Shape shifting smartphones: Riding the waves in post-secondary education

Téléphones intelligents à géométrie variable : leur mise à profit en éducation supérieure

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Abstract

The smartphone is a recent technological addition to post-secondary education and it has both educational and non-educational applications. This study examines the educational use of smartphones using principles from actor-network theory (ANT). The purpose of the investigation was to learn about the multiple entanglements of students, teachers and smartphones in overlapping networks or assemblages and to examine the pedagogical practices created within these assemblages. The discussion begins with an introduction to the mobile technology literature, an overview of ANT and an explanation of some key ANT terms and concepts. The research design and methodology are presented and the concepts of "fluid" and "fire" objects are explored. The new descriptor "protean" is proposed as a way to describe the highly mutable and unpredictable nature of the student-smartphone assemblage. The article concludes with a discussion of how these human and non-human assemblages are influencing and changing pedagogical practices and the significance for education.

Résumé

Dernière invention technologique à pénétrer le domaine de l'éducation supérieure, le téléphone intelligent offre des possibilités tant pédagogiques que non- pédagogiques. Cette recherche étudie l'utilisation pédagogique des téléphones intelligents à partir des principes de la théorie de l'acteur-réseau. L'enquête visait à connaître les multiples enchevêtrements entre étudiants, enseignants et téléphones intelligents au sein de réseaux imbriqués ou d'assemblages, et à examiner les pratiques pédagogiques créées dans ces assemblages. La discussion introduit d'abord la littérature sur la technologie mobile, donne un aperçu de la théorie de l'acteur-réseau et explique certains termes et concepts clés de cette théorie. Le plan de recherche et la méthodologie sont présentés et les concepts d'« objet «fluide» et d'«objet-feu» explorés. Le nouveau descripteur «protéiforme» est proposé pour qualifier la nature extrêmement changeante et imprévisible de l'assemblage étudiant/téléphone intelligent. L'article se termine par une discussion sur la manière dont ces assemblages humains et non humains influencent et modifient les pratiques pédagogiques et sur leur portée en éducation.

Introduction

Contemporary educational practice is intimately intertwined with its material objects. Classrooms are equipped with tables, chairs and interactive white boards; libraries are filled with computers and books; and science laboratories and workrooms have specialized equipment and supplies. Teachers and students habitually overlook these objects and take them for granted, but as Fenwick and Edwards (2010) note, "Pedagogy centres around, and is constantly mediated by, material things. Pedagogical encounters change radically when its things change..." (p. 5). This observation suggests that some of the newest objects in education, smartphones and tablet computers, may be profoundly shaping and influencing educational practice, whether we are aware of it or not.

A distinctly 21st century invention, the smartphone is one of the newest technical objects to appear on the post-secondary education scene. Now nearly ubiquitous, a recent survey claimed 63% of post-secondary students in Canada own smartphones, well above the Canadian average rate of 54% (*Survey about Canadian,* 2012). Smartphones can be used for a variety of educational and non-educational purposes, including reading, research and communicating with peers and instructors, texting and browsing the Internet. Often, the fact that students use smartphones for learning is not obvious to instructors or administrators. Perhaps this is because they are such small, and distinctly personal devices. Instructors see students using their phones but they often do not know for what purpose. In order to learn more about the educational use of smartphones, I initiated a study, grounded in principles from actor-network theory (ANT), to learn more about students who regularly use smartphones for learning in post-secondary education. Based on observations of and interviews with six university students, this study attempts an ANT-informed account of the multiple ways that the smartphone is tangled up with students and instructors in overlapping networks or assemblages.

Overview of the article

The discussion begins with an overview of the mobile technology literature and an explanation of the choice of ANT for this study. The next section provides an introduction to ANT and discussion of some key terms and concepts including "symmetry," "black boxes," as well as "fire" and "fluid" objects. Following is a description of the study's research design and the methods employed. The balance of the article is a description of the study itself, organized around several key participant anecdotes. I propose that while smartphones are indeed "fluid" and "fire"-like, the descriptor "protean" captures more accurately the highly mutable and unpredictable nature of this "shape-shifting" object. The discussion concludes with a description of how the student-smartphone assemblage is influencing and changing pedagogical practices and the significance of this for education.

Overview of the Mobile Technology Literature

Interest and research in mobile technology and mobile learning is growing. Many topics have been explored in the literature including the educational application of mobile technologies (Caudill, 2007; Pinkwart, Hoppe, Milrad & Perez, 2003; Torre, 2003), the need to develop a theory of mobile learning (Koole, 2009; Sharples, Taylor & Vavoula, 2005; Sharples, Taylor & Vavoula, 2007), applications of mobile learning (Diaz-Vera, 2012; Kukulska-Hulme, 2006; Motiwalla, 2007; Polishook, 2005; Trinder, Magill & Roy, 2005), and usability factors and

guidelines for m-learning projects (Ally 2005; Vavoula, Lefrere, O'Malley, Sharples & Taylor, 2004).

Actor-network theory and mobile technology

Fewer studies have used actor-network theory to examine mobile technology and learning. Wright and Parchoma conducted two ANT studies with mobile technology. In the first one, they considered the different types of discourses that exist in the mobile technology literature (2011) and, in the second they traced how one brand of smartphone formed into actor-networks in informal learning (2012). ANT was a suitable approach for this study because it provided a way of studying humans and objects *together* rather than separating them or considering ways that humans *use* objects in education (Sørensen, 2009). It also offered an opportunity to transport objects such as smartphones out of the background of our everyday world and make them important participants of the study (Adams & Thompson, 2011). Waltz (2004) notes that humans and objects interact and co-create educational environments together, and this observation highlights how the material and relational are interrelated in education and the importance of studying them together.

Another advantage of using ANT was the opportunity it offered to examine and reflect on different pedagogical practices. In ANT, the term practice is used broadly to refer to a multitude of activities. In this study, some of the practices that emerged were: accessing and gathering information, receiving feedback from instructors and collaborating with other students. ANT's focus on practice is valuable for it reminds us that practices emerge from the interactions of humans and technology, rather than existing independently before humans and objects form into overlapping actor-networks.

An Introduction to Actor-Network Theory

ANT originated in the work of many scholars, including the science-technology-society (STS) researchers Michel Callon (1986) and Bruno Latour (1992) and the sociologist John Law (1987). ANT identifies how objects, artifacts and people (called actors) combine together into actor-networks or assemblages and how they work together. The formation of actor-network is not predictable or stable; actors can, at any moment redefine their relationships to one another in new ways and enroll (or bring) new actors into the network (Callon, 1987). The actor-networks overlap and intersect; some parts work co-operatively and provide stability, while others conflict with one another, causing network strains and breakages. In early ANT studies, the word *actant* was sometimes used instead of the word *actor*. Harman (2007) has observed that "An actant is nothing without networks; with networks, it is all" (p. 43). Although the notions of actors and actants are thought provoking, ANT is more focused on the assemblages of actors into networks and the work that is performed within and through these networks of relations (Law, 1999).

ANT as a Sensibility

There are many different opinions about the suitability of the term "actor network theory" for this method of study. Callon (1986) has used the phrase "sociology of translation" while Law (2009) has argued that the term "material semiotics" is a more suitable way to describe this approach. Instead of calling ANT a theory, Fenwick (2010) suggests that we think of it as a sensibility and a way of investigating how the socio-material enacts reality. Meanwhile, Law

(2009) argues that actor-network is not a theory because it does not provide explanations, but instead focuses on descriptions and telling stories about how actor-networks assemble together and Fox (2005) explains that the goal of ANT is "...to illuminate *the processes*, rather than explain end results..." (p. 102). The different opinions about the suitability of the name actor-network theory and the debate regarding whether it is really a theory or not, can make it challenging to say anything definitive about ANT. One of the main characteristics of ANT studies is that they are highly descriptive accounts of the many actor-networks that form and stabilize and they usually describe the work (or pedagogy) that is occurring within them. Other than these general characteristics, each ANT study focuses on just a few terms, concepts or sensibilities within a given subject area. This variation of ANT studies is further compounded by a shift in research topics over its history from translation (Callon, 1986; Law, 1992) to objects (de Lat & Mol, 2000; Mol 2002; Law & Singleton, 2005).

Symmetry

One of the central tenets of ANT is that humans and nonhuman objects are equally important; one should not be privileged over the other. It is a characteristic of our humanist, anthropocentric era to imagine ourselves in the centre of networks and relegate the non-humans to the periphery. However, it is important to resist this tendency and to take a broader viewpoint in order to learn how humans and non-human technological actors assemble, circulate, and disassemble in fluid and unstable networks. This symmetrical outlook gives ANT researchers the opportunity to identify, study, and unravel the complex web of human-technological networks that co-constitute every human-technology interaction.

In addition to the notion of symmetry and the terms actors, actor-networks, and assemblages, there are numerous other concepts employed in ANT including: mediators, intermediaries, translation, immutable mobile, fluid objects, fire objects and black boxes. At times, the sheer number of terms and the many variations and interpretations of them can make ANT seem complicated and needlessly complex. While this is a fair criticism of ANT, the diversity of terms also reflects the disorderly, shifting, messy, "in the wild" situations that ANT studies. When people, objects, and artifacts combine together, these form into unstable, dynamic assemblages that may not be fully described or understood in simple terms. When there is flow and movement, interruptions, breakdowns and contradictions to account for, it is helpful to have a rich vocabulary at hand. Yet, not all terms in ANT are equally significant in all studies. In this particular investigation of smartphone use among post-secondary students, the notions of black boxes, mediators, fluid objects, and fire objects were most important. The next section provides brief definitions of these terms before the details and findings of the smartphone study are presented.

Black Boxes

The term black box is used in ANT to describe the way that we focus on what an object produces (or does) and overlook what goes on internally that makes this possible (Latour, 1999). The term black box can be misleading if we focus too much attention on objects alone and overlook the ways that humans and objects are entangled together into actor-networks. Latour (1999) writes, "Open the black boxes; examine the assemblies inside. Each of the parts inside the black box is itself a black box full of parts. If any part were to break, how many humans would immediately materialize around each?" (p. 185). One of the advantages of using ANT in this study is the

opportunity it provides to open up the black box of smartphones and examine the many actor-networks or assemblages within.

Mediators and Intermediaries

In ANT studies, it is important to follow those actors, or mediators, that change and produce tensions and upheavals in the assemblages in which they are entangled. According to Latour (2005), "Mediators transform, translate, distort, and modify the meaning or the elements they are supposed to carry." (p. 39). Mediators may lead in many directions and they are usually complex and contradictory (Latour, 2005). Intermediaries are actors that "...transport meaning or force without transformation..." (p. 39) or change and they are not as interesting to follow as mediators (Latour, 2005). Any actor, whether they are human or object may act as a mediator or intermediary and their status is not fixed or permanent; mediators can become intermediaries and intermediaries can become into mediators. The fluid and changing nature of intermediaries and mediators can make them difficult to follow.

Fluid Objects

Fluid and fire objects are two of the most confusing concepts in ANT. The first difficultly begins with the word "object" itself. Object can be understood in terms of the expected, dictionary definition of "material things that can be seen and touched" (Barber, 1998). However, this definition does not apply to all ANT studies. For instance, de Lat and Mol's (2000) study of the Zimbabwe bush pump is an object that can be seen and touched but Law and Singleton's (2005) study of alcoholic liver disease and Mol's (2002) analysis of atherosclerosis does not fit this definition. Unfortunately, the difficulty is further complicated by the ANT definition of fluid objects as something that "...flows and *gently* changes shape, bit by bit." (Law & Singleton, 2005, p. 338). This definition is misleading for it also suggests that objects in ANT are like other objects; they are things that can be seen and touched. But Latour (2005) offers advice for how to think differently about objects and to see them as more than just material things. He explains, "...when faced with an object, attend first to the associations out of which it's made..." (p. 233). This suggestion highlights how important it is to consider objects in terms of networks or assemblages in which they are entangled. It also prompts us to think about how an object can change when influenced by changes in other parts of the network.

Fire Objects

The term fire object is another term in ANT. Law and Singleton (2005) used this term to describe the discontinuous patterns of absence and presence that they noticed in the treatment of alcoholic liver disease. They suggest that "fire object" captures how the absence of one thing depends on the presence of others and vice versa. They explain, "An object is a presence. It is present, here and now. But, whatever the form of its presence, this also implies a set of absences. The present object implies realities that are *necessarily* absent, that *cannot* be brought to presence..." (p. 343). They called this a fire object because they noted the way that fires have patterns of presence and absence. They distinguished between fire and fluid objects by noting that the transformation in fluid objects is slower and gentler, while the transformations in fire objects are more abrupt and disjointed. These notions of fluid and fire objects (which overlap and share similarities) captured some of the messy and unpredictable qualities of smartphones in post-secondary education.

Overview of the Study

One undergraduate and five graduate students participated in this study; they were recruited by referrals and recommendations from other students over a two-month period. This study received formal review and approval from the University of Alberta's ethics review board. The only criterion to participate was that students had to own and use a smartphone. Their particular use of smartphones was on their own initiative. Students did not have any formal approval or support from their instructors or universities to use this technology. The purpose of the study was to examine students' everyday use of smartphones, particularly as they related to educational tasks. Of course, during the interviews students described non-educational uses of their phones but this use was not the focus of the study. As Wright and Parchoma (2011) have noted, examining students' informal use of mobile technologies is a chance to gain insights into students' situated learning practices.

Data for this study was collected during semi-formal interviews that lasted for approximately one hour. Most of the participants brought their smartphones to the interviews and they both described *and* demonstrated how they used their phones during the meetings. At one session, a participant forgot to bring her phone and this made it hard for her to describe in detail how she used it. At the other meetings, the participants already had their smartphones at hand and they demonstrated what they were describing as they went along. It seemed that the smartphone had to be physically *present* and *in use* during the interviews, in order for students to talk in detail about how they used their phones.

The study asked the following three research questions: What actors and assemblages emerge when smartphones are used in post-secondary education? What pedagogical practices are created within these assemblages? How are these pedagogical practices different from the ones that were already occurring in post-secondary education?

In the next sections, I probe the concepts of fluid and fire objects from actor-network theory and propose that it is more helpful to think of smartphones as protean objects instead. In addition, I share some of the anecdotes from the interviews and reflect on the ways that smartphones are influencing and shaping teaching and learning practices.

The Physical Characteristics of Objects

This study began by considering the physical characteristics of smartphones. This strategy is one that was used by De Laet and Mol (2000) when they studied the Zimbabwe Bush Pump. They described the bush pump as having: a pump head, lever, base and underground parts. At first glance, smartphones seem like objects that can be similarly described. We might say of them that they are: small devices made of metal, glass and plastic, with five buttons and they fit comfortably in one hand. But there are many issues with this description. To begin with, what object do we mean when we use the term smartphone? Are we referring to Apple's iPhone, Research in Motion's BlackBerry, or devices running Microsoft Windows Phone or Google Android? Differentiating among these brands is important because not all smartphones have five buttons, nor do they have the same physical dimensions. De Laet and Mol (2000) studied a single bush pump, the Zimbabwe bush pump "B", which made it easier to confidently describe that object. This study looked at smartphones as a group and did not focus on one particular brand or model, so it is only a starting place to consider the phones' physical characteristics. For the

purpose of this study, a smartphone is defined as an computing device with a screen, one that is small enough to be held in one hand, that supports cellular and Wi-Fi connectivity and telephone calling and that has the ability to download, install and run applications.

One of the risks of focusing on the physical characteristics of smartphones is that we may conclude they are intermediaries (objects that do not change) and we overlook the interesting and exciting changes and modifications that occur. Succinctly put, smartphones and bush pumps are very different kinds of objects. Smartphones are designed to be modified on the *inside,* in numerous, subtle and easily overlooked ways while modifications to the bush pump, especially those on the outside, are easier to observe.

Instead of focusing on smartphones' physical characteristics, a more effective approach is to examine the ways that smartphones may be internally and externally transformed. Unlike bush pumps, smartphones can only be nominally modified on the outside. We may use cords to attach them to electrical outlets and computers and we can use protective anti-glare film to temporarily mend a broken screen or tape to hold a broken button in place, but we cannot permanently replace these parts with locally available items, as was the case with the Zimbabwe bush pump. But we can substantially change our phones on the inside by downloading and installing a wide range of free and low-cost software applications. As Chen (2010) has noted, "Such is the undeniable appeal of a device whose minimal hardware disappears and, in the form of an app, becomes anything its owner wants" (p. 10). Within seconds, smartphones can shift between their many built-in applications such as email, text messaging, GPS navigation, web browsing and calling, to function as a dictionary, thesaurus, e-book reader, second-language translator and periodic tables of elements. These applications are just a few of the many educational ones that are available.

Opening up the Black Box of Smartphones.

When we look at the smartphones and consider the internal transformations that are possible, it becomes clear that these devices are entangled with numerous other actor-networks. Using the iPhone as an example, students and teachers have to use at a minimum: iTunes, wireless Internet connections and the App Store to get new applications. Behind each of these actors are many other actor-networks. As students skim through the apps, they might suppose that Apple has created them, but what they are actually seeing is the work of numerous independent software creators and the other actor-networks with which they are assembled. Depending on what application a student installs, other humans and objects will be added to this assemblage. Although this is not a complete account of all the actor-networks that are possible on iPhones, it brings to light some of the many actor-networks that exist within them and how these are more noticeable when we open up the black box.

Understanding Anecdotes

In order to examine some of the actor-networks discovered in this study, anecdotal descriptions or remembered moments were collected from the participant interviews. A few of these anecdotes are presented below. Anecdotes allow researchers to start with a specific incident and explore its complex associations (Michael, 2012). The intention of using them is to gain a firsthand, admittedly "human," glimpse of the numerous connections that exist between actors—both human and non-human—as well as the work done within these assemblages. ANT

researchers commonly use anecdotes as a key methodological heuristic, most famously Latour's seatbelts, doorstops and sleeping policemen (1992), and also Leander and Lovvorn (2006), Singleton (2005), and Verran (1999). Although such anecdotal accounts reconstructed from participant interviews necessarily present the "human" point-of-view, once subjected to ANT analysis, they may serve to show how humans and non-humans share agency in the immediacy of the everyday (Introna, 2007).

First Anecdote: Pictures at the Library

> Adam is looking for books for his research project at the library. When he finds some that look interesting, he takes pictures of the call numbers on the computer screen with his phone's camera. He heads upstairs to find some books on the shelves. While doing this, his phone rings. He answers the phone but no one speaks, there is just a buzzing sound. He realizes that someone wants him to open the main door of his apartment building. Adam presses the number one on his phone, which makes the apartment door (located 20 blocks away) open. Adam and his roommates do not have a home telephone, so it is his smartphone that rings when someone is waiting in the lobby. When they call, he lets them in, whether he is there to greet them or not.

This anecdote illustrates the ways that a smartphone can be considered a fluid object. At the beginning of the anecdote, the smartphone is used for researching and information gathering. The phone's camera capabilities have replaced pencil and paper as the means of recording the call numbers of library books. Then suddenly, the phone shifts its function and acts as a remote entry system. Thinking about smartphones as fluid objects allows us to see that there has been an important shifting of purpose in this instance, despite the fact that the phone has not physically changed shape.

Smartphones as Protean Objects

While it is helpful to think about smartphones as fluid objects, the concept does not fully capture the complex mediating activity of the object in this anecdote. Sometimes, the smartphone gradually changes shape, but at other moments, the shape shifting is sudden and abrupt. For instance, when the phone rings and Adams presses one, the phone suddenly switches from being a research tool to being a gatekeeper and remote entry system. There is no gradual changing here; it is interruptive and nearly instantaneous. Using the notion of mediators and intermediaries in this case is also unsatisfactory. On the one hand, the phone acted as intermediary for it did not transform or modify the meaning of what it was supposed to carry. Adam set it up to act as a notification system and it functioned perfectly in this role. But in another respect, the phone-entry system behaved like a mediator. The security system alone was originally designed to be a means of restricting access in the building but when it is assembled together with a smartphone, it becomes a way of enabling access at a distance. While we might say that this illustrates how actors can quickly switch from being mediators to intermediaries, there is another feature of this anecdote that is not accounted for: the sudden and unexpected shape-changing that occurred.

Instead of conceptualizing smartphones as mediators and fluid objects, it would more fully capture their behaviour if we thought of them as protean objects. According to the Canadian Oxford Dictionary, the word *protean* is used to describe a person or thing that is variable and assumes many forms. The word comes from the Greek sea-god Proteus who had the power of

prophecy but who preferred to assume different shapes rather than answer questions about the future (Barber, 1998).

Using mythological and historical figures as a means of describing human-technology relations is evident in the writing of others. For instance, Postman (1992) incorporates the anecdote of the Judgement of Thamus into his book about technology and culture, Latour (1999) used the notion of Pandora's box in his collection of essays about science and technology, and Arnold (2003) discussed the "Janus-Faced" nature of mobile phones in his writing. Sometimes, using mythological figures can help us capture an important trait or aspect of technology that we notice. Conceptualizing a smartphone as a protean object emphasizes the phone's continuous shifting quality. Like the sea-god Proteus, the shape shifting in phones comes in waves; sometimes, the waves move gradually and the shape shifting is gentle but at other moments, the waves are powerful and the change is sudden and unexpected.

Fire Objects

In ANT, the notion of fire objects has some overlap with protean objects. Law and Singleton (2005) use the term *fire objects* to describe objects that have patterns of discontinuity in their absence and presence. They write, "...fires are energetic and transformative, and depend on difference – for instance between (absent) fuel or cinders and (present) flame" (p. 344). This argument is relevant to smartphones because there are obvious patterns of absence and presence with these devices. The smartphone permits Adam to manipulate his presence and absence; at one moment, he is present in the library and absent from his apartment, and in the next, he is virtually present in his apartment building *and* physically present in the library. Protean objects and fire objects also share a sense of randomness; both are unpredictable and dynamic (Law & Singleton, 2005).

It is when we consider the concepts of place and time that we begin to see important differences between fire objects and protean objects. In their study, Law and Singleton, traced one object, alcoholic liver disease, and examined three versions of it in three differences: a hospital, a community-based psychiatry office and a GP's surgery. Although different, these versions of alcoholic liver disease were also related to one another because they were contained within a single health care system (p. 347).

In the anecdote of Adam, the two different versions of the smartphone existed in the same location: at the library. We did not have to physically move, as Law and Singleton did, in order to see two different versions of the smartphone. In addition, the smartphone versions were unrelated (searching for library books has nothing to do with acting as a gatekeeper and a doorbell to an apartment). The concepts of time and place have different meanings in protean objects and fire objects. Time moves faster for protean objects and virtual and actual places can momentarily fuse together. Unlike alcoholic liver disease, protean objects can present different versions of themselves at the same moment, within the same assemblage.

The next anecdote, from an interview with a student, illustrates this collapsed sense of time and place.

Second Anecdote: Morning Commute.

It's 9:30 am on Wednesday and Karen is travelling to school on the train. She takes out her phone, checks her calendar, launches a database application and begins searching for articles for a paper that's due on Friday. As she waits for the search results, her phone vibrates twice. She knows there are new email and text messages. There are three new text messages: her mom asks for the name of a hotel in Vancouver, a classmate wants to know whether they can meet at 11:30 am to discuss an upcoming group project, and a good friend, who knows her exact location thanks to a surveillance application they both use, asks to borrow her chemistry textbook. Karen checks her email messages next. One is from the library about a book on hold, one is from a clothing company advertising this week's sales, and the last one is from her English instructor reminding her that today's class has been moved to a different room. She responds to the important messages and then switches back to the database application and skims through the seven pages of results. She flags the articles that look most promising for review later. Next, she logs on to the university's learning management system to see the feedback on an assignment from her chemistry professor. Suddenly, her phone vibrates; it's a reminder that her first class begins in ten minutes. Karen slips her phone back into her knapsack and prepares to get off at the next stop.

Shape Shifting

All the events of this anecdote occurred within ten minutes. During that time, Karen searched for learning resources, communicated with others, and received feedback from an instructor. Besides noticing these learning practices, there were also many interesting examples of shape shifting occurring. Some of them, like shifting from a calendar to a database-searching device, went smoothly while others, such as being interrupted by new text messages and reminder alarms, happened unexpectedly. Establishing Karen's sense of actual place in this anecdote is difficult, since she was travelling between locations and in perpetual motion. It is easier to identify the virtual places that she temporarily occupied. At a minimum, she was in the virtual places of the university's learning management system and the database. When she read the text message from her English instructor, she may also have briefly recalled the place of classroom where their meetings are normally held. In order to see these many different versions of the smartphone, it was not necessary to physically move between actual locations; the phone showed us these versions all within condensed time and space dimensions.

Relevance for Education

Another interesting aspect of this anecdote is the way that the student's personal and professional lives intermingle and overlap. There is no clear distinction or separation between school and personal life assemblages on Karen's phone. There has been a gradual, barely noticeable and ongoing translation of object here: from personal device to education tool, then back to personal device. In ANT, the term translation has been interpreted in many different ways (Callon 1986; Clark, 2002; Singleton, 2005). In this instance, the translation of the smartphone is closest to Singleton's interpretation, for there was a gradual transformation that occurred, from personal device to education tool and back to personal device. One of the interesting educational dimensions in this anecdote is the challenge that it poses for educators and administrators. If universities do not own smartphones, then they have less influence and control about how they will be used in education. Among the students who took part in this study, all had control over

what tasks they would complete; they did not receive official support or endorsement from their university to use their phones. The Bring Your Own Device (BYOD) practice that is occurring in many workplaces is also now a part of education and a common occurrence among students (Alberta Education, 2012; Rockel, 2012).

Another interesting educational issue that was exposed in this study is how a seemingly simple practice, such as reading, is actually more complex that it first appears. Law (1999) notes that ANT can be a way to think about and appreciate complexity, especially as it relates to objects and this observation is particularly relevant to the practice of reading on smartphones.

Third Anecdote: Losing the Word

> *Donna is reading an article for school on her phone. There are many unfamiliar words so she has trouble understanding what the author is saying. She switches out of the reading program, launches the dictionary application and begins typing one of the unfamiliar words. She can't remember how the word is spelled, so she goes back to the reading program, but the screen on the phone is small and she can't find the word. She shifts the phone from vertical to horizontal position, hoping this will make the screen appear larger. The image on the phone freezes — it is momentarily caught between the vertical and horizontal alignment. In frustration, she pulls out her tablet computer, opens up another reading program that has built-in links to an online dictionary, as well as for Google and Wikipedia. Now she can read and look up words simultaneously. Of course, now she has to figure out how to get the article from her phone onto her tablet computer.*

Besides the challenge of focusing on one task (will it be reading the article or looking up unfamiliar words in the dictionary?), this anecdote also shows us how complicated reading can be. Students with smartphones and tablet computers do not just simply read content but, they also look up the meaning of words and phrases. But what does this tell us about reading? Perhaps we might say that the practice of reading is becoming *fragmented* because students are less likely to extrapolate what a word means from the context and more apt to seek out a definition from the dictionary. The anecdote also reminds us that while students have more options in terms of how they will read (will it be from a printed copy, on a smartphone, an e-reader, or from a tablet computer?), there is more complexity in the human-technology assemblages. When there are accidents or breakdowns in the network, such as when the screen display is caught between vertical and horizontal alignments or the student cannot find an unfamiliar word, he or she may abandon one human-computer assemblage for another. There is no guarantee that the next student-tablet computer assemblage will work any more smoothly because there are still problems in this network, such as how to transfer an article from phone to tablet.

Some parts of the learning networks that assemble together are hidden and they only become noticeable when there are accidents or breakdowns in the network. The next anecdote makes one commonly concealed actor briefly visible, which allows us to examine it more closely.

Fourth Anecdote: Studying in the Cloud

> *Three graduate students are working on a group project; two of them have full-time jobs and rarely have time to come to campus. They meet once a week at night class but the rest of the week, they communicate through text messaging and email. Near the end of the*

semester, they begin writing a document together and they all share access to it through a free, online document-sharing service. One day, one of them notices that the other person is making edits to the document that he does not agree with. He logs in and begins correcting the other person's work. Then the first student sends him text messages asking: "what's going on?" Eventually, after sending many text messages back and forth, they agree on how they will format this group project.

The hidden part of this learning assemblage is the online document-sharing service that they are using. No one has ever actually seen this part of the learning network. Of course, they see their document on the screen, but they are not aware of the many other actors-networks that are connected to it. And yet, all parts of the networks are critical to the operation and success of their work. If these parts work cooperatively, the network functions smoothly and does not experience any accidents or breakdowns. But if there are problems, the network may momentarily fail or permanently break down. There are many other hidden actors in the learning assemblages that these students encounter including: search engines, learning management systems, virtual learning communities and wireless Internet connections.

Conclusion

By considering one object, the smartphone, and the ways that it is assembled together with other human and non-human actors in post-secondary, it is possible to learn more about how the socio-material is influencing educational practices. Studying smartphones' use shows us that there is no clear separation between students' personal and school lives and that the threads or actor-networks in these assemblages overlap, intersect and entangle with one another. It is also possible to observe the ways that smartphones are influencing and changing learning practices. We can learn about how accessing and gathering information, receiving feedback from instructors and collaborating with other students changes when students use smartphones and we momentarily notice some of the concealed actors that assemble together in the networks. We can also reflect on the ways that smartphones act as a fluid and fire objects and consider how they can be described as protean objects. Using this new terminology calls attention to how smartphones are continually going through a process of shape shifting and how time seems to speed up and the ways that virtual and physical spaces can be briefly be fused together. These understandings raise important questions for educators and administrators that need to be further explored and reflected on, as smartphones and tablet computers are integrated into all levels of education.

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