

Association for Information Systems AIS Electronic Library (AISeL)

ECIS 2015 Completed Research Papers

ECIS 2015 Proceedings

Spring 5-29-2015

The Question of Materiality: Mattering in the Network Society

Ella Hafermalz

University of Sydney, ella.hafermalz@sydney.edu.au

Kai Riemer

University of Sydney, kai.riemer@sydney.edu.au

Follow this and additional works at: http://aisel.aisnet.org/ecis2015_cr

Recommended Citation

Hafermalz, Ella and Riemer, Kai, "The Question of Materiality: Mattering in the Network Society" (2015). *ECIS 2015 Completed Research Papers*. Paper 66.

ISBN 978-3-00-050284-2

http://aisel.aisnet.org/ecis2015_cr/66

This material is brought to you by the ECIS 2015 Proceedings at AIS Electronic Library (AISeL). It has been accepted for inclusion in ECIS 2015 Completed Research Papers by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

THE QUESTION OF MATERIALITY: MATTERING IN THE NETWORK SOCIETY

Complete Research

Hafermalz, Ella, The University of Sydney, Sydney, Australia, ella.hafermalz@sydney.edu.au

Riemer, Kai, The University of Sydney, Sydney, Australia, kai.riemer@sydney.edu.au

Abstract

While materiality is an important concept in IS research, there is little consensus as to how "materiality" ought to be understood. We find that the term is typically used, often implicitly, to mean "physicality" or the corporeal existence of objects. Grounded in a widely held "folk ontology" characteristic of modern Western thinking this view makes intuitive sense to us. It breaks down however when we consider typical entities of concern to IS researchers, such as software or information, or emerging phenomena in the network society, such as online social networks or virtual work. In response to unhelpful distinctions emerging from this view, such as between the "virtual" and "real" world, we put forward a relational view grounded in the emerging sociomateriality research orientation. This alternative position sees materiality not as a pre-given quality of entities but rather as an ongoing achievement of "mattering" situated in practice. We demonstrate with examples how this view enables IS researchers to grasp in more productive ways how materiality is achieved in an increasingly networked society.

Keywords: Materiality, Sociomateriality, Relational Ontology, Network Society, Practice, Mattering.

1 Introduction

Materiality is the topic of much discussion in the IS community and is undergoing a renaissance across the social sciences (Pinch and Swedberg, 2008, Hodder, 2012, Leonardi et al., 2012, Carlile et al., 2013a). Calls to renew the discipline's interest in materiality come as a reaction to the recent history of organisation studies, which are said to have 'traditionally overlooked the ways in which organizing is bound up with the material forms and spaces through which humans act and interact' (Orlikowski, 2007). Such an approach has been associated with extreme social constructivism, which Kallinikos et al. (2012) criticise for placing too much emphasis on human agency thus neglecting the consistencies of materiality across organisational contexts. This research essay contributes to this debate by considering how materiality is most usefully conceptualised.

In a recent book, Leonardi et al. (2012) brought together IS and Organisation Studies scholars to discuss their views on this topic. Leonardi (2012) explains that there has been insufficient agreement on a definition for *materiality* and related terms, and that 'without some definitional clarity, the terms remain jargon...instead of serving as useful tools for understanding and explaining the symbiotic processes of technological and organizational change.' We agree and argue that to gain clarity we must ensure that we bring to the fore existing ontological assumptions that inform the current use of *materiality* and related terms.

We live in a networked world infused with technology. Workplaces change as people work remotely with others, electronic forms of media have emerged as replacements for face-to-face communication, electronic files replace paper documents and software tools automate formerly manual tasks (Zuboff,

1988). Against this backdrop, the notion of materiality becomes an important device for studying the emerging networked (re)configurations of the entities making up these new organisational realities.

Yet, we argue that the dominant understanding of materiality widely held in the field is unhelpful in grasping fully the nature and implications of these changes. We aim to demonstrate that the current, common-sense notion of materiality breaks down when aiming to make sense of everyday IS phenomena, and that it creates unhelpful distinctions that act as distractions which cover up more than they reveal. The question at the heart of our enquiry is: Does an entity “have” materiality, or is materiality an accomplishment? And by extension, how do these two distinct ways of thinking about materiality limit or further IS research relevant to the network society?

A common-sense response to the first question is that an entity (object, person, tool) “has” material properties that are intrinsic to it. This response represents a substantialist ontology, which holds that “matter” refers to the physical “stuff” that the object is made of. In other words, materiality is that which persists over time and doesn’t ‘go away’ ‘when everyone packs up their bags and goes home at the end of the day’ (Leonardi, 2012). Hence, materiality is equated with *physicality*. The entity “has matter”, it exists because it “is there”, can be seen, touched, interacted with “in real life”. In other words, if an entity has corporeal presence, it is material, if it doesn’t, then it is not. This view makes intuitive sense, because it is grounded in a deeply held rational scientific worldview that permeates modern Western thinking (Spinosa et al., 1997). Yet, in IS this notion of materiality is problematic.

Take as an example the calculator application on your smartphone. Would the app qualify as material under the above substantialist definition? Its buttons are made of light and are called into being only by pressing on glass. It just as quickly disappears from view. Does it still “exist” when it lies dormant? The calculator app certainly depends on physical phenomena (such as light and electricity), but does it have the same materiality as a “real calculator”, or as pen and paper or an old-fashioned wooden counting device? Intuitively we would say that they differ – that software is somehow different from “real” entities. But is software therefore *less* real? Are the virtual worlds created on the Internet *less real* than the “real world”? And as IS scholars wouldn’t we also equally intuitively qualify the calculator app, the Internet and virtual worlds as material, despite their ambiguous relationship to physicality?

In the following we explore the common-sense substantialist position on materiality and consider the consequences of this view for IS research. We then introduce a contrasting view grounded in a different, relational ontology, which sees materiality as co-constitutively entangled with the social aspects of practice. In doing so, we locate this alternative view in the recently emerging sociomateriality research orientation, and in particular in Butler’s (1999) seminal discussion of *Bodies that Matter*, in which she defines matter as: ‘that which matters about an object’. We adapt Butler’s words in proposing that IS research can better grasp the phenomena of the network society by adopting a view which holds that *that which matters about an entity is its materiality*.

This relational view sees materiality as an ongoing accomplishment situated within *practice* (Nicolini, 2012). This view allows us to effectively divorce the notion of materiality from physicality. We then demonstrate how this cleavage opens up a productive space for IS research by emphasising that there is indeed a relationship between materiality and physicality, and that this relationship is complex, relevant and interesting, but can only be investigated when materiality and physicality are not conflated. We begin by motivating the important role of materiality in understanding networked phenomena. We then engage with the etymology of materiality and contrast the substantialist with a relational, socio-material understanding, before we draw on four example vignettes to illustrate how the two different views illuminate IS phenomena in different ways. This will lead us to argue that a relational view is more appropriate for grasping the emerging IS phenomena characterising the network society.

2 Rethinking IS concepts in the Network Society

According to Manuel Castells (2007b), in the ‘digital age’ networks extend across ‘all domains of social life’. ‘The network society’ (Castells, 2011) is the result of two related phenomena: communica-

tion technologies and communication itself. Communication technologies such as mobile phones facilitate communication between people who are brought together through this communication in complex networks. Castells (2007a) captures some of the contradictions inherent in these pervasive communication networks, which are ‘at the same time global and local, generic and customized in an ever-changing pattern’. Such contradictions are very familiar to us in everyday practice, for example we can attend a local conference while we simultaneously interact via Twitter with an ever-changing global community. In this example the communication network is simultaneously global and local, generic (the conference format) and customised (in our use of Twitter).

While being technologically connected is commonplace in the network society, it is nevertheless difficult to describe and theorise such global/local practices in IS research. From a theoretical perspective the network society is marked by complexities that conventional analytical categories have difficulty grasping. Our connectedness requires us to rethink concepts in IS research that have traditionally been thought of as oppositional, in particular the categories of near and far, present and absent, or real and virtual. Much IS research and practice is concerned with these traditional dichotomies.

But what relevance do they hold today? And how do our traditional understandings of these categories help or hinder us in conducting relevant, interesting and useful IS research? In the network society, pedestrians distracted by far away friends risk road collisions; advertisers struggle to reach viewers who engage with multiple screens at once; University campuses fight for relevance as students browse digital readings and access lectures online; and wars are waged using devices such as drones and computer worms that can be controlled or let loose at a distance yet enact devastating local effects. We argue that before the discipline is able to assess the outcomes of the network society as dystopic or utopic, our first task will require a sharpening of our analytical tools so that we can better grasp, describe, and understand the phenomena relevant to IS in this new era.

Against this backdrop, we argue that materiality emerges as a crucial concept in helping us to understand and overcome distinctions that reveal themselves to be incongruous to the network society. For example what is far and near in a globally connected world? I can be physically crammed in a train carriage full of people but feel closer to a friend in another country whose Facebook message I am reading on my smartphone. What counts as virtual and what is real in a society where experience and relationships are heavily mediated by technology? What does it mean to be present or absent in remote working environments? We enlist a relational understanding of the concept of materiality to enable us to come to terms with these tensions. We aim to demonstrate how the term materiality has come to be implicitly, and sometimes explicitly, associated with corporeal presence, that is with *physicality*. This association in turn is tied to a belief that things that are physical and that are close enough to touch are in some ways more “real”. A contribution of the paper is therefore to show that how we conceptualise materiality has implications for how we conceive of distance, virtuality, and presence, concepts central to our understanding of networked phenomena.

3 What is materiality?

In this section we first locate our argument in the recently renewed debate about the importance of *materiality* for IS research. In order to then shape our understanding of materiality, in the second subsection we will unearth the etymology of the term before we contrast the dominant, everyday notion, termed the substantialist view, with an alternative relational view, which we formulate on the background of the emerging research orientation of *sociomateriality*. We note that this second view is ‘alternative’ only in that it is less prominent. Both views have long histories, as we will show.

3.1 Renewed interest in materiality in IS research

Leonardi et al.’s 2012 book allows us to canvas IS scholars’ responses to the question: *What is materiality?* These responses illustrate the difficulty of delineating materiality from physicality. Leonardi (2012) for example draws on the work of Faulkner and Runde (2011) and others in proposing that ma-

teriality is ‘the arrangement of an artefact’s physical and/or digital materials into particular forms that endure across differences in place and time and are important to users.’ This catchall definition invites further questioning – what, for example, is the “material” alluded to here, and what is the difference between physical and digital material? And why does it have to be important to the user?

Similarly, Faulkner and Runde (2012) argue for ‘the word “material” to refer to the physicality of entities’. This subsequently requires an explanation of ‘non-material technological objects’, which they define as ‘those that do not have a physical mode of being such as computer programs, search algorithms, technical standards and protocols, and so on (Faulkner and Runde, 2011)’. Under this definition typical IT artefacts such as software do not have physical existence and therefore are not material. Accordingly, Yoo (2012) argues that ‘digital technology is immaterial’ because, as a string of bits, they do not ‘have tactile existence on their own’.

The problematic consequences of this view are acknowledged by Pentland and Singh (2012), who point out that ‘nonmaterial artifacts have had enormous practical consequences, but there is *no-thing* there...these examples [therefore] challenge our intuition about ideas such as materiality and artifact’. In search of a resolution to this challenge, Pentland and Singh (2012) are inspired by pragmatist philosophy to look at how financial auditors make sense of materiality in practice. They discover that for the auditors, how *material* something is depends on how much it *matters* to the situation and action at hand. Pentland and Singh (2012) surmise that ‘materiality is not about artifacts, people, ideas, or any *thing*...it is about all of them, but they only become *material* when they influence a particular course of actions or events that we value. Materiality is all about actions, values, and consequences in context’ (Pentland and Singh, 2012).

In just this one book the diversity of definitions and attitudes towards materiality are on display. It becomes obvious that some of these views are incommensurable, and yet the words materiality, material and matter are often used without qualification in IS research. When a definition is provided, it is not always clear. Take for example the following, from Leonardi (2012):

To be clear, “materiality” does not refer solely to the materials out of which a technology is created and it is not a synonym with “physicality.” Instead, when we say that we are focusing on a technology’s materiality, we are referring to the ways that its physical and/or digital materials are arranged into particular forms that endure across differences in place and time. Such a definition suggests that the usefulness of the term “materiality” is that it identifies those constituent features of a technology that are (in theory) available to all users in the same way.

According to this definition there are two aspects to materiality. Firstly, technology (as an example) *has* materiality. Secondly, materiality is a rhetorical device that allows us to talk about a technology’s physical or digital “materials” which do not change over time or in different contexts. The caveat ‘in theory’ is important because it separates the definition of materiality from action, from *practice*. The inference in this definition is that what is material stays the same, during or in spite of changes in the social aspects of context. Materiality in this definition is therefore largely separate from individual or social contingencies and is grounded instead in endurance of physicality and form, despite the early disclaimer.

The question now is: does this lack of clarity or consensus on the definition of materiality *matter*? It is not our concern here to present one view as more “correct” than the other, however we borrow from Pentland and Singh (2012) in taking a pragmatic approach. We spell out firstly what grounds these views and secondly ascertain how each affords us a different view of IS phenomena, with particular emphasis on how these distinctions are relevant to researching the network society. To this end we now offer an overview of the etymological legacy of *materiality* and *matter* as its associated concept.

3.2 Materiality: an etymology

The term *materiality* and its root *matter* have long and varied histories. These histories are introduced here in order to shed light on how two different perspectives on materiality have emerged over time. The first perspective is based on *substantialist* ontology and associates materiality with physicality and

corporeality, in that materiality is a physical property of an entity that is durable over time. The second perspective is based on a *relational* ontology and views materiality as an active accomplishment that emerges in practice. We first introduce the etymological origins of these two views before briefly showing that the relational view, while in many respects the elder of the two, emerges only more recently in a range of contemporary academic literature.

The word *matter* derives from the Anglo-French *matere* which comes from the Latin *materia* meaning ‘substance from which something is made’ (Gentile, 2014). Other links include the Latin word *mater* which means ‘origin, source, mother’, and a reference grounded in the Greek word *hyle* meaning the ‘hard inner wood of a tree’ from which other entities are made (Butler, 1999, Gentile, 2014). Butler (1999) notes that these original meanings imply temporalisation – for Aristotle, for example, matter is equated with ‘potentiality’, [dynamis]; similarly *hyle* refers to wood that has been cut from trees but is ‘on the way to being put to use’ and *materia* is defined by having the potential to be made into something. Implicit in these early usages is a sense of teleology, of emergence and transformation. We note that matter was originally associated strongly with change, not persistence.

It was in the mid-14th century (a period marked in Europe by the Hundred Years War and the Black Death) that *matter* came to be associated with the ‘substance of which physical objects are made’ (Gentile, 2014). At around the same time, the meaning of the word shifted to include ‘grounds, reason, or cause for something’ (Gentile, 2014), as in the phrase ‘a matter for serious thought’. In the mid-15th Century another level of abstraction was introduced and the phrase ‘what is the matter?’ was first recorded, followed by the verb usage ‘to matter’, which is still used today to mean ‘to be of importance or consequence’ (Gentile, 2014).

Implicit in these varied etymological roots and associated meanings are two distinct ontological positions. The first is the substantialist view, which defines matter as the ‘substance of which physical objects are made’ (Gentile, 2014). In this view, an object *has materiality*, and its materiality can be understood through physical examination. The second is the relational view, which acknowledges the networked relationship between entities implied in some sense in the early definition of *materia* as ‘substance from which something is made’ and furthered by the verb form, meaning ‘to be of importance of consequence’. The difference between ‘of which’ and ‘from which’ here is important. The latter definition requires that matter and by association materiality is always understood in relation to other entities in practice. The wood or *hyle* that has been cut from trees *matters* because it is on its way to being made into a house or a ship, it *matters* precisely because it holds a networked relationship in a particular practice.

From this brief etymology we can see that over time two ontological positions have emerged that underpin the notion of matter and that both derive from a rich historical tradition. The implications of both positions for IS scholarship and practice are now explored.

3.3 The Substantialist View of Materiality

In a substantialist ontology, materiality is viewed as ‘intrinsic’ to a technology (Leonardi, 2012). In this commonly held view, materiality is often associated with “the real, material, world” (see for example the usage of the term in Howard-Grenville and Carlile, 2006). We suggest that this substantialist view of materiality links strongly with the notion of “physical objects”, and that therefore in this view, materiality is attributed to those aspects of an entity that can be observed, measured, and often, touched. We find two problems with this view for IS research. Firstly, this view suggests that materiality is fixed, unchanging, and separate from human activity. Secondly, it preferences the physical at the expense of considering the ways in which entities without corporeal presence play a very real and consequential part in IS and organisational phenomena.

The substantialist understanding of materiality is deeply engrained in contemporary Western thinking and stems from a worldview that forms the basis of the rational scientific attitude that has dominated Western thought since the enlightenment (Spinoza et al., 1997). It has its early roots in Greek

philosophy. Under this view, what it means *to be* is a matter of physical existence, or as King (2001) puts it, ‘when Greek-Western philosophy speaks of *to be*, it thinks of the *is* of a thing’ (emphasis added). Today this view constitutes a powerful folk ontology. Because we grow up immersed in this understanding, it appears self-evident. At the same time however, this view has largely crowded out any other way of understanding the world. Due to its ubiquity, this substantialist ontology tends to be largely invisible and thus difficult to challenge (Spinosa et al., 1997).

3.4 A relational view of materiality and “mattering”

The relational perspective that we bring to the fore in this paper conceives of materiality as an active accomplishment, in that materialisation is a *becoming* that is achieved in a context of intelligibility. This means that under this view materiality is a) not a given, but b) is relational, in that *mattering* depends on relationships between entities in the context of practice. It posits that the very notion of “an entity” requires that there is already some socially agreed distinction being made in practice, for example: a hammer might be made from wood and steel in a certain way to afford pounding, but it is its relationship with nails, the activity of hammering and carpentry practice more generally that renders it a hammer in the first place (Heidegger, 1962).

The relational ontology has a long lineage, more recently informed by how the notion of *mattering* is interpreted by feminist and post-humanist theorists, such as Butler, Harraway, and Barad, and by scholars in disciplines such as sociology, psychoanalysis, and psychology. Feminist theorists have held a particular interest in working through and beyond the notion that *mattering* is intrinsic to or determined by physical form. It is important in their theorisation that the capacity to be consequential is not dependent on the physical biology of the human body, nor are the ways in which things matter self-evident extrapolations of their physical existence. This is summarised by Butler (1999) when she explains the thinking behind her book’s title *Bodies that Matter*:

To speak within these classical contexts of bodies that matter is not an idle pun, for to be material means to materialize, where the principle of that materialization is precisely what “matters” about that body, its very intelligibility. In this sense, to know the significance of something is to know how and why it matters, where “to matter” means at once “to materialize” and “to mean”.

Butler (1999) here builds on ancient Greek notions of materiality and signification to coin the phrase ‘that which matters about an object is its matter’, which we adapt to *that which matters about an entity is its materiality*.

We embrace the word *entity* here, in line with the work of Latour (2005) and the influential *A Cyborg Manifesto*, in which Harraway (1991) proposed the notion of the cyborg as an emancipatory figure that is not defined by being man or woman, human or non-human, but rather is defined as an entity in practice, through action. Similarly, Barad (2003) explains that this ‘move toward performative alternatives to representationalism’ is not about tying materiality to language and other systems of representation; rather, a relational, performative approach is beneficial because it ‘shifts the focus from questions of correspondence between descriptions and reality (e.g., do they mirror nature or culture?) to matters of practices/doings/actions.’ We take care to point out that this view of materiality is not to be conflated with the endless “relativity” associated with postmodern views of subjectivity. Rather, we emphasise the way in which social agreement in the form of practice solidifies certain boundaries over time, in a process of materialisation.

Sociologists and psychologists have drawn on this relational view in work on social inclusion. Rosenberg and McCullough (1981) theorised that ‘mattering refers to the individual’s feeling that he or she counts, makes a difference’, which always stands in relation to some activity or context. They explain the importance of this concept in understanding transition periods in life such as retirement, where it is common to feel that ‘one no longer matters; others no longer depend on us’ (Rosenberg and McCullough, 1981). The importance of mattering during transitional periods was developed by Schlossberg (1989) who studied college students’ experience in terms of ‘mattering’ and ‘marginality’. She theorised that ‘mattering is the experience of others depending on us, being interested in us,

and being concerned with our fate; while the experience of marginality results in opposite feelings—the feeling of not fitting in and not being needed or accepted’ (Schlossberg, 1989, Rayle and Chung, 2007).

In IS and Organisation Studies Orlikowski (2007, 2009) and Orlikowski and Scott (2008) have more recently introduced the perspective of sociomateriality. In reaction to both technological determinist and human-focused approaches, Orlikowski (2010) calls for our rethinking of ‘the capability to posit and theorise the material effects of technological artifacts’. In response, sociomateriality, ‘focuses on how meanings and materialities are enacted together in everyday practices’ (Orlikowski, 2010). Sociomateriality is underpinned by a relational ontology in which ‘entities, human beings, and things exist only in relations: they are performed and continuously brought into being through relations (Latour, 2005, Orlikowski, 2010)’ (Cecez-Kecmanovic et al., 2014). The view of materiality that we put forward in this paper is in line with this perspective. We additionally note that our analysis of a relational view of materiality should not be taken as breaking with the ontological inseparability postulated by sociomateriality, as this position does not mean that one cannot analyse specific parts of sociomaterial practices (such as their materiality), but that any parts are co-constituted ontologically through their relation to other parts.

We have provided this inter-disciplinary account of matter, mattering, and materiality to demonstrate that the meanings of these words have a history and must not be taken for granted. We come to understand materiality as an ongoing, active accomplishment against a background of social meaning that is re-enacted over time. At the same time we do not deny the existence of a physical world – quite the opposite. We acknowledge that physicality is important to the materiality of many entities, but advocate to keep the two concepts separate precisely to be able to understand their interplay.

4 Two views of materiality: illuminating IS phenomena

In this section we illustrate with four case vignettes how the two ontological positions of materiality differ. The phenomena captured in these vignettes were chosen for their capacity to highlight key differences and have been taken from everyday experiences and recent research. The vignettes are necessarily stylised and the analyses brief so as to illustrate a typical response in each case.

4.1 The many faces of a calculator

On a Chinese flea market a Western tourist is interested in buying a hat. The tourist points to the hat and asks for a price. The trader pulls out a plastic calculator and types in her price, displaying it to the tourist. The tourist, knowing the exchange rate but too tired to do the sum, unlocks his smartphone and taps to bring the phone’s calculator app into view. He puts the trader’s price into the app, but the result is more than he wants to pay. The tourist enters a lower number and presents the smartphone screen to the trader, who shakes her head and returns to her calculator. After several turns of this they agree on a price and the sale takes place.

There are two kinds of calculator involved in this vignette. One is made of plastic and is limited in what it is able to do. The other is an app that has the same functionality, but disappears easily in order to make room for other applications such as a camera or music player. We intuitively recognise the plastic calculator as having corporeal existence, but the smartphone calculator app is fluid and can take several forms. The plastic calculator we can readily point to as physical, but the calculator app’s physicality is much harder to pin down. The calculator app does not change often in appearance, but like all software it undergoes periodic transformations, mostly invisible, when the phone’s operating system updates.

If we approach the scenario from the substantialist view that thinks of materiality as ‘that which stays the same over time’ (Leonardi, 2012) and presents itself uniformly in different contexts, the plastic calculator in our vignette would be deemed material, while the calculator app’s materiality is ambiguous. Yet in our scenario the trader does not even use her calculator to calculate, she uses it to com-

municate her price and to cross a language barrier. The smartphone too has a certain physical existence as an object; it is made from metal, glass and plastic - when it runs out of battery or if the software is fatally corrupted, it could be called a 'brick'. And yet in our vignette, the smartphone is a calculator, enlisted in practice as a calculation and communication and translation device. Where do we situate the smartphone calculator app's materiality then? From the substantialist view we may associate the app's materiality with the shape and size of the smartphone, or conclude that the app is digital, and therefore "immaterial", or "non-physical", even though it *matters* very much in this practice of trade.

Rather than trying to pin down and categorise each device according to its unchanging intrinsic properties (Weber, 2012), we argue it is more useful to IS research to consider the materiality of these devices as an active accomplishment. The vignette highlights how, from a relational view, physical and digital entities both are able to accomplish materiality in practice.

Although in the above scenario the plastic calculator and the smartphone calculator app are materially similar (they matter in much the same way) this is not always the case. For example, the practice of sitting a maths exam would treat the two devices very differently. The plastic calculator harmonises with the convention of sitting a maths exam and the good student can confidently place their plastic calculator on their desk. The smartphone, however, with its capacity to photograph, research and communicate, is immediately removed from the students' desk for being transgressive to exam practice. Similarly, in our vignette the plastic calculator may be preferable in the trader's practice precisely because it is not a phone, because the plastic calculator's materiality as a translation and negotiation tool is not threatened by other materialisations such as interruptions from a phone call or personal text message.

4.2 Demetrifying the Facebook 'Like' Button

The social networking platform Facebook includes a number of features that collect and display metrics. The "Like" button is the most well-known of these. It is a "thumbs up" icon that is clicked on by users, most often to show approval or just that the post has been seen. A metric next to the "Like" button displays the collective number of likes that the post has received. In 2012, as a protest against such quantification in a social arena, the artist Benjamin Grosser created a web browser extension called "Facebook Demetricator". In the artist's words: 'Facebook Demetricator is a free and open source web browser extension that removes all metrics from the Facebook interface. Friend counts disappear. "Like" quantifications vanish. Shares are no longer enumerated' (Grosser, 2014). Since 2012 Demetricator has been used and discussed by thousands of users internationally (Dewey, 2014).

What is the materiality of the "Like" button on Facebook, and how should it be studied by IS researchers? The substantialist view would consider it to be a "feature" of Facebook. The implication is that this feature offers users functionality – a user has the option of clicking or not clicking on the Like button. It is generally assumed that the purpose of the Like button is to show approval, agreement, or recognition towards the attached post. Studies grounded in the substantialist view might investigate how often and in which circumstances this button is clicked. Introducing the Facebook Demetricator however raises an interesting problem. The little counter next to the feature is taken away, but the feature remains the same, it can still be clicked or not clicked – its neighbouring metric function has been erased, but the same options are essentially still available to the user. How does this change the materiality of Facebook and of the Like button itself? Is it simply that a feature is deactivated?

This take would not explain Grosser's project, or rather what the artist reacted against. The artist's ambition to 'demetrify' Facebook was about more than reducing its functionality. He targeted Facebook as a *practice*, which he argues revolves too much around competitive quantification of approval. By taking away all metrics, and most notably those associated with the Like button, from the Facebook experience, he found that people were not only using the platform quite differently, the entire experience changed. A Washington Post journalist described their experience of this change as fol-

lows: ‘I was immune to viral posts, to Facebook peer-pressure, to acutely targeted ads. Only I determined what I clicked, and oddly, in that vacuum, I clicked almost nothing’ (Dewey, 2014).

When the numbers associated with the Like button are erased, the *practice* of ‘Facebooking’ changes; using Facebook feels different, the tone and mood of communication changes. Our point here is that what might be interpreted under the substantialist view as a material change to Facebook regarding the displaying of metric information, the demetrification actually brings to the fore the materiality of the Like button as we experience it conventionally. The materiality of the Like button is holistic/systemic, it is implicated in the entire practice, activities and behaviours of Facebook users. When the numerical result generated by the button is taken away, the materiality of Facebook as a whole is changed. The relational view highlights how practices shift after demetrification, and how the Like button itself will subsequently be materially different – because it matters in different ways within the practice.

4.3 Stuxnet: ‘The world’s first digital weapon’

Stuxnet is a sophisticated computer worm that emerged in 2010 specifically targeting a uranium enrichment facility in Natanz, Iran, with the apparent goal of disrupting the Iranian nuclear program. A computer worm is different from a computer virus: ‘while a computer virus relies on an unwitting victim to install it, a worm spreads on its own, often over a computer network’ (Kushner, 2013). Stuxnet was heralded as the ‘world’s first digital weapon’ because it was used ‘to physically destroy a military target – not just metaphorically, but literally’ (Langner, 2011). Stuxnet was not aimed at ‘the confidentiality, integrity, and availability of information’ as such programs usually are, rather it was aimed at manipulating controllers involved in a ‘physical production process’ (Langner, 2011). Specifically, Stuxnet was designed to target controllers only from the manufacturer Siemens. The virus successfully found a target in Iran’s Natanz uranium enrichment plant. Its ‘dropper loaded rogue code to the controller’ - and stayed quiet while the ‘legitimate code...continued to be executed’ (Langner, 2011).

Kushner (2013) describes the worm’s attack as follows: ‘This worm was an unprecedentedly masterful and malicious piece of code that attacked in three phases. First, it targeted Microsoft Windows machines and networks, repeatedly replicating itself. Then it sought out Siemens Step7 software, which is also Windows-based and used to program industrial control systems that operate equipment, such as centrifuges. Finally, it compromised the programmable logic controllers. The worm’s authors could thus spy on the industrial systems and even cause the fast-spinning centrifuges to tear themselves apart, unbeknownst to the human operators at the plant. (Iran has not confirmed reports that Stuxnet destroyed some of its centrifuges.)’ (Kushner, 2013).

One of the reasons that ‘the world’s first digital weapon’ (Zetter, 2014b) so astounded people was because it produced *physical* consequences. In Langer’s initial description above he emphasises that the effects of Stuxnet were not just ‘metaphorical’, occurring in the realm of ‘information’, but “literal” in that it impacted machinery physically. This sentiment is asserted even more strongly by Kim Zetter, the author of a book on Stuxnet (2014a), who explains the worm’s novelty as follows: ‘rather than simply hijacking targeted computers or stealing information from them, it escaped the digital realm to wreak physical destruction on equipment the computers controlled’ (Zetter, 2014b).

What does all of this tell us about the materiality of Stuxnet? Stuxnet has *no corporeal presence*, yet it escaped the ‘digital realm’ to destroy mechanical entities that *do*. Stuxnet therefore poses a problem for conventional ways of thinking because despite its lack of corporeality it has transgressed a boundary carefully erected and maintained in theory and practice between the virtual/digital and the physical/real. The above vignette thus brings to the fore how a separation between the ephemeral and the physical realm has a strong tradition in Western thought, harking back to the Kantian supposition that the mind and body are fundamentally different. This substantialist view draws from a tradition where an entity is either corporeal or spiritual, and is supposed not to be able to travel between the two realms or have the capacity to directly impact the realm it does not belong to.

Stuxnet was and is a perplexing and complex phenomenon. Yet, because of its transgressive ways, it presents a particular challenge to IS research grounded in a substantialist view. An autonomous digital entity having an effect on the physical world is problematic under the definition of materiality as “having corporeal existence” and being “that which stays the same”. Is Stuxnet, in its digital, sophisticated, elusive, and adaptable configurations, material? The relational view would say, of course. This view would consider Stuxnet’s materiality as an active accomplishment in the context of practice. In the context of Siemens Step7 software and the practice of Uranium production in Iran, Stuxnet has and does matter a great deal. The materiality of Stuxnet is therefore relational to the entities with which it is tied and is achieved over time in action. The problem of whether and how the digital is able to impact the material (or better: physical) recedes when we think of Stuxnet in terms of relational materiality, in how it comes to *matter* in the context of practice. This opens a space to consider in which ways the materiality of Stuxnet is an achievement of the interplay between digital and physical entities.

4.4 Remote Workers: Called back to the office

In 2013 the CEO of Yahoo! Marissa Mayer recalled all her remote-working employees back to the office, explaining to her staff that creativity and collegiality happen through interaction in office corridors and around water coolers. A memo was sent to staff that read ‘We need to be one Yahoo! That starts with physically being together’ (Keller, 2013). The New York Mayor Michael Bloomberg came out in support of Mayer, calling remote work ‘one of the dumber ideas I’ve ever heard’ (Daily Mail Reporter, 2013). Richard Branson had a different perspective, deeming Mayer and Bloomberg’s views a sign of ‘old school thinking’ and predicting that ‘In 30 years’ time, as technology moves forward even further, people are going to look back and wonder why offices ever existed’ (Branson, 2013).

Remote working has been the topic of much debate. The Yahoo! example is often cited as a motivation for the inquiry: does remote working work? In the vignette we see two drastically opposing responses to this question from two successful CEOs. There are of course practical logistical issues to consider when setting up remote working arrangements, however there are also deeper issues at play here. In Mayer’s memo for example, being a cohesive organisation is explicitly equated with being physically co-located. Branson on the other hand can imagine a future in which offices, the stand-in for physical co-location, become unintelligible. This conflict can be understood in the context of the two perspectives on materiality. It is not our intention to take sides in the above debate, but rather to use this scenario to illustrate how the two perspectives allow grasping the remote work phenomenon differently.

Under the substantialist view a remote worker is defined by being corporeally distant (in a Cartesian sense) from the organisation’s central point or hub – the “head office”. This distance cannot be fully overcome by digital means because there is a “material reality” to the distance between the remote worker and their manager at the head office. The remote worker is, due to their *lack* of physical co-location, not “materially present” in the organisation. They can try and overcome this by communicating often and doing their work effectively, but it is always a hurdle that is *best* overcome by bringing the remote worker physically back into the hallways and meeting rooms of the “real” physical office. This view is associated with the problem of “presenteeism”, where employees feel they need to put in “face time” at the office even if they are unwell or unproductive (see Johns, 2010). The assumption that being corporeally present is “better” cuts both ways – remote workers are defined by their absence, while it is (often falsely) assumed that “showing up” is vital to, or even all that is required for an employee to matter in the organisational context.

On the other hand, a relational view allows us to grasp the remote working scenario differently. If the remote worker’s materiality is thought of as how they *matter* in the context of practice vis-à-vis shared social activity, then a remote worker can be very much material in the organisation even while they are corporeally present elsewhere. Provided that the organisation’s work practices are accommodating of the ways in which a remote worker can accomplish materiality. For example, if the organisational norm is to make decisions in the kitchenette over tea and biscuits then the remote worker is unlikely to

accomplish materiality in the context of this decision-making practice (it is difficult to teleconference to a kitchenette). Equally, if the organisation's work practices revolve around the physical arrangement of desks, partitions, board room tables and water coolers, it will be very difficult for the remote worker to matter.

If organisational practices are however changed to accommodate remote workers, communal corporeal presence need no longer be the only way in which organisational members can contribute to the organising process. While there will always be a role for co-located interaction that might not be replaced by technology, managers are starting to reimagine what it means to be material in the organisation. For example, organisations dedicated to the practice of Working Out Loud (Aten et al., 2014), where decisions are continually discussed and recorded on Enterprise Social Networking platforms, allow a remote worker every chance of contributing to the decision making process. If the remote worker is meaningfully involved in the organising practice then they can accomplish materiality – they can materialise – from wherever they happen to be.

5 Discussion: what's the difference, then?

We have outlined the importance of materiality for the study of IS phenomena in the network society and distinguished two views grounded in very different ontologies, one substantialist and one relational, which we illustrated with four case vignettes. In this section we now highlight selected examples of IS writing in order to discuss the implications of these ontological groundings for IS research.

Cecez-Kecmanovic et al. (2014) in line with Carlile et al. (2013b), Emirbayer (1997) and Introna (2013), have argued that the substantialist ontology is the dominant position in IS and management research. We too find evidence for the prevalence of this position. Importantly, those scholars writing from a substantialist ontological viewpoint often do so implicitly, without mention of the possibility of an alternative approach. This is in keeping with a dominant worldview held more widely in society, which renders it unnecessary to articulate or even be aware of that which is already taken-for-granted.

5.1 Illustration of differences with an IS research example

We now want to outline the ways in which the relational notion of materiality comes to make a difference. For illustration purposes, we draw on an IS study by Howard-Grenville and Carlile (2006) 'The incompatibility of knowledge regimes: consequences of the material world for cross-domain work'. In this study the authors conduct a case study of knowledge integration in the context of two groups involved in semiconductor manufacturing. The authors claim that the work practices of the groups under investigation are 'structured by the material world and broader collective conventions' (Howard-Grenville and Carlile, 2006).

The phrase 'material reality' is used in the paper as a proxy for the physical context of semiconductor manufacturing. In trying to separate out the 'material level', the 'work practice level' and the 'industry convention level', the authors quickly come across difficulties because the 'EnviroTech' manufacturing group and the traditional 'Tech' group see the 'material reality' of the environment *differently*. The authors explain this incongruence by pointing out that 'environmental problems are not easily divisible' because 'materials do not simply go away...they get transferred between media – from air, to water, to land, and vice versa – or assume different forms that may have different effects' (Howard-Grenville and Carlile, 2006).

Such a qualification points to the futility of associating materiality with an un-changing, physical 'reality'. Howard-Grenville and Carlile (2006) to an extent acknowledge this when they summarise a section on the 'material level' of semiconductor manufacturing by concluding that 'the material world relevant to the environmental specialists presents constraints, as it does to those within Tech. But the constraints are almost never predictable, and past successes do not scale to enable future ones.' This research shows that the notion of 'material reality' is not easily conflated with that of the 'physical environment' because how the environment matters to each group depends on their practices and their

concerns. A shift in perspective to a relational view would enable the study of materiality as enacted by and relevant to the stakeholders in the case thereby allowing the IS researcher to unearth the role of materiality in the unfolding of the phenomenon under study.

5.2 Overcoming the conflation of physical and material

We argue that to grasp IS phenomena in a network society we need to move away from the notion that physicality is the “gold standard” for materiality. This we believe will open up new areas for meaningful inquiry. A digital algorithm can inform decisions and bring people together. An idea can galvanise. A computer worm can disable millions of dollars’ worth of physical equipment in a faraway location. Who we feel close to is not determined by physical proximity.

We do not claim or attempt to solve how the world “really” is, nor do we argue that the physical existence of entities does not matter. Rather we offer an alternative view against which the equation of physical with material as well as the various unproductive distinctions it creates, such as virtual/real, near/far, can be tackled. In doing so, we follow others who have sought to put entities such as people, objects, and ideas on an equal footing, and we argue that all can come to be material, and to matter, in practice; and that materiality is always a social accomplishment.

At the same time this view does not deny physicality; quite the opposite, it allows us to take physicality seriously. Only if we do not conflate the two are we able to study the role of physicality in the accomplishment of materiality, and vice-versa. This is particularly important for a discipline that studies the material changes brought about by the wide-ranging digitisation of activities, content, communication, etc.; in other words: changes in the role of physicality.

Consequently, a relational view of materiality opens a number of productive research avenues. Firstly, it allows us to study how the replacement of physical entities with digital ones changes materiality in practice. One of the most prominent examples is the change that the music industry has experienced brought about by the replacement of physical music media with digital music consumption. Secondly, it allows grasping how entities that have a physical role in practice lose their materiality over time. For example a Firewire cable no longer matters in computing practice and so the cable and the devices it connects are discarded and decay or are recycled. Thirdly, it allows studying the opposite phenomenon, how entities can change their physical make-up over time, but sustain their materiality. For example, the hammers of today share little of their physical construction with the hammers that our grandparents would have used, but their materiality in hammering practice remains largely unchanged.

6 Conclusion

Materiality is an important concept for IS researchers. Yet we have argued that materiality is commonly understood, explicitly or implicitly, in terms of the corporeal existence of entities, that is their *physicality*. This substantialist view makes intuitive sense to us, as it is grounded in a widely held worldview characteristic of modern Western thinking. At the same time we have argued that this view leads to a number of distinctions and contradictions that are unhelpful for the study of IS phenomena in a society that is increasingly infused with technology.

As an alternative, we have outlined a relational view of materiality and demonstrated with a number of examples that this view is more useful in addressing diverse IS phenomena in the network society. We suggest that operating from a view that *equates* materiality with physicality will lead us down less fruitful paths than if we think of materiality as that which matters about an entity in practice. For example, is an album of MP3s *less* material than a CD? Does an email need to be printed on paper to become material? Is a computer worm such as Stuxnet immaterial? We have shown that these questions arise when we investigate IS phenomena from a substantialist perspective. We argue that it is not productive to define in advance of inquiry what the materiality of any given entity is. Rather, when we study the materiality of a certain phenomenon in IS, it is more useful and interesting to study how

technology, and people through technology, come to matter in practice. This requires us to think of materiality as a relational quality, a practical accomplishment.

A relational view allows us to overcome existing unhelpful distinctions that hinder our understanding of the networked society, such as the one between virtual and real. Under a substantialist view, the notion of virtual suggests that if an entity is not physical - if it does not have corporeal existence - it is not material. At the same time however, the notion of virtual or immaterial suggests that the entity is somehow “nowhere”, as it is present in the virtual but not in the “real” world. Our point is that the conflation of material and physical leads to unhelpful distinctions that in turn lead to these apparent contradictions. We suggest that these contradictions can be overcome productively from a relational view, because this view opens up a space for IS research to investigate the ways in which materiality is accomplished in new ways characteristic of today’s network society.

Viewing materiality as an active accomplishment in the context of practice also creates new distinctions, most importantly by disentangling the notions of materiality and physicality. Our view of materiality does not deny physicality or dismiss the importance of embodied experience. Rather, we layer the (socio)material over this physical dimension, and point to the ways in which the two feed into one another. The way a phone feels in the hand is vitally important to how it is taken up in practice. But without the practice of phone use, which is always changing, the lump of smooth glass and metal becomes meaningless and immaterial *as a phone*. In this way entities are in a constant struggle for relevance. If they do not matter in practice, their physical existence may also be jeopardised. For other entities however, it is this loose relationship with corporeality that makes them so successful, for example cloud computing has a tenuous, fluid relationship to physicality, yet its presence is felt strongly in everyday work practice, to the point where workplaces are being physically re-designed to accommodate workers who are no longer tethered to desktop computers and mainframes.

We therefore argue for a relational view of materiality, in which we understand entities as becoming material when they are implicated in and co-constitutively entangled with other entities in social practices. Rather than implicitly constituting a lack of physical presence as a *problem* when understood against the taken-for-granted “gold standard” of physicality, a relational view allows us to investigate the interesting and relevant question of the role of physicality in the accomplishment of materiality, as well as the implications of materiality for the physical world. In this view, “digital” is no longer an antonym for “material”. Being able to discuss the materiality of the digital in turn opens up a new vocabulary for IS researchers that allows us to grasp more meaningfully the phenomena that are increasingly relevant to our work.

As we move towards an increasingly networked society we are in great need of effective tools to grasp emerging phenomena that are challenging our everyday understanding of the world. We have argued that this can only be achieved by bringing to the fore the taken-for-granted assumptions on which our commonly held worldview rests, even though such a gestalt shift in ontological understanding is difficult to achieve (Riemer and Johnston, 2011). As such, our paper stands in the lineage of and contributes to a broader debate that calls for new ontological approaches for the study of phenomena of organising with IT, most notably recent calls for a sociomateriality research orientation (Orlikowski and Scott, 2008).

References

- Aten, K., Nardon, L. and Stanko, T. L. (2014), "Working Out Loud: Adapting Communication to Support Distributed Collaboration", in *Academy of Management Proceedings*, Vol. 2014, p. 11002.
- Barad, K. (2003), "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter", *Signs*, Vol. 28 No. 3, pp. 801-831.
- Branson, R. (2013), "One day offices will be a thing of the past", virgin.com.
- Butler, J. (1999), "Bodies that matter", *Feminist theory and the body: A reader*, pp. 235-245.
- Carlile, P. R., Langley, A. and Tsoukas, H. (2013a), *How Matter Matters: Objects, Artifacts, and Materiality in Organization Studies*, Oxford University Press.
- Carlile, P. R., Nicolini, D., Langley, A. and Tsoukas, H. (2013b), "How Matter Matters: Objects, Artifacts, and Materiality in Organization Studies -Introducing the Third Volume of *Perspectives on Organization Studies*", in Carlile, P. R., Langley, A. and Tsoukas, H. (Eds.) *How Matter Matters: Objects, Artifacts, and Materiality in Organization Studies*, Oxford University Press.
- Castells, M. (2007a), "Communication, power and counter-power in the network society", *International journal of communication*, Vol. 1 No. 1, p. 29.
- Castells, M. (2007b), *Mobile communication and society : a global perspective : a project of the Anenberg Research Network on international communication*, MIT Press, Cambridge, Mass.
- Castells, M. (2011), *The rise of the network society: The information age: Economy, society, and culture*, John Wiley & Sons.
- Cecez-Kecmanovic, D., Galliers, R. D., Henfridsson, O., Newell, S. and Vidgen, R. (2014), "The Sociomateriality of Information Systems: Current Status, Future Directions", *MIS Quarterly*, Vol. 38 No. 3, pp. 809-830.
- Daily Mail Reporter (2013), "Michael Bloomberg backs Marissa Mayer's ban saying that he's always thought working from home is 'one of the dumber ideas I've ever heard'", *The Daily Mail UK*, Australia, ninemsn.
- Dewey, C. (2014), "The (one) simple thing fueling your social media addiction", *The Washington Post*.
- Emirbayer, M. (1997), "Manifesto for a relational sociology 1", *American journal of sociology*, Vol. 103 No. 2, pp. 281-317.
- Faulkner, P. and Runde, J. (2011), "The social, the material, and the ontology of non-material technological objects.", *European Group for Organizational Studies (EGOS) Colloquium*, Gothenburg.
- Faulkner, P. and Runde, J. (2012), "On Sociomateriality", in Leonardi, P., Nardi, B. and Kallinikos, J. (Eds.) *Materiality and Organizing: Social Interaction in a Technological World*, Oxford University Press, Oxford, pp. 49-66.
- Gentile, J. (2014), "On Mattering, Materiality, and "Transitional Memory": A Discussion of Jonathan H. Slavin's Essay", *Psychoanalytic Perspectives*, Vol. 11 No. 1, pp. 35-43.
- Grosser, B. (2014), "What do metrics want? How quantification prescribes social interaction on Facebook", *Computational Culture*.
- Haraway, D. (1991), "A cyborg manifesto: Science, technology, and socialist-feminism in the late twentieth century", *Simians, cyborgs and women: the reinvention of nature*, pp. 149-82.
- Heidegger, M. (1962), "Being and time, trans. J. Macquarrie and E. Robinson", New York: Harper & Row.
- Hodder, I. (2012), *Entangled: An archaeology of the relationships between humans and things*, John Wiley & Sons, West Sussex.
- Howard-Grenville, J., A. and Carlile, P. R. (2006), "The incompatibility of knowledge regimes: consequences of the material world for cross-domain work", *European Journal of Information Systems*, Vol. 15 No. 5, pp. 473-485.

- Introna, L. (2013), "Otherness and the letting-be of becoming: or, ethics beyond bifurcation", in Carille, P. R., Nicolini, D., Langley, A. and Tsoukas, H. (Eds.) *How Matter Matters: Objects, Artifacts, and Materiality in Organization Studies*, p. 260.
- Johns, G. (2010), "Presenteeism in the workplace: A review and research agenda", *Journal of Organizational Behavior*, Vol. 31 No. 4, pp. 519-542.
- Kallinikos, J., Leonardi, P. and Nardi, B. (2012), "The Challenge of Materiality: Origins, Scope, and Prospects", in Leonardi, P., Nardi, B. and Kallinikos, J. (Eds.) *Materiality and Organizing: Social interaction in a technological world*, Oxford University Press, Oxford, pp. 3-24.
- Keller, E. G. (2013), "Yahoo CEO Marissa Mayer's work-from-home memo is from bygone era", *The Guardian*, UK, theguardian.com.
- King, M. (2001), *A guide to Heidegger's Being and Time*, SUNY Press, New York.
- Kushner, D. (2013), "The real story of Stuxnet", *Spectrum, IEEE*, Vol. 50 No. 3, pp. 48-53.
- Langner, R. (2011), "Stuxnet: Dissecting a Cyberwarfare Weapon", *IEEE Security&Privacy Magazine*, Vol. 9 No. 3, pp. 49-51.
- Latour, B. (2005), *Reassembling the social: an introduction to actor-network theory*, Oxford University Press, Oxford.
- Leonardi, P. (2012), "Materiality, sociomateriality, and socio-technical systems: What do these terms mean? How are they different? Do we need them", *Materiality and organizing: Social interaction in a technological world*, pp. 25-48.
- Leonardi, P., Nardi, B. and Kallinikos, J. (Eds.) (2012), *Materiality and organizing: Social interaction in a technological world*, Oxford University Press.
- Nicolini, D. (2012), *Practice theory, work, and organization: An introduction*, Oxford University Press.
- Orlikowski, W. J. (2007), "Sociomaterial practices: Exploring technology at work", *Organization studies*, Vol. 28 No. 9, pp. 1435-1448.
- Orlikowski, W. J. (2010), "The sociomateriality of organisational life: considering technology in management research", *Cambridge Journal of Economics*, Vol. 34 No. 1, pp. 125--141.
- Orlikowski, W. J. and Scott, S. V. (2008), "10 Sociomateriality: Challenging the Separation of Technology, Work and Organization", *The academy of management annals*, Vol. 2 No. 1, pp. 433-474.
- Pentland, B. T. and Singh, H. (2012), "Materiality: What are the Consequences?", in Leonardi, P., Nardi, B. and Kallinikos, J. (Eds.) *Materiality and Organizing: Social Interaction in a Technological World*, Oxford University Press, Oxford, pp. 287-295.
- Pinch, T. and Swedberg, R. (2008), "Living in a material world", *Economic Sociology Meets Science and Technology Studies*, Cambridge: MIT Press.
- Rayle, A. D. and Chung, K.-Y. (2007), "Revisiting first-year college students' mattering: Social support, academic stress, and the mattering experience", *Journal of College Student Retention: Research, Theory and Practice*, Vol. 9 No. 1, pp. 21-37.
- Riemer, K. and Johnston, R. (2011), "Artifact or Equipment? Rethinking the Core of IS using Heidegger's ways of being", in *The International Conference on Information Systems*.
- Rosenberg, M. and McCullough, B. C. (1981), "Mattering: Inferred significance and mental health among adolescents", *Research in community & mental health*.
- Schlossberg, N. K. (1989), "Marginality and mattering: Key issues in building community", *New Directions for Student Services*, Vol. 1989 No. 48, pp. 5-15.
- Spinosa, C., Flores, F. and Dreyfus, H. I. (1997), *Disclosing New Worlds: Entrepreneurship, Democratic Action, and the Cultivation of Solidarity*, The MIT Press, Cambridge.
- Suchman, L. A. (2007), *Human-machine reconfigurations : plans and situated actions*, Cambridge University Press, Cambridge ; New York.
- Weber, R. (2012), "Evaluating and Developing Theories in the Information Systems Discipline", *Journal of the Association of Information Systems*, Vol. 13 No. 2, pp. 1-30.

- Yoo, Y. (2012), "Digital Materiality and the Emergence of an Evolutionary Science of the Artificial", in Leonardi, P., Nardi, B. and Kallinikos, J. (Eds.) *Materiality and Organizing: Social Interaction in a Technological World*, Oxford University Press, Oxford, pp. 134-156.
- Zetter, K. (2014a), *Countdown to Zero Day: Stuxnet and the Launch of the World's First Digital Weapon*, Random House LLC, New York.
- Zetter, K. (2014b), "An Unprecedented Look at Stuxnet, the World's First Digital Weapon", *Wired*.
- Zuboff, S. (1988), *In the age of the smart machine: The future of work and power*, Basic Books, New York.