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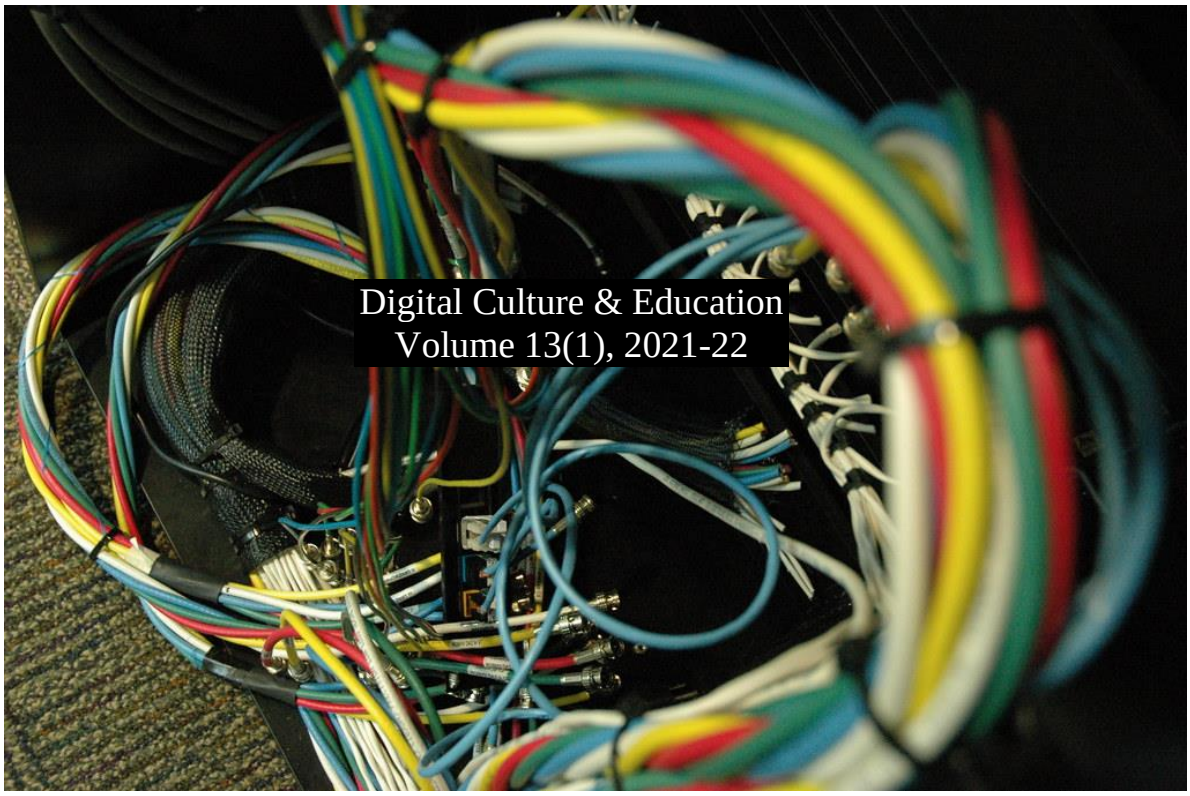

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PEDAGOGIES OF THE DATAFIED: MATERIAL FOUNDATIONS FOR LITERACIES OF THE SUBJECT IN THE 21ST CENTURY

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Abstract: *What it means to be human, relevant and meaningful is no longer certain within emerging regimes where computational complexity and data analysis increasingly determine conditions of prosperity and authority. Preparing students for futures within this transforming landscape of emerging technologies and new patterns of social organization raises important issues of literacy, power and subjectivity alike. If the hailing mechanisms of the subject are largely modulated through digital and algorithmic protocols, what kinds of literacies might help expand individual and group influence over subject formation? Traditional approaches to digital literacy have tended to overlook techno-material aspects of network functionality, which risks diminishing the degree to which individuals and groups can extend influence over subject formation. This paper argues for an expanded approach to digital literacy that addresses the techno-material foundations and full range of computational protocols on which network societies depend. Learning to navigate and manipulate the material-discursive apparatus in network societies can help individuals and groups apperceive assemblages of biopower while expanding possibilities for shaping subjectivities in datafied contexts.*

Keywords: digital literacy, datafication, subjectivity, power

"Critical literacy entails a process of naming and renaming the world, seeing its patterns, designs, and complexities, and developing the capacity to redesign and reshape it ..."
------ Allan Luke (2012), Queensland University of Technology

Introduction

The link between literacy and power is inseparable from processes of subject formation. The degree to which, and how, literacy skills are applied within the discourses of a time and place are in many respects the foundation of social formation, a process that shapes and reflects relations of power in part by involving subjects in the complexities of political, social, cultural, professional, and economic activities. In network societies (Castells 2010), social formation and digital technologies are inseparable which raises questions about the kinds of competencies required for individuals and groups to play a meaningful role, not only in wider social processes of social formation, but in shaping their own identifies.

None of this is particularly new. What is often overlooked, however, is the degree to which the techno/material foundations of network societies set new parameters for the kinds of competencies required to meaningfully participate in society. Literacy practices are increasingly entangled in the materialities of digital technologies, but our competencies with respect to these technologies are often relegated to what computer scientists refer to as the 'application layer' in digital networks: where

computational activities are translated into the meaningful semantic systems most of us are familiar with – language, art, reason, narrative, and so on. But despite the ubiquity of digital technologies in the day-to-day discursive environments for many people, understanding of the material foundations of digital discourses remains quite limited. This presents a number of problems, not least among which is the ability to challenge and shape identities. Defining subjectivities is a key part of how societies manage people and how people can expand their say over the kinds of societies they live in.

The datafication of social reality including subjectivity, serves economic, administrative and political goals, but it also presents complications with respect to who and how participation in society manifests. Algorithmic cultures present the possibility of what Yuval Harari has described as the "irrelevant class", people whose subjectivities hold little value within the computational systems of social formation he speculates will and are already taking a leading role in shaping the world we live in. Algorithmic biopower emerges as a new landscape of decentralized social control with its own unique epistemic demands for subjects to learn and manipulate in pursuit of well-being and prosperity. One aspect of this emerging landscape is its foundation in network protocol, the regulation of participation in network functionality that puts subject formation into the 'hands' so to speak of automated systems. Or in other words, algorithmic biopower suggests a social contract modulated by computational protocol rather than political decisions, and so the question arises how best to meaningfully engage in a system of meaning-making where engagement itself technically depends on capitulating to the protocols of the network?

The technical terminology this discussion requires is a disincentive for many readers, but in a certain sense, that is the point. Many people lack a certain foundational competence with the techno/material foundations of network societies, which leaves individuals and groups vulnerable to being interpellated with little say in the process. In this paper I argue that literacy education needs to embrace the 'material-discourse apparatus' (Barad 2010) of network societies, in particular, by expanding literacy competency beyond the 'application layer' (of TCP/IP Internet protocol) to include the social layer, the link layer, the physical layer and beyond to the material conditions of meaning-making on which computation and network functionality depend. These are efforts well underway in different settings through what Cote and Pybus describe broadly as 'techno-cultural interventions' (Cote and Pybus 2016), and what are perhaps more commonly referred to in discussions of technology literacies, maker spaces, tinkering, and so on. But what has yet to be widely embraced is the epistemic significance of techno-cultural interventions and their relevance to meaning-making through subject formation and its political consequences. To what extent, we must ask, do new conditions of power in network societies present literacy demands linked to network functionality, and how might such conditions be confronted? This paper argues that contemporary approaches to literacy must also address the material foundations of digital cultures, not only for individuals struggling for relevance and justice within the material-discursive apparatus of algorithmic cultures, but also for groups caught in larger networks of techno-social relations that present barriers to their own self-determination – for example, indigenous communities asserting 'techno-sovereignties' in the face of ongoing colonial legacies (Maretinez 2019; Duarte 2017), intersectionally marginalized youth re-inscribing identities through technical expertise (Tan and Calabrese 2018), young women and girls asserting identities that challenge patriarchal values and relations (Toupin 2014), among others. Continuing to ignore the materialities of digital cultures within the parameters of basic literacy acquisition risks setting the subject afloat in a sea of algorithmic

and technical conditions with little more ability to navigate subjectivity than that of a cork caught in a rising tide of techno-social transformations.

The paper is divided into three parts: In the first, I consider emerging contexts of network societies where authority is actualized more and more through distributed automated, computational systems and the political implications of this for subject formation. In the second part, I consider overlooked aspects of network protocol as a guide to developing new digital competencies. As the protocol that governs the flow and distribution of digital information on the Internet, TCP/IP is an essential aspect of digital network infrastructure. Elements of the differentiated layers of TCP/IP protocol suggest competencies generally overlooked by conventional approaches to digital literacy. These competencies I argue can expand capacities to actively engage in infrastructural processes that influence subject formation – for example, the ability to design and create a locally owned ICT network as an articulation of cultural sovereignty, or the ability to both understand and influence the values that shape protocol design and its implications. In the third and final section, I consider digital literacy learning practices in settings where subject formation and digital-material experimentation are being explored hand-in-hand. New materialities require new literacies, and techno-cultural skills training presents a long overdue corrective for developing the literacy skills network societies demand.

Datafying the subject: A New Socio-material Context for Literacy Learning

Contemporary societies are marked by the integration of social reality and computational function, what van Dijck describes as "the gradual normalization of datafication as a new paradigm in science and society" (2014, 198). More and more of what we do and how we do it involves translating human experience into digital information. We can understand the implications of these broad changes through two related but distinct frameworks. The first is called dataism and describes a shift in ontological perception that posits data at the root of all reality (Harari 2017). Everything in the universe, dataism would argue, can be understood in terms of the flow, analysis and transformation of information. Dataism reflects a philosophical shift that argues "value and wisdom reside in data" which will provide the foundation for how decisions "will be – and perhaps should be – made in the future" (Lohr 2015, 30, 15).

In a dataist framework, human dominance on earth is due to the human brain being the most efficient processor of the most amount of information. The historian Yuval Harari argues that we are on the cusp (or perhaps over it) of algorithmic intelligence surpassing the data processing capabilities of the human brain, thus raising the specter of what he calls the 'useless class' – a growing demographic of individuals whose functionality in network society becomes redundant (Harari 2017). For example, researchers following trends in the use of artificial intelligence by industries to replace human workers suggest about half of current jobs in the US economy are likely to be automated (Frey and Osborne 2017). In the new political regime, Harari argues, the struggle will not be over human rights, but rather for relevance.

The second framework, datafication, is a more technocentric parallel to dataism's philosophical assertions. Datafication describes the transformation of phenomena - natural phenomena, social behavior and experience - into a quantified format for computational analysis (Mayer-Schoenberger and Cukier 2013). Big data computation is perhaps the most advanced form of datafication, the real

time tracking and analyzing of vast and historically unprecedented volumes of data produced by large populations (Baack 2015; Lohr 2015; Mayer-Shoenberg and Cuckier 2013; Richterich 2018). Datafication emerges from what Kitchin and Larrieault (2014) call data assemblages, the data producing systems and infrastructures, along with the contextual political, social and economic frameworks that give them legitimacy. Datafication presents a significant historic shift in the constitution of knowledge in that aspects of human experience – for example, historically unprecedented volumes of digitized data and their real-time computational manipulation - are being incorporated into social formation (i.e. through political and policy decisions justified through big data analysis) for the first time, thus suggesting possibilities for new human subjectivities (Baack 2015; Cheney-Lippold 2017).

The ghost in the machine, so to speak, in this philosophical shift towards a view of data as the primary stuff of reality, and the growing and increasingly ubiquitous drive to translate every aspect of human experience into analyzable data, is computational intelligence: the ability of computational automation (i.e. algorithms) to replicate certain kinds of human functionality (Dobrev 2012; Duch 2007; Harari 2016). Automated drivers, legal assistants, psychological counsellors, medical diagnostics, to name only a few applications, all reflect algorithmic function that mimics human capability for specific tasks.

A key tension in this trifecta – of a philosophical shift that ontologically privileges data over everything else, a techno-social apparatus that strives to datify more and more aspects of human (and non-human) experience, and algorithms that in some contexts function as well as or even better than biological cognitive systems – is the question of human subjectivity within changing social systems. To what extent can and should individuals and groups have the capacity to shape their own subjectivities in this emerging algorithmic context? The answer may seem obvious, but even in non-digital contexts the ability of individuals and groups to shape their own subjectivities reflects both opportunities and limitations of hegemonic conditions (Foucault 1982, 1977/1995, 2007; Grabahm et al. 2009; Griffiths, Mustasaari and Mäki-Petajä-Leinonen 2016; Spivak 1988). As the studies in the preceding list of references suggest, the conditions of discourse, political and economic contexts, social hierarchies and relations of power in a time and place can criminalize and marginalize individuals and groups based on race, poverty, gender, practices of dissent, sexual orientation, ablebodiedness, and so on, setting into motion political struggles for recognition and legitimacy. But in a societal context where social formation is increasingly modulated through distributed computational automation, what does 'political struggle' look like? What kinds of literacy are necessary for a subject to encounter and engage in social formation discourses governed by the protocol of network functionality and algorithmic computation?

Digital Interpellation

Dataism and datafication present historically unprecedented conditions for thinking about social formation, literacy and subjectivity. One way to approach these tensions is through Foucault's understanding of subject formation as emerging from within the disciplinary regulation of the subject within the discourses of a time and place (Foucault 1977/1995; 1982). Foucault's notion of subject formation has been widely applied to understand how hegemonic discourses reinforce the subjugated status of individuals and groups in different contemporary settings – for example, through the

production of racialized subjectivities, gendered subjectivities, classed subjectivities, (post)colonial subjectivities, and so on (Cremonesi et al. 2016; Mama 2002; McLaren 2012; Strozier 2002).

Louis Althusser described the process by which discourses produce subjectivities as interpellation (Althusser 1971). The often-cited example offered by Althusser is of the police hailing someone on the street. A contemporary instance of this would be racial profiling. The subject is hailed by the regulatory authority of the police based on skin colour and thereby interpellated into the subjectivity of a racialized suspect. If datafication and dataist arguments prevail, the subjectivities hailed through digital modulation present forms of subjectivity that reflect network functionality as much as they do any sense of human expression and experience. Or in other words, the event of subject formation in contemporary societies must increasingly address conditions of computational biopower, the means by which large populations are managed "to ensure, sustain, and multiply life" (Foucault 1978/1998, 138) through automated systems. Participation in these systems at the material level is a function of the rules that manage the flow and use of data. This is what Gilles Deleuze described as a 'control society' where the exercise of power is in effect automated, distributed and continuous, and where in the equation of social control "individuals" have been replaced by 'dividual' data (Deleuze 1992, 5-6). In this scenario, relations of power manifest through the continuous monitoring and manipulation – the modulation – of 'dividual' data. Authorship, then – that is, the ability to shape subjectivity in this new regime – is as much or more so a question of code as it is one of semantic meaning. The design and creation of the technical systems that modulate and regulate dividualized subjectivities within the networks that underlie social formation reflect the material conditions of the discourses from which subjects emerge.

There are numerous studies of how automated computation can drive subject formation in limiting and troubling ways. Tara McPherson has argued that, at its most basic, the architectures of dominant programming languages can reinforce the racist, segregated and oppressive social contexts from which they emerge (McPherson 2012). Algorithmic treatment of subjectivities has been documented reinforcing the exclusion and marginalization of particular groups (Birhane and Cummins 2019), rendering some subjects democratically voiceless (Cinnamon 2017), organizing gender in trans-exclusive ways (Keyes 2018), engendering racist and other problematic forms of policing (Grace 2019). More broadly, Shoshana Zuboff has written about emergent datafied social conditions as "a ubiquitous networked institutional regime that records, modifies, and commodifies everyday experience ... with a view to establishing new pathways to monetization and profit", or what she calls surveillance capitalism, or more colloquially the "Big Other" (Zuboff 2015, 81). Surveillance capitalism expresses radically reconfigured relations of power derived from the datification of both the interior of the body and the world around through proprietary algorithmic analysis and production, a condition from which she suggests there is little escape. But Zuboff's pessimism is rooted in what seems to be a conflation of two important but distinct attributes of contemporary societies: the ubiquity of digital technologies and the ubiquity of the neoliberal, capitalist relations and values from which these technologies have emerged and whose affordances flourish in lockstep with the ever-widening hegemon of neoliberal structures of economic organization. Lockstep is not the same as identical. The conditions of functionality for the technologies themselves – the material foundations of the neoliberal discourses at work in network societies – may offer a more hopeful path forward, or at the very least, one that harbours opportunities for the subject to more meaningfully direct the processes of interpellation.

In Judith Butler's critical reassessment of Althusser's iconic example of the subject being hailed on the street by the police (in her essay "Conscience doth make subjects of us all"), she draws attention to an important oversight in Althusser's original description (Butler 1995). In Althusser's story, when the subject walking along the street turns towards the police, there is in this gesture more than the authority-backed command of the police; there is also an expression of the subject's desire to be seen (Butler 1995). The subject's potentiality exists *before* the moment of interpellation – for example, the subject could conceivably respond in different ways, e.g. refusing to respond, responding with aggression, etc. - thus raising the possibility of alternative outcomes stemming from the moment of interpellation initiated by authority. In network societies, where the hailing mechanisms are increasingly part of some process of datafication (i.e. whatever the subject must be, it must first and foremost function within the technical demands of computational networks), subjectivity in excess of network demands must 'turn differently' at this very fundamental juncture between biological potentiality and technological modulation. It is in this transition that I am suggesting that literacy learning can play a role. Or in other words, in order to address the question of 'turning differently', we must consider the capacities available to the subject that would allow them to do this. One approach is through literacy studies, and in particular, the socio-material turn in literacy studies which acknowledges both the inseparability of literacy from the materiality of literacy practices, and its implications for formation of the subject within problematic relations of power.

Literacy and Subject Formation at the Digital Cross-roads `

Socio-material approaches to literacy recognize literacy as a situated and contingent bundle of practices and values that, in the course of allowing practitioners to share pan-social systems of meaning, manifest in local contexts in conjunction with particular technological artifacts, for specific purposes, and within contingent social relations (Hamilton 2016). As Fenwick, Edwards and Sawchuck write, a sociomaterial understanding of education recognizes that learning activities and material artifacts are equally enmeshed within networks of relationships and associations. The pedagogical shift, they suggest, is from an emphasis on teaching epistemic rules used to represent a world exterior to the learner, to teaching ontologic conditions for knowing whereby the learner is co-constructing meaning from within social and material entanglements (Fenwick, Edwards and Sawchuck 2015, 3). Orlikowski describes it as 'constitutive entanglements' wherein humans are understood as constituted through relations of materiality, and materials are understood as constituted through human practices (Orlikowski 2017). As Orlokowski writes:

> *"we see how the researcher's Google search is constituted by the performativity of computers, networks, software, algorithms, directories, databases, and infrastructure, as these are enacted by the human agencies entailed in their design, construction, and operation"* (Orlokowski 2017, 1445).

The performance of literacy in a digital network - in addition to the semantic systems engaged – is also entangled in the systems of meaning underlying network functionality.

The link between literacy and subject formation has also been recognized in critical literacy approaches which also make explicit how literacy can function to challenge relations of power.[1] Critical literacy views literacy as a way to engage with and challenge the status quo by linking the personal with the political in the social construction of self (Shor 1999). Further, Pahl and Rowsell argue that critical literacy is best understood as *artifactual literacy,* that the interrogation of relationships of power inherent in creating and understanding texts is inextricably entangled in materials – notebooks, pencils, computers, networks, etc. (Pahl and Rowsell 2011, 133). In every configuration of literacy - from papyrus scrolls to augmented reality - literacy expresses a symbiotic relationship that links cultural tools with cognitive activity through embodied practices (Haas 1996). The embodied subject in a place and time, their cognition, their tools of expression and understanding, and the relations of power constituted by discourses are linked together through capabilities and practices of literacy. The pan-social necessities of literacy found in shared systems including language and computational technologies are not "created nor exhausted by the locales in which they are taken up" (Brandt and Clinton 2002, 338), but they take on different meanings, significance and both shape and are shaped by the settings in which they are engaged.

In conceptualizing the significance of materiality to literacy, the notion of agential realism is also helpful for drawing attention to the ways that reality is co-constituted by material objects (including technologies), bodies and discourses (Barad 2007). Basing their observations in part on quantum assessments of matter as indissoluble from the observations made about it, Barad describes the world as 'material-discursive apparatuses' wherein and through which matter and bodies take shape as phenomena "enfolded and reworked in the ongoing reconfiguring of apparatuses" (Barad 2007, 206). This is important when thinking about the relationship of digital tools to human subjectivities. Just as artifactual literacies cannot extract practices from the objects of their practice, the co-constitution of human subjectivity also depends to some extent on the materiality of literacy engagements. Or as Schachtner puts it:

> *"Digital media, as material–immaterial objects, trigger something in us that goes beyond pure utilisation; in interactions with digital media, subjects become involved in a way that cannot solely remain external ..."* (Schachtner 2013, 37).

The software experiences, design effects, routers, cables, WIFI specifications, fiber optic requirements, analytic capacities, robotics and protocols of digital culture are phenomena arising from the material-discourse apparatus through which subjects emerge. Barad's work suggests that an attempt to make sense of digitally composited subjectivities without encountering the materiality of practices will present an incomplete picture at best, and at worst, an incoherent understanding of subject formation where discourses are inextricable from digital technologies.

If, then, we accept that literacy involves social and material considerations, and that subject formation and literacy are inextricably bound, and finally that subject formation through practices of literacy necessarily involves the material-discourse apparatus of network societies, what are the kinds of competencies required to engage meaningfully with material-discourse apparatus in the digital age?

[1] Paulo Freire, whose foundational text in the field of critical literacy studies – *Pedagogy of the Oppressed* – playfully informs the title of this paper, argued that the praxis of naming, understanding and then trying to solve problems was essential for education *within* relations of power without *succumbing* to them (Freire 1972).

Overlooked Areas of Digital Competency: Network Protocol As Guide

Conventional approaches to digital literacy take some digital materialities into account. For example, multimodal literacies acknowledge that computation has introduced a wide range of changes to literacy practices including the necessity of working in different representational frames, e.g. images and animation, design, video, audio, interactive texts (Cope and Kalanztis 2000; De Sylva Joyce 2018; Jewitt and Kress 2003). Digital literacy studies tend to focus on content production and interpretation, and other aspects of user experience - the use of social media and email, finding and assessing information, navigating e-governance platforms, questions of privacy and surveillance, online identity profiles, gaming and other forms of digital interactions, augmented reality, and so on. These are of course critically important aspects of digital literacy experience, and there is considerable literature dedicated to their study (Daly, Devitt and Mann 2019; van Deursen and van Dijk 2014; Jones and Hafner 2012; Lankshear and Knobel 2008; Mills 2016). But these approaches generally leave unexamined the material foundations of network societies, namely the computational and network functionalities on which digital cultures depend.

Emphasis on these kinds of user experience is not surprising. These are the most visible and generally the only way many of us experience digital cultures, and they occur in what computer scientists call the 'application layer' of Internet protocol. But the Internet (and digital networks more generally, see footnote 1) operates by dividing the flow and management of information into four layers – in essence, four different kinds of functionality. The rules governing this process are collectively called TCP/IP, which stands for Transmission Control Protocol / Internet Protocol. Each layer reflects a different way that digital information – bits and bytes – are handled while establishing and maintaining network connections. Figure 1 illustrates the different layers in use[2].

The layers are *metaphors* helpful for making distinctions between different aspects of network function (i.e. in each "layer" information has different uses and significance) the sum of which allows participation in network flow. The layer metaphor is also helpful for anyone trying to troubleshoot and isolate problems in network operations. As mentioned, most users of digital networks are familiar with the 'application layer' where digital information emerges into the sensory experiences (visual, tactile, affective, acoustic) that make up the semiotic systems through which cultures, societies and subjectivities take shape. This is sometimes called the 'semantic layer' because this is where data flow takes on meaning in wider social contexts. The layers of TCP/IP comprise the infrastructural protocol for digital networks.

[2] TCP/IP is a slightly older and augmented version of the Open Systems Interconnection Reference Model (or OSI) for digital networks, a standard introduced in 1984 by the International Organization for Standardization. OSI is the universal standard for digital networks worldwide and divides network function into seven layers: Application, Presentation, Session, Transport, Network, Data, Physical. TCP/IP combines the first three layers into the Application layer, and the last two layers into the Network Access layer, but the functionality remains the same. For the purposes of the discussion, the differences are irrelevant because the network functionalities they describe are comparable.

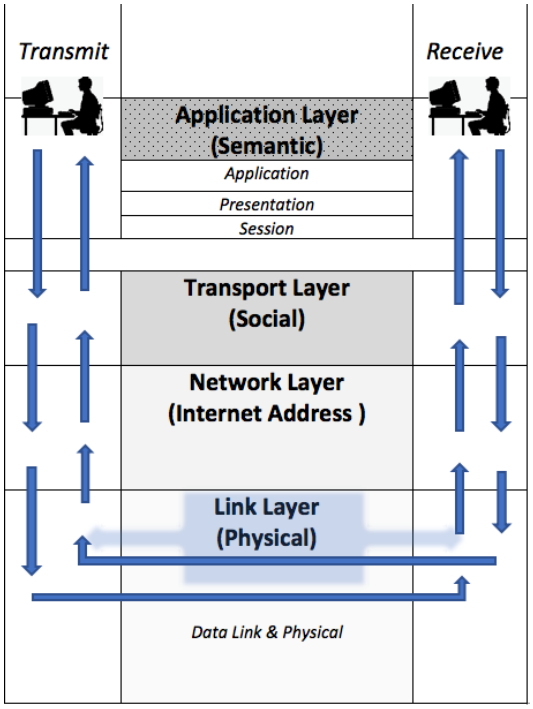

Figure 1 TCP / IP [image created by the author]

*[**Alternate text for Fig. 1**: Image of two figures, each at a computer and arrows linking one to the other down a vertical array of visually segmented layers: Application (semantic) layer, including application, presentation and session; Transport (social) layer; Network (Internet address) layer; Link (physical layer, including data link)]*

But the semantic layer, as the diagram suggests, is only one aspect of a more complex and encompassing apparatus for digital network discourse. The manipulation and modulation of information through the network is as essential to discourse in a network society as the semantic content. Or to say it slightly differently, in societies dependent on digital networks, it isn't exactly clear where discursive significance begins and ends among and between semantic systems and the network protocols and computational activities on which network functionality depends. As described earlier, Barad (2007) convincingly argues that these distinctions are artificial. My point here is that the TCP/IP layers of Internet protocol which describe how information flow is managed on the Internet is not only a critical aspect of network materiality, but it also provides a useful *metaphor* and to some extent guide for thinking about overlooked competencies related to the material foundations of networks when addressing questions of literacy in the digital age.

Protocol as Infrastructure: Making the Link Between Digital Competencies and Subject Formation

What makes TCP/IP layers particularly interesting as a guide to overlooked literacy competencies is the role of TCP/IP in - *and as* - telecommunications infrastructure. Media infrastructure like all infrastructure emerges from within, extends and is embedded within material and discursive conditions (Parks and Staroelski 2015). Media infrastructures embody processes of distribution and allocation of resources; the materialities of physical structures, labour, hardware, software, etc.; and

technological literacies – this last, encompassing capacities and knowledges that *re-order* one of the defining qualities of infrastructure: it's invisibility (Parks and Staroelski 2015). Appel, Anand and Gupta (2018) have shown that infrastructure can exercise authority and power in different ways – organizing social life through class, gender, race, kinship, etc; distributing resources and social relations temporally and geographically; materializing policies and knowledge practices; extending performing empire and state building. By acquiring the literacies required to engage meaningfully in some or all of these expressions of authority and power, these dimensions of social, political and subjective reality are opened for re/negotiation.

TCP/IP protocol is an aspect of the material foundations for media infrastructures required for digital cultures. The materialities of digital networks have implications for lived realities – topological and temporal, boundaries and scale, implementation and operability, decentralization and delegation, conventions of use and practice (Dourish 2015). It is admittedly a complex array of implications, but they have practical outcomes. Topologies and temporalities can shape "the significance, the pace, and the consequences of change and disruption" in networks (192); boundaries and scale influence institutional and organizational structures of dependence, independence and control; implementation and operability shape access (i.e. deviations from protocol produce connectivity failures); decentralization depends on other kinds of centralization; and conventions of use and practice are subject to change and politics – "network addressing, for example, or topologies and practices of connectivity among service providers" (194) are all fluid arrangements (Dourish 2015). To say it differently, media infrastructures delimit possibilities: for change and disruption, organizational development and dependencies, vulnerabilities to and with other kinds of centralization (such as ICAAN). Media infrastructures have important consequences that affect social organization and its attendant demands on subjects and their formation.

Conventional digital literacy focuses on the tip of the digital iceberg, so to speak – on skills and competencies applicable in the application layer -- while overlooking these other critical dimensions of how digital technologies mediate power and social formation. The link layer in Fig.1, for example, encompasses the technical specifications for how data physically gets from one place to the next in a communication network based on the material specificity of the corridors through which it passes: the twisted pair telephone wires, ethernet and coaxial cables, fiberoptics, spectrum allocations, satellite link-ups, subnet routers and switches, and so on. The link layer describes a material substrate of geographically located nodes and the links between them, the material infrastructures of telecommunications networks. The implications of telecommunication infrastructures for subject formation have been well documented on a macro scale. For example, the dispersal of economic activities into a de-territorialized, virtual global economic system has depended in part on the concentration of management and control functions in specific geographic and territorialized spaces, or what Saskia Sassen calls "global cities" (Sassen 1991; 2005; 2018). These are particularly strategic nodes in the global telecommunications system that have emerged in locations where subnetwork interlinkage is dense, and where there is ready access to capital, technological, managerial and financial expertise (Sassen 1991; 2018). In cities like London, Tokyo and New York, these advantages have afforded the growth of advanced telecommunications facilities which make possible the high-speed hypermobility of money transfers, investments, and the management of decentralized operations and financial services on which the global economy depends (Graham 2002; Sassen 1991; 2005; 2018). These new architectures of telecommunications functionality – the switches, multiplexers, cables and

computational complexities required to manage the dense flow of digital information from one global node to the next – have given rise to new political orders where deregulation and migration have produced vulnerable populations. New political orders require new political literacies in order to transform subjectivities from the pools of low-cost, migrant labour demanded by these emergent economic systems, into human beings who deserve safety, security, human rights and political recognition (Sassen 2002;2018). The material infrastructures linking together global nodes are entangled with emergent processes of subject formation. Through the macro lens, it is easy to recognize how subjects are understood to emerge in both subjugated and nascent politically resistant forms in response, at least in part, to the material conditions of telecommunications networks.

This understanding of subjectivity in relation to global networks, subjugation and resistance focuses on how network outcomes shape the subjectivities of people *who are not* involved in creating and operating the network technologies (i.e. service labour outside of managerial and technical expertise). In fact, it assumes a separation between those that have this expertise (in Sassen's framework, the experts who manage and control corporate activities, including network functionality) and those exploited in this process. But subject formation can also be shaped through practices of creating and operating networks. Duarte's notion of "network sovereignty' in the exercise of control over ICT networks in indigenous communities in the US articulates well the potential for technical competencies to play a role in emancipatory forms of subject formation (Duarte 2017). In Duarte's study of broadband projects conceived and deployed by the indigenous communities themselves, she observed the practice of self-government playing out in broadband infrastructure project planning, in ICT deployment strategies, in decisions about network upgrades and technical training. For Native peoples, she writes,

> *"it is as if the imperial urge to westward expansion moved into the cybersphere. Understanding the contemporary ICT landscape in Indian Country with regard to the governmental power and technological advance of the United States reveals the roots of factors that continue to preclude Native peoples' acquisition of sovereign control over their own telecommunications and Internet service provision efforts*" (Duarte 2017, 113).

The problematics of how ICT infrastructure can function as an extension of colonization has been well studied (Cornellier, 2016; Gigler, 2006; Hamel, 2010; Hernandez and Calcagno, 2003; McMahon et al., 2014; Pieterse, 2010; Salazar, 2007; Sandvig, 2012; Unwin, 2009). The skills and competencies required to intervene in these technically oriented processes of colonization are rooted in understanding how digital networks function – the physical, Internet and transport layers of network protocol.

Another example of the articulation of technical competency and subject formation can be found more specifically in the 'Internet layer' of TCP/IP protocol. The Internet and transport layers regulate how information flows through the Internet. Internet protocol (IP) transforms semantic information – a text document, for example – into packets of information, puts a destination address on each one, regulates their flow through virtual circuits, and reassembles them so that they can be made available as instructions for activities in the application layer. The Internet layer transmits, routes, reassembles and error checks the flow of packets, while the transport layer (transport control protocol, or TCP) regulates the interface between client terminals and the underlying network, ensuring a connection between client terminals. Key to all of this is domain name service (DNS), a centralized index of

addresses for every machine connected to the Internet. IP translates words (e.g. www.google.com) into numbers (e.g 142.251.33.68)[3] and vice-versa allowing a human-friendly lexicon for IP addresses. The regulation of IP addresses and domain names works much like a phone book and is fundamental to the functionality of the Internet.

When an application in the semantic layer requests a website (for example: www.google.com), the request is sent to a Domain Name Server (DNS); for the typical home user, this is hosted by their Internet service provider. The DNS either answers the request from a cache of stored information based on previous requests, or sends the request along to a root DNS server. Root DNS servers manage IP addresses for the whole of the Internet and are organized into domains: .com, .org, .edu, .uk, .ca, etc. (there are now over 1400 top level domains (ICANN 2021), and there are hundreds of root servers around the world, managed by 12 different groups, a semi-formal collaborative regulatory system and legacy of how DNS protocol was originally created and how it has evolved).[4] A request received by a root sever will be answered or forwarded to another root sever until an answer is found – for www.google.com, the IP address is 216.58.217.36.

In this process of user-request-to-root-server(or cache)-and-reply, the DNS query like all information on the Internet travels along routes that are not predetermined, meaning that the request could pass through routers and servers managed by people who would use the information in the request in ways unintended by the sender. What kinds of information? Usage patterns including timestamps, geo-locations of senders and receivers, and application data (CDT 2016). To get at this information takes expertise and resources, but these are available to many actors, governments included. A request could be disclosed -- for example, requests for a blog articulating politically controversial opinions. A request could also be answered incorrectly, for example redirecting requests away from the dissident blog to a government website. DNS privacy risks have existed since DNS protocol was introduced to manage IP addresses in 1983, but have only recently come to the fore as an issue needing more attention through system-wide changes to Internet protocol (Greenberg 2017). And while commercial organizations have been taking steps to secure their DNS query information for some time, most individual users lack both the resources and technical literacy to address DNS security issues.

In April 2020, the Canadian Internet Registration Agency (CIRA) introduced the Canadian Shield, an app(lication) for desktop and mobile computers to help anonymize DNS query data for individual Canadians (CIRA 2020). This came in the wake of the wholesale migration of cultural activity to digital platforms during the Covid-19 pandemic. The Oblivious DNS standard (ODoH) was also recently introduced as a universally applicable redesigned DNS ecosystem to protect DNS privacy across the Internet (Schmitt et al. 2020). ODoH is being adopted by a growing number of enterprises, including a cloud network service called Cloudfare, who is using the amended protocol to offer a free DNS

[3] In IPv4, each number in the sequence represents a different element in the DNS hierarchy. The first two sections identify the network: 142.251. The last two sections identify the machine on the network. The IP address is in binary code allowing for 4.3 billion unique addresses, a limitation overcome by IPv6, a related but different addressing system.

[4] Currently, the root server system has 1378 servers, organized into 13 logical root servers, each assigned a letter from A to M, and operated by 12 independent root server operators (as of July 13, 2020 according to https://root-servers.org/07-13). Each DNS server has a record of the IP address of every other DNS server. If the domain name queried is not in its own records, a server will look for it in the other DNS servers. When searching for a name, the request is made to a top level server first, which then indicate which DNS server hosts the next part of the DNS name, and so on until the name is found. DNS protocol also facilitates email exchange and instant messaging.

privacy service for all, called 1.1.1.1 (Adams 2018; Cloudfare nd). There is also Quad9, is a Swiss-based not-for-profit foundation providing yet another free DNS protection services to the general public protecting against malware, phishing, spyware, and botnets. From the Quad9 website:

> *Every transaction on the Internet starts with a DNS event. This name lookup reveals critically sensitive data about the person triggering that transaction. The nature of those name lookups has created a strong and dangerous motivation for commercialization of personal data from DNS recursive resolver services. Quad9 is the only large DNS resolver with a founding charter that includes privacy as a primary goal, and the Quad9 team is devoted to the concept of keeping personal data under the control of the end user.*

There are other DNS privacy services available, and they seem to be growing in number. My point to this lengthy digression is that, not only will many Internet users not have heard of this important and inherent risk in Internet use, many will either be unable to implement these free DNS privacy protections (which require some technical fussing), or be too intimidated to even try. Largely because – and this is the crux of the argument - the relevance of these kinds of technical literacies to subject formation have been overlooked. An understanding of how IP addresses are managed on the Internet and by whom, provides cognitive infrastructure for the discursive significance of terms like 'privacy' and 'surveillance' in that technical and structural limitations and possibilities found within the parameters of TCP/IP will dictate certain outcomes. If a user understands how the network manages the data requests they are making on the network, privacy is as much an understanding of DNS protocol as it is about ethical or political limitations. One can imagine scenarios where these knowledges take on profound significance – for example, citizens living under repressive regimes worried about state surveillance trying to decide the extent to which their subjectivities will reflect dissident orientations and how and where this might occur.[5]

I have presented three examples of how network protocol, understood as an aspect of digital infrastructure, can point to specific kinds of competencies relevant to subject formation: (i) in response to new political orders emerging from the outcomes of global telecommunications systems on social formation; (ii) communities expanding sovereignties (political and economic, linguistic, cultural and territorial including control over the flow, retention and use of sovereign data) by acquiring protocol competency in the buildout of locally owned ICT networks; and (iii) a competency with Internet Protocol that reveals inherent privacy risks associated with how digital information moves through the Internet. But network functionality more generally encompasses a broad range of computational capacities (for example, it is hard to imagine the Internet functioning today without machine intelligence, algorithms, robotics, sensors, etc.), all of which create opportunities to re/negotiate, or at the very least, to understand more deeply infrastructural elements of the digital world – what makes it tick, the risks and opportunities presented by technical architectures, and their implications for subject formation and well-being. Subjects encounter the conditions of their own possibility when they struggle against the effects of power (Foucault 1980). In the digital realm, one of the ways this happens is through network protocol.

[5]This is only one example. Understanding the IP addressing system can also help users quickly identify fraudulent domain names. The [main domain].[top domain] labels and their positioning in an IP address are crucial for locating information on the World Wide Web, and they provide a clear guide for identifying mislabeled domain names. Internet protocol for naming ensures that users can locate the websites of authentic hosts, and provides a foolproof way of ensuring that domain names encountered will take users to the places they intend to go.

From Biological to Protocological Subject

Before turning to some practical responses to the need for expanded digital literacies, I want to briefly consider more specifically the politics of protocol. The examples above help to demonstrate, at least to some extent, social outcomes where network technicalities play a role in subject formation. But if, as I am arguing, literacy learning is to encompass technical knowledges in order to ensure the subject can play a role in their own subject formation, then protocol must be understood as a discourse. Or in other words, what exactly are the politics of protocol?

One way to think about network protocol is as the interface between human experience and digital experience. Network protocol converts biophysical inputs into the coded patterns of voltage that we understand as digital information. As Galloway writes (Galloway 204, xx):

> *From the perspective of protocol, the nature/culture, body/technology binarisms do not matter. Literally. Rather, what matters is the ability of protocol to operate across material energetic substrates ... From the perspective of protocol, there are no biologies, no technologies, only the possible interactions between "vital forms" which often take on a regulatory, managerial, and normative shape. This can be called biopolitics.*

This offers a more functional description of dataism describe earlier: the biophysical becomes meaningful in the network through the biopolitics – the interface – of network protocol. On a societal level, this kind of regulation of human experience presents a new kind of social order, as I mentioned in passing earlier, one that Deleuze described as a "control society" where individuals become dividuated into data, and where societal control shifts from discipline to code (Deleuze 1992). In a discipline society, meaning and subjectivity are derived from disciplinary processes for making particular subjects behave in particular ways in particular places; in a control society, meaning is determined by access to network functionality (Deleuze 1992). Or to say it differently (Savat 2012, 49):

> *In short, whereas the function or aim of disciplinary power is the production, as efficiently as possible, of an object, that is the individual, the function or aim of modulatory power, of the operation of power in context of digital technologies, is pure functionality.*

The question of power and who can exercise it and who can resist its effects (i.e. politics) is located in the processes of determining the rules for network functionality. In a network society, if you do not have access to the network, you do not exist. In practice, we live with both models of power, where the processes of discipline produce the productive individual who is then "dissolved into [the] flow" of digital data (Savat 2012, 57). The dissolution of the individual into data produces the 'dividual', subjects whose identifies are called up by the data-needs of the networks within which they exist.

When DNS protocol was created, decisions were made (and continue to be made) that emerged from value systems, political preferences and so on that have direct bearing on how both DNS protocol

operates and subject formation. Since 1983, the Internet has functioned with DNS protocol IPv4. Since at least 2012, there has been an Internet wide push to adopt IPv6, a new DNS protocol developed and refined over the previous decade, one that can among other things accommodate trillions of unique IP addresses. But the adoption of IPv6 is fraught with political inputs and outputs, not least among which is a structural deployment that creates scarcity while locating economic and political control geospatially in the US (Malcic 2018). More controversially, IPv6 calculates an IP address based in part on a local MAC address (this is the unique number given to every network interface controller (the part of your computer that interfaces with the Internet). Unlike IPv4, there is a permanent link created in IPv6 between you and your online activities (Malcic 2018, de Nardis 2009). Concerns about user privacy and state designs on security and surveillance shaped the new protocol (IPv6 came into its own as a real alternative to IPv4 when the US began to advocate for it in the aftermath of the 9/11 attacks; being able to trace data was at the forefront of US interventions for new protocol.) IPv6 was implemented with extensions that change the IP address regularly in an attempt to anonymize the link between your machine and your data (de Nardis 2009), but even with these accommodations for privacy, there appears to be a new level of visibility for what was once private information, including the ability to correlate Internet activity, time and geolocations (White nd), so much so, that cloud managed network services are touting IPv6 as a way to "get greater visibility of user or customer behavior on the Internet" (Hogg 2019). A foundation of knowledge about how IP functions would provide a putative subject with an ability to understand changing technical conditions and their impacts on associated risks. If technical changes like those in IPv6 alter political and social obligations and parameters for agency, then an understanding of technical dimensions would allow users more latitude to negotiate outcomes.

My point in this is that the analysis of power and how it operates has shifted and is shifting away from semantic investigation alone towards the investigation of the codes through which digital machines express functionality. Protocol is, as Galloway suggests, "against interpretation" in that semantic meaning (the application layer) is ignored in network functionality (Galloway 2004, 52). Protocol has its own rules for meaning. Codes are called languages because they have syntax and grammar, and part of my argument is that we need to expand our literacies with respect to these languages if we want to continue exercise influence over subject formation. But network protocols are rooted not in the philosophies of meaning, but rather in "the sciences of possibility (physics or logic)" in the sense that their outcomes are the regulation of patterned sequences of electrical signals that compel a machine to behave in a certain way (Galloway 2004, 52). Following the rules of protocol allows possibility (of participating through network functionality) and not following protocol denies possibility. The information age, suggests Galloway, refers to a social reality that emerges from the ontological appreciation of matter as information and code, thus promoting protocol to the controlling force in social life (Galloway 2004). In the discussion about subject formation in a digital context, network protocol presents at least in part some of how subjectivities are and will be hailed into relations of power.

Expanding Subject Literacies in the 21st Century

Recalling the questions raised at the beginning of this article, from the above discussion we can now articulate more clearly some of the mechanisms by which 'being human' is translated into and modulated by digital functionality. As described, one of the keys to this lies in the technological

foundations of networks, the physical and computational limits and rules that govern the flow and exchange of digital information. But is turning everyone into a computer scientist the only meaningful response to subject literacies in the 21st century?

I am not entirely convinced this path doesn't have something to offer a future where subject literacies are valued, but the level of expertise suggested by the term "scientist" is misleading. The traditional notion of literacy (as in reading, writing and math) is now understood to exist on a continuum, in a cultural and historic context, as a changing set of skills over a lifetime (Kalanztis and Cope 2012; UNESCO 2017). The goal is rarely expertise, but rather competency in a context (UNESCO 2017). Broadly conceived in this way, the goal of literacy is to allow individuals and communities the ability to participate in society and achieve goals. The expertise required of an engineer or scientist is not necessary for an expanded literacy of the subject in a digital context.

Maker-spaces & Hacker Literacies: Playing with Digital Materials

One interesting and relevant model for achieving practical subject literacy skills are maker-space pedagogies, strategies for bringing people together with digital technologies and knowledgeable facilitators to explore collaborative problem solving in an informal, hands-on and playful environment (Blickstein 2013; DiSalvo 2014; Lang 2017; Shivers-McNair 2019; Tucker-Raymond et al. 2017; Vassoughi and Bevan 2014;). Maker-spaces have traditionally been explored as third-space opportunities for students to engage in largely student lead problem solving workshops (Potter and McDougall 2017) Making and maker-spaces fall under a constructionist approach to education, championed by Papert in the 1980s, also building on ideas of Paulo Freire, advocating that "knowledge happens" when "students build, make and publicly share objects" (Blikstein 2013, 5; Papert 1993). Eglash and Banks describe "hacker interventions" - another form of hands-on maker pedagogy - as having "recursive depth" where deep recursion "can expand the user's generative capacity" (Eglash and Banks 2014, 106-7). Maker pedagogies emphasize open-ended exploration, personal expression and "aesthetically compelling" possibilities (Peppler 2013).

Maker-spaces link together basic (digital) knowledges such as learning to use and manipulate specific kinds of hardware and programming skills, with problem solving and collaboration. They are generally intended as less formal (than traditional second-space learning environments in schools), more playful, and experimental engagement with artifacts for real-world problem-solving. What makes maker-spaces a relevant focus for this discussion is the centrality of problem solving with hardware and software in a context where students can acquire non-expert but functional levels of ability to renegotiate digital contexts beyond the application layer. In a meta-analysis of 60 maker-space studies focusing on outcomes, Lin et al. (2020) found that maker-spaces produced measurable outcomes in three broad categories: cognitive skills, affective experience and collaboration. All are relevant to the question of subject literacies, but the category most directly related to the discussion above about the underlying material conditions of digital culture is cognitive skills.

Lin et al. (2020) further divided the cognitive outcomes of maker-spaces into three specific skill-sets: "(a) STEM-related content knowledge that includes knowledge of science, technology, engineering and mathematics; (b) programming knowledge that focuses on computational principles and/or programming concepts; and (c) skills and competence, which are comprised of different thinking skills

and abilities in problem solving" (p. 103943). These describe the ways capacities were expanded among participants including knowledge and skills related to electronics and circuitry, the ability to diagram working circuits, understanding computational concepts, understanding how to use programming languages, the ability to read/design/remix code for circuits, and deeper understandings of computation generally (Lin et al 2020).

Critical-making is an offshoot of maker-spaces that emphasizes the political implications of learning to use, make and design technologies (Cipolla 2019; Higgins et al. 2018; Ratto et al. 2014). Critical making asks that the maker reflect on the relationship between themselves and things being made, focus on the process rather than the finished product, and understand making as an intervention in hierarchical power systems. Feminist making would add three additional learning goals: (i) the political potential of knowing how things work; (ii) the intellectual value in frustration (iii) the ability to apply technical skill outside of classrooms to address real world problems (Cipolla 2014).

Others have referred to these kinds of subject-centered material explorations as hacker literacies, a not uncontroversial term[6], but one useful for the way it reveals the challenge to hegemonic discourses (material-discourse apparatuses) through material interventions. Cote and Pybus refer to hacking workshops as techo-cultural interventions aimed at expanding subjectivities in the context of datafication: "an emergent techno-cultural political space [designed] to open other possibilities for critical engagement" 2016, 76). They argue that the techno-cultural workshop "can unpack not only the material objects that seek to capture our own socio-cultural practices when we use applications but how that mode of technical existence engenders – that is, enables and constrains – subsequent modes of human existence" (Cote and Pybus 2016, 78).

As mentioned above, a clear demonstration of technical knowledge engaged in contexts of subject formation can be found in the work of communities asserting political, economic and cultural independence through their own development of ICT network infrastructure. Martinez has identified "hacking" literacies as a key pedagogical strategy in the development of what he calls 'techno-sovereignty' in the context of Indigenous communities in the United States. As alluded to above, ICT connectivity in Indigenous contexts presents unique challenges in the clash of values between settler / colonial technological systems and aboriginal knowledge systems. The dematerialization of place, for example, in virtual settings often conflicts with the affirmation of place accompanying assertions of indigeneity (Gigler, 2006; Hernandez and Calcagno, 2003; McMahon et al., 2014; Salazar, 2007;

[6]The term "hacker" has been applied to individuals committing cybercrimes – breaking into networks, stealing information, spying, etc. But hacking and hacker movements encompass a much broader range of ethically defensible activities including white-hat hacking to develop better cyber security, hacking as a form of activism (hacktivism) to address injustices and to foment progressive social change, hacking as a feminist intervention into a patriarchal technological social millieux, hardware hacking in the fine arts, and so on. See: Harper, A., Harris, S., Ness, J., Eagle, C., Lenkey, G. and Williams, T., 2011. *Gray hat hacking the ethical hackers handbook*. McGraw-Hill Osborne Media; Hampson, N.C., 2012. Hacktivism: A new breed of protest in a networked world. *BC Int'l & Comp. L. Rev.*, *35*, p.511; Fox, S., Ulgado, R.R. and Rosner, D., 2015, February. Hacking culture, not devices: Access and recognition in feminist hackerspaces. In *Proceedings of the 18th ACM conference on Computer supported cooperative work & social computing* (pp. 56-68). ACM; Toupin, S., 2014. Feminist hackerspaces: The synthesis of feminist and hacker cultures. *Journal of Peer Production*, *5*, pp.1-11; Collins, N., 2014. *Handmade electronic music: the art of hardware hacking*. Routledge.

Sandvig, 2012). Pieterse argues that ICT development can lock Indigenous communities into "new forms of dependency" (p. 308) and tie them to systems of prosperity and regulation that serve the necessities of post-Fordist, neoliberal logics rather than local needs (Pieterse 2010). Martinez and others argue that the assertion of Indigenous identities will require engagement with the discourse-materialities of network technologies in new, innovative and material ways (Martinez 2017). As described above, Duarte's notion of "network sovereignty" in indigenous contexts encompasses not only digital content (i.e. application layer literacies), but also the physical system and infrastructures through which data is streamed, the network hardware such as towers and servers, network administration, hardware and software expertise, system and interface designers, and the policies regulating network buildout (Duarte 2017).

Conclusion

In societies organized through digital networks, new kinds of competencies are demanded: the ability to participate in cultural exchange using digital tools - what is usually meant by the term digital literacy – but also competencies related to the digital infrastructures through which human semantic exchange increasingly takes place. Learning to play with the hardware and software on which network societies depend opens possibilities for new outcomes. Maker-space like pedagogies invite subjects into the material-discourse apparatus at the design and manipulation level, encouraging exploration of the skills required to re/make and re-arrange the apparatus. The Internet, transport and physical layers point to knowledges and practices relevant for making IT infrastructure not only visible, but malleable. The notions of techno-sovereignty and network sovereignty described above, express the deep articulations between material, technical capacities and Indigenous resilience and resistance in the context of ongoing colonial and postcolonial relations. As digital infrastructures become more visible, in the sense of being understood as a resource to be manipulated in a context to solve specific, local problems – ones that may have little to with the state, market and financial relations that have tended to dominate the development and application of digital infrastructure historically – what were once perceived as given conditions begin to emerge as variables to be adjusted to suit needs. Who will understand how future possibilities are limited and created by technical decisions today? Who will be able to exercise political will in the arenas where global technical standards are set? Who will be able to ensure algorithmic outcomes reflect values that serves local needs? My argument in this paper is that, to the degree that we believe that the wider the pool of people who can step into these questions with understanding and purpose, the better the outcomes -- questions of literacy need to be extended to the material foundations of digital cultures.

The perils and opportunities of dataism and datification lurk around every corner. Most pressing are the implications of digital interpellation for subjectivity. How is it possible to intervene in the hailing mechanisms of digital protocols? A place to start, I suggest, is with the competencies pointed to by the overlooked layers of TCP/IP network protocol, the foundation of data flow and human-machine interface on the Internet. Understanding how digital information makes its way from the human experience to a digital document, to the packets that flow in the intermittent circuits, to cables and switches that regulate data flow, creates possibilities for better understanding and confronting computational biopower as it manifests in a society of control that manages subjectivity as dividuated data.

The range of learning practices engaged and studied under the banners of technology literacy, maker spaces, hacker literacies, techno-cultural interventions and techno-sovereignties suggest a way forward for expanding notions of literacy in the 21st century. Each in its own way addresses the material-discourse apparatus of network societies. But this leap has yet to be made within the wider discourses of literacy and policies for addressing literacy in formal educational settings. Network protocols provide a useful metaphor and starting point for identifying overlooked competencies. If subjects will be hailed into the digital apparatus through (hardware and software) protocol, the opportunity to have a say in the process must lie within capacities to transform imposition to negotiation.

The growth of interest in maker-spaces and other materially-oriented digital learning contexts is more often than not siloed from conversations about basic literacies - digital literacy, multimodal literacy, critical literacy, data literacy, and so on. But this is an oversight that unnecessarily and unhelpfully limits not only the kinds of literacy capacities citizens could acquire, but the range and depth of discussions about how they might best be acquired, i.e. strategic and innovative approaches to literacy pedagogies. There is growing interest in the role digital competencies beyond the application layer can play in subject formation - in addressing racial and gender injustice, peer bullying and police brutality (Barton and Tan 2018); barriers and exclusions tied to able-bodied norms (Unterfrauner et al. 2020); aboriginal and indigenous self-determination (Barajas-López and Bang 2018; Duarte 2017; Kariippanon and Gurruwiwi 2020; Winter and Boudreau 2018); queer youth articulating place and meaning (Berliner 2018). But there is clearly a need for more granular research on the kinds of subject outcomes expanded digital literacies can play a role in and how best to achieve these goals. There needs to be broader and deeper studies of subject formation through technological hacking, experimentation, innovation and play; and more diverse exploration of technology literacies in different contexts. Breaking down the disciplinary barriers between literacy studies and techno-social activism is a necessary next step in ongoing efforts to bring critical pedagogies into the digital 21st century in a way that addresses structural conditions of power with the creative potentials of a subject able to exceed the limitations of the material-discursive apparatus in which they must struggle for meaning and well-being.

Biography

Dr. Michael Lithgow is an Associate Professor of Communication and Media Studies, in the Faculty of Humanities and Social Sciences at Athabasca University. His research focuses broadly on citizen engagement in public cultures and the aesthetic, epistemic and power implications of competing discourses. His current research is focused on knowledge building in communities in connection with digital technologies as infrastructural tools for self-determination, political independence and professional development. He is also part of a research group investigating changing practices in professional news rooms in response to the growing use of user-generated content (UGC) in news production.

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