to self-direct their learning, further demonstrating that their use was far from simple (Premkumar et al., 2010).

ANT helped me describe the dynamic roles ETs play within the medical education network. I demonstrated how, through the action of teaching, ETs and human actors teach medical students and are affected by other actors within the medical education network, including instructional designers, IT support staff, accreditation authorities, and the medical institution itself. When teaching is distributed to ETs they are shown to function as both intermediaries and mediators, demonstrating they are more than simple tools. When ETs functioned as mediators within the medical education network, their integration had latent and manifest impacts. These impacts demonstrate that ETs are also more than useful tools, as they can cause new problems as they're employed to solve problems. Based on the reactions of actors within the medical education network, was ET solving the problem it was intended to or simply triaging it? For example, one problem ETs are intended to solve within medical education is the limited access students have to patients during their training. Between modern patient care practices that focus on patient safety first before student education and modern medical practices that lead to quicker patient recovery and shorter hospital stays, there is less time spent treating patients and medical student interaction (Castilano et al., 2009; Cook & Triola, 2009; Gorden et al., 2010). About 76-78% of physician diagnoses are made based on information gathered from the patient's history. Thus, learning how to organize and ask questions to gather the right information from patients is a fundamental skill of a doctor (Gruppen, Woolliscroft, Wolf, 1988; Peterson, Holbrook, Von Hales, Smith, Staker, 1992). Limited access to patients makes this a problem for medical educators. Simulation, both human and ETs are designed to solve this problem. Ellaway (2012) asserts that "everything is simulation" (p. 954). The patient in medical education is always a simulated entity which permeates through every aspect of medical education, whether explicitly stated or not. From low-tech instruction consisting of lectures and textbooks, to online modes, and human or technology simulated patients, the future patients of medical students are always present and simulated in varying degrees. The simulated patient may exist via simple diagrams of the different chambers of the heart, as a method of teaching students about how their future patients' hearts operate, to advanced simulation of patients featuring real or ET teachers. Today, simulations that involve ETs assisting human teachers in contextualizing knowledge through extending the teaching of the patient is becoming the status quo within medical education institutions (Castilano et al., 2009; Cook & Triola, 2009; Gorden et al., 2010). The literature demonstrates how medical educators worked alongside ETs to extend and preserve this human element in patient care. One example involved an ET that physically consisted of a mannequin designed to represent a human patient for students to diagnose and treat. In this case, the ET reproduced sounds and vitals consistent with a patient in distress and placed in a clinic room to also simulate the context in which medical students would interact with their patients (Gordon et al., 2010). The human teacher, with a microphone and speaker attached to the ET mannequin communicated with the medical students, answering their questions and pleading with the students to make them feel better. The dynamic and emotional pleas and responses of the human teacher, through the mannequin transformed the ET into an extended human, enabling students to be emotionally invested in the ET patient's care. This type of simulation, which provides students with an opportunity of being primary care providers of a patient in a safe, controlled, environment, is argued to create lasting impressions for students (Gordon et al., 2010). These simulation ETs provided consistently sick patients with specific illnesses and ensured students received standard experiences with these illnesses.

However, whenever technology is brought in to replace a human role, like the simulation of a patient, there is the risk of losing the human element in that interaction, especially when not all simulations are conducted in tandem with a human teacher. Teachers expressed concern that relying on simulation ETs as the solution to patient access during medical students' training ultimately undervalue the complexities involved with clinical practice (Gorden at al., 2010). While it is difficult to say how this generation of medical students will differ in the care of their patients after simulation-based training than their predecessors, the research demonstrates differences in how students treated simulated patients versus real patients. For example, students treat virtual patients (ETs) less warmly than human, standardized patients (Cook & Triola, 2009, p. 305). In simulations that involve ill patients and include scenarios where the patient may die if the student does not choose the right care options, faculty struggled to re-create high-fidelity and empathetic patient care scenarios while effectively gamifying the treatment of a patient (Tully et al., 2015).

Another problem medical institutions are attempting to solve with technologies is finding a place to fit an extensive amount of content into a four-year undergraduate medical degree. Jenkins et al., (2008) argued that ET "has become increasingly utilized in the teaching of undergraduate medical students because of the increasing amount of educational material is addition to the lack of sufficient teaching time in the classroom” (p. 258). The affordances provided by anywhere anytime learning is intended to solve this problem by providing materials and learning opportunities for students outside the classroom (Ellaway et al., 2014; Jenkins et al., 2008; Premkumar et al., 2010). Anytime anywhere learning requires medical institutions to invest in ET infrastructure and support staff, and faculty to invest time into adapting or creating ET content (Billings-Gagliardi & Mazor, 2007; Cardall et al., 2008; Craig et al., 2014; Ellaway et al., 2014; Jenkins et al., 2008; Martin et al., 2013; McNulty et al., 2009; Mi & Gould, 2014; Owston et al., 2011; Premkumar et al., 2010; Rasmussen et al., 2013; Tully et al., 2015; Zureick et al., 2017). However, as Kanuka (2008) noted with mobile technologies, the ETs for anytime anywhere learning becomes a black box. The input of anytime anywhere technology will lead to an output of student learning. Solving the problem of too much information with anytime anywhere information did not always sit well with students. First, students did not automatically assume that because a module was online, it automatically had intrinsic value; in fact, some students preferred more traditional media such as books when they studied (Ellaway et al., 2014). Second, a few of the online ET resources faculty and IT support staff developed for students to use as primary learning material, were instead used for supplementary studying by students (Craig et al., 2014; Ellaway et al., 2014; Premkumar et al., 2010). Also, students expressed frustration at having to complete technology-based learning outside scheduled class time (Craig et al., 2014; Mi & Gould, 2014). Faculty also occasionally expressed the need to standardize how anytime anywhere ETs were utilized in the curriculum by reporting they wanted online ETs to be mandatory and deliberately integrated into the curriculum so that students received course credits for taking them (Ellaway et al., 2014). So while anytime anywhere provides students access to resources outside the classroom, it does not solve the problem of the sheer amount of information students must learn in a four-year time period.

Through addressing the second research question regarding how the distribution of roles from human to ET are acknowledged by human teachers, I identified a noteworthy trend in the literature. Frontline faculty teachers' experiences are minimally provided even though they play key role in integrating ETs into the classroom. Also troublesome was the way in which medical educators, through being paraphrased, expressed concerns regarding the diminishment of the value of their teaching role, the utility of integrating an ET for the purposes it is being employed, and the culture shift within medical education due to ETs implementation into the medical education curriculum (Billings-Gaglardi & Mazor, 2007; Cardall et al., 2008; Martin et al., 2013; Owston et al., 2011; Zureick et al., 2017). These concerns are glossed over in the literature as minor worries to be quickly disproved and placated rather than critically considered. Harden and Heart state that "the tutor has a very important role in e-learning, and can be thought of as "part teacher, part party host, and part sheepdog" (2009, p. 263). Integrating ETs into standard teaching practices requires role adjustment and re-evaluation from human teachers. At the same time, human teacher voices are the least highlighted in medical education literature. This is a significant gap in medical education literature.

MacKenzie and Wajcman (1985) argued that "determining the effects of a technology is an intensely difficult and problematic exercise, that one requires a good theory of how society works, an understanding of the overall dynamics of society, before being able to specify the effects of a technology (cited in Woolgar, 1991, p. 30). Medical education research cannot effectively understand how or what ET teaches medical students while ignoring the medical educators who are often both students' primary teachers and facilitators. Further Cook and Triola

(2009) argued that for ET integration to be successful, not only does the ET need to be effective, but a significant number of educators need to be trained in the use (p. 308). Also concerning is the ways in which human educators' teaching without technology is discussed in frequently unflattering terms in the literature. One of the key roles faculty play in medical education is specialist lecturers. The terms used to describe lecture-based teaching is frequently 'traditional', 'didactic', or 'teacher'centered' (Dolev et al., 2010; Jenkins et al., 2008; Mi & Gould, 2014). These descriptions themselves are not necessarily negative, but when they are juxtaposed against the words used to describe teaching with technology (flexible, innovative, non-linear, authentic, or dynamic), within the same articles, those teaching without technology begin to appear old and dated (Billings-Gaglardi & Mazor, 2007; Cardall et al., 2008; Dolev et al., 2010; Jenkins et al., 2008; Martin et al., 2013; Mi & Gould, 2014; Owston et al., 2011; Zureick et al., 2017).

The way in which technology is positioned is that of a requirement of teaching this new generation. McGee and Kanter (2011) argue that "students entering medical school now have grown up using the Internet for both learning and social activity. This generation of learners possesses advanced skills and unique expectations for technology in all parts of their lives" (p. 284). However, as discussed, this expectation does not resonate with all medical students. There are some who prefer low-tech books and attend lectures to show professionalism and respect for the specialist teacher (Cardall et al., 2008; Ellaway et al., 2014). When ETs do not enhance a learning experience beyond low-tech options, students and faculty are unimpressed (Jenkins et al., 2008; Rochlen et al., 2017; Tully et al., 2015). ETs extending the teacher's teaching is shown to be helpful in some instances and time-consuming and overwhelming for students in others. Despite the actors expressing dissatisfaction, ET integration is still heavily supported in the literature (Billings-Gaglardi & Mazor, 2007; Gorden et al., 2010). This demonstrates a misalignment of the role and value of ETs in medical education between researchers and the students and teachers who interact with them. In order to better understand this misalignment of the role and value of ETs in medical education, we need to adjust the way in which we research them. Woolgar (2002) says we

> Need to understand the manner and extent to which our efforts at researching the social dimensions of electronic technologies are already constrained by the ways we pose the research questions in the first place. In order to do this we need to dissect these terms of reference, the frame being used and the underlying assumptions of this kind of research rationale. (p. 6)

The way in which the literature poses research questions regarding ETs in medical education literature effects our understanding of them. When research focuses on the role of the ET within the learning environment, and ignores the role of the human educator, the ET is given credit for any learning that occurs, even though they are shown to be modified and implemented by human educators.

4.1 Conclusion

In the introduction, inspired by Ellaway's (2012) work, I presented three core principles to follow within this thesis. The first is that ETs be considered partners in teaching. Ideally, a partnership would benefit both parties. ETs and ALTs transform human teaching in ways that are either unforseen or deemed not worthwhile by teachers. Treating ETs as partners in medical education networks requires that roles of human and nonhuman teachers be deliberately thought out and executed to create a symbiotic environment. Current research in medical education neglects the distribution of the human teacher, leaving out the voices of teachers who experience the distribution to ETs first-hand. To understand contemporary learning environments, attending to the actions and voices of human and nonhuman teachers, as partners in teaching, is essential.

The second principle is that once ETs are introduced into a learning environment, they become socially embedded and their participation impacts the teaching network, requiring continued attention and critique. By transforming teaching, ET shapes learning environments. While ETs are not external to ‘the social’ of medical education, since they are positioned as positive actors in the literature, their integration involves modification and customization. Thus, ETs require continued attention to intended and unintended effects of integration within a learning environment. ETs and ALTs are not simple tools for educators to use. They function as complex actors within the medical education network. Instead of assuming ETs act as obedient tools in medical education, ETs and ALTs are mediators.

Third, when examining the effectiveness of ETs roles in the learning environment, practitioners and researchers should consider ways in which integration is deliberate, transparent, and accepted by other actors. ETs perform inconsistently in different contexts (Ellaway et al., 2014). Like human teachers, some properties and roles are rational and smooth and others irrational and erratic. This thesis explored distributions of these properties and roles, albeit less deliberate and transparent than admitted, and the relative neglect of these distributions within medical education.

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Appendix

Figure 1 illustrates the results of a database search and subsequent inclusion and exclusion criteria made in the collection of literature to form the foundation of this thesis.