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Active Algorithms: Sociomaterial Spaces in the E-learning and Digital Cultures MOOC

Algoritmos Activos: Espacios Sociomateriales en los E-learning y en las Culturas digitales Mooc

ABSTRACT
This paper will explore two examples from the design, structure and implementation of the 'E-learning and Digital Cultures' Massive Open Online Course (MOOC) from the University of Edinburgh in partnership with Coursera. This five week long course (known as the EDCMOOC) was delivered twice in 2013, and is considered an atypical MOOC in its utilisation of both the Coursera platform and a range of social media and open access materials. The combination of distributed and aggregated structure will be highlighted, examining the arrangement of course material on the Coursera platform and student responses in social media. This paper will suggest that a dominant instrumentalist view of technology limits considerations of these systems to merely enabling or inhibiting educational aims. The subsequent discussion will suggest that sociomaterial theory offers a valuable framework for considering how educational spaces are produced through relational practices between humans and non-humans. An analysis of You Tube and a bespoke blog aggregator will show how the algorithmic properties of these systems perform functions that cannot be reduced to the intentionality of either the teachers using these systems, or the authors who create the software, thus constituting a complex sociomaterial educational enactment.

KEYWORDS
MOOC, Sociomaterial, Instrumentalism, Essentialism, Determinism, Blog aggregation, You Tube, Space.

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1. Introduction

The Massive Open Online Course (MOOC) has emerged as one of the most prominent themes in recent discussions of education and technology. Media accounts have stressed the disruptive potential of MOOC initiatives, often foregrounding the large enrolment numbers acquired in early offerings (see Adams 2012, Lewin 2012, Marginson 2012, Pappano 2012, Pérez-Peña 2012), while more formal reports have emphasised the threat to existing business models and pedagogical practices in higher education (BIS 2013, Inside Higher Ed. 2013, Universities UK 2013). Motivated by reports of low retention rates (Parr 2013, Kolowich 2013, Rivard 2013, Jordan no date), emerging research has focussed on the identification of MOOC learners and the categorisation of student behaviour (Christensen et al. 2013, Breslow et al. 2013, Milligan et al. 2013, Perna et al. 2013, Ho et al. 2014).

Less attention has been given to the specific technologies involved in MOOCs, and the ways they might shape the kind of education that takes place. The prominence of the three major MOOC organisations, Coursera, edX and Udacity, and their partnerships and affiliations with elite universities, positions the MOOC as an important site for considering the influence of networked and digital technologies on higher education. Understanding the particular arrangements of resources, services and activities in the MOOC is thus a crucial part of the discussion around centralised, distributed and aggregated models of educational provision in an increasingly digitised sector. The rapid rise of the MOOC demonstrates that education is not exempt from the wider infiltration of code into all aspects of social life (Dodge et al. 2006, Manovich 2013). This paper therefore seeks to explore the implications of the algorithmic processes that are entering mainstream education through MOOC arrangements.

This paper will analyse specific technologies from 'E-learning and Digital Cultures' (known as the EDCMOOC); a MOOC from the University of Edinburgh in Partnership with Coursera, with the aim of unravelling some of the relationships between the different spaces of the course. While debates around the use of e-learning technologies are often infused with assumptions about their neutrality or bias in the learning process (Kanuka 2008), this examination will draw upon sociomaterial theory (Fenwick et al. 2011) to challenge prevailing determinist positions and consider the entanglements of technology and educational purpose in the MOOC. Rather than assuming the necessary or innate value of centralised or distributed arrangements, this perspective will suggest the need for more nuanced analyses that acknowledge the relational processes through which educational spaces are produced. During the first instance of the course, the EDCMOOC was suggested to be a hybrid of the 'cMOOC' and 'xMOOC' varieties (Rodriguez 2013) that tried 'very hard to subvert its own conditions of production' (Stewart 2013a). It therefore serves as a useful example to consider the different kinds of technologies employed in MOOCs, as well as the spatial arrangements they are often considered to entail. Rather than looking at the EDCMOOC as comprising of inherently centralised or distributed space, this paper will suggest that such arrangements are produced from relations between human and non-human activity.

2. E-learning and Digital Cultures

The EDCMOOC was a five week course on the themes of digital technology, education and popular culture offered in January and November 2013 using the Coursera MOOC platform. The course was divided into two sections: notions of utopia and dystopia in relation to technology; and ideas about being human associated with technological change. The first instance of the course attracted 42,844 enrolees, of which 21,862 were registered as active (MOOCs@Edinburgh Group 2013). The EDCMOOC was designed to foreground student discussion. Rather than producing the kind of video lectures that are standard in the 'xMOOC' model (Rodriguez 2013), the course used a range of public domain videos, short films and animations, combined with a selection of openly accessible papers and articles. This curated material was made available within the pages of the Coursera course, and intended to prompt written responses from students in the form of discussion posts or blogs. Google Hangout live videos were also broadcast by the teaching team at specific times during the course, for the purposes of summing up themes and activities, as well as allowing participants to pose questions

and comments. EDCMOOC students were invited to submit a final assignment in the form of a 'digital artefact' that represented any aspect of the course. It was suggested that this work took the form of a web page, image, or video resource, and was required to be made publically available on the web for the purposes of peer assessment, as well as to make the work accessible to others. The EDCMOOC made use of the peer assessment functions on the Coursera platform to allow students to share the link to their work, and have it allocated randomly to at least three peer markers.

The EDCMOOC invited and encouraged participants to respond to the teacher-curated materials through dialogue and discussion, both within and outside of the Coursera platform. The Coursera discussion forum in the first EDCMOOC hosted 1,430 separate threads, which contained 8,718 posts and 5,146 comments (author removed for peer review 2014). The number of individual forum posters stands at 2,615, while 1,444 commented on existing posts (author removed for peer review 2014). Participants were also encouraged to use social media channels discuss the course materials, and while the teaching team suggested services such as Facebook and Google Plus in introductory communications with enrolees, these spaces were created and maintained exclusively by course participants. A Facebook group created during the first instance of the EDCMOOC attracted 4,820 participants (author removed for peer review 2014), and became active space for dialogue and resource-sharing outside of the Coursera platform. A similar Google plus group considered of 1,945 members (author removed for peer review 2014). Following the specifying of a course hashtag (#edcmooc), Twitter became a prominent space for EDCMOOC activity. In a period extending beyond the start and end date of the EDCMOOC in order to encompass the anticipation and aftermath, a Twitter analysis revealed 18,745 unique tweets (author removed for peer review 2014). These statistics reveal a considerable interest in engaging with distributed and public social media spaces outside of the Coursera platform, and significant movement between different spaces.

This course design involved the use of a range of functions and services, both within the Coursera platform and outside in the public web. The ensuing analysis of a selection of these technologies will make the case that, rather than simplistic binaries between open and closed, or centralised and distributed educational arrangements, activities in the EDCMOOC performed complex amalgamations of space, constituted by both social and material factors. However, before this can be done, an overview of the dominant perspectives of technology needs to be outlined in order to explain the specific theoretical position which underpins this analysis.

3. Perspectives on Technology

Decisions about the use of e-learning technologies are 'embedded in our philosophical views about both education and technology; underlying these views is our interpretation of the world and our actions within it' (Kanuka 2008, p92). It is therefore crucial to clarify the dominant views of technology in education in order to identify where limitations and possibilities may lie. The prevailing educational view of technology in education is that it has inherent properties, and predefined universal functions which are separated from social conditions and contexts (Sorensen 2009). This intrinsic separation between technology and individual human beings, or society in general, is a notion that has been widely critiqued in other disciplines, such as the philosophy or sociology of technology (Hamilton and Friesen 2013). Hamilton and Friesen suggest that educational research is dominated by instrumentalist or essentialist perspectives, the former viewing technology as the transparent means to accomplishing educational aims, and the latter assuming innate and absolute properties (2013). These determinist perspectives maintain a separation between human beings and technology that posit either as the driving force that regulates and controls the other. Drawing from Dahlberg (2004), Kanuka suggests that educationalists tend to adopt one of three positions: 'uses determinism' involving the view that technology is a transparent tool for the realisation of educational aims (aligning with instrumentalism); 'technological determinism' concerning the effects of technology on individuals and society (aligning with essentialism); and 'social determinism' which perceives societal contexts to drive changes and uses of technology (2008). While 'social determinism' appears to acknowledge broader contingencies (Kanuka 2008), the division between tech-

nology and human beings remains, the former rendered subservient to 'social systems and cultural contexts' (Kanuka 2008, p95).

The most prominent approaches to the MOOC have tended to assume just such determinist positions, aligned closely with the idea that technology either provides increased opportunities for dialogue and connection between individuals, or the means to gain admittance to the esteemed educational content of a prestigious institution (Stewart 2013b). It is this dualist arrangement which underpins the designations 'xMOOC' and 'cMOOC', frequently used to describe what are often considered to be two fundamentally different MOOC models (Rodriguez 2013). The former is suggested to be underpinned by behaviourist pedagogy, while the latter is informed by the proposed theory of connectivism (Rodriguez 2013). I suggest that both behaviourism and connectivism have tended to adopt determinist views: either perceiving technology to influence preferred conduct and supress undesired behaviour (Kanuka 2008), or to be the invisible means to achieving educational aims (Hamilton and Friesen 2013), in this case the formation of connections with other participants in the form of a Personal Learning Network (Siemens 2010, Kop et al. 2011).

However, a clear position on the role of technology in the MOOC is difficult to find, and the discourse often adopts both instrumentalist and essentialist perspectives. The rhetoric of disruption and innovation accompanying the promotion and advocacy of Coursera, edX and Udacity appears to adhere to the typical behaviourist view of the role of technology; as determining 'effective and efficient learning' that is 'more reliable, accurate, faster, and cost-effective than humans' (Kanuka 2008, p100). It is the video streaming and automated assessment technologies of the MOOC platform that are claimed to drive educational change, and break down barriers to access. As the recent Department for Business Innovations and Skills report in the UK suggests, 'MOOCs herald an unstoppable "Napster moment" which will break the old business model of Higher Education' (BIS 2013, p13), implying essential qualities of disruption. Positive media reports have also been suggested to 'hail MOOCs as the hi-tech engine of a transformative revolution that will remake education as a highly engaging, open and low cost activity' (BIS 2013, p64). Alongside such sentiments are frequent claims of emancipation, with Coursera claiming that its services will 'empower people with education that will improve their lives, the lives of their families, and the communities they live in' (Coursera 2014b), appearing to frame technology in instrumental terms. Multiple deterministic approaches are also detectable in the connectivist approach to MOOCs. For example, while Anderson and Dron suggest that connectivist 'learning is the process of building networks of information, contacts, and resources that are applied to real problems', they also claim that 'technology has played a major role in determining the potential pedagogies that may be employed' (2011, p87). Technology appears to be both a transparent tool for the creation of learning networks, but also a disruptive force that changes educational activity. For Hamilton and Friesen, such claims 'leave us with a paradox – technology is at once an all-powerful determinant and utterly insignificant in the face of human will' (Hamilton and Friesen 2013, p10).

Rather than defaulting to one of the three determinist positions, Dahlberg calls for a non-reductionist methodology which 'recognizes that each so-called determining factor is itself embedded within and constituted by a system of inter-linked constitutive processes' (2004). It is this suggestion of irreducibility that is taken up by sociomaterial theory.

4. Sociomaterial Theory

I suggest that the fundamental difference hailed by sociomaterial theory is a shift away from the identification of determining factors and towards a consideration of what is produced through co-constitutive relations (Fenwick et al. 2011). Rather than beginning with the foundational categories of 'technology', 'society' or the 'user', the most radical sociomaterial approach contends that '[a]ll things – human and non-human, hybrids and parts, knowledge and systems – emerge as effects of connections and activity' (Fenwick et al. 2011, p3 emphasis original). In other words, a clear determinist position is impossible because any object, concept, person or thing is necessarily determined by other relations. More generally, the sociomaterial signals a range of

approaches that foreground the relationships and entanglements between what is considered social and human, and what is thought to be material and non-human.

This paper considers the algorithms, software and infrastructure of the web to act in ways that cannot be reduced to the purpose defined by their human authors or creators, and thus to involve non-human, material characteristics. Rather than simply reflecting human intentions, Scott & Orlikowski claim that code is considered active, generative and performative in shaping online space (2013). This reflects the growing discipline of 'software studies' (Dodge et al. 2006, Manovich 2013), in which protocols and algorithms are considered to have 'the capacity to govern and manage users' (Bucher 2012, p2). Such ideas 'destabilize the widespread account of technology as stable singular tools separate from and under the control of human beings' (Sorensen 2009, p32). However, in suggesting that technology has agency is not to adopt a technological determinist position. A sociomaterial perspective views agency as distributed rather than situated exclusively within human beings. As Latour suggests, 'action should rather be felt as a node, a knot, and a conglomerate of many surprising sets of agencies that have to be slowly disentangled' (2005, p44). Importantly, this is to recognise that human actions and desires 'emerge through the myriad translations that are negotiated amongst all the networks – movements, talk, materials, emotions and discourses' (Fenwick et al. 2011, p104). The sociomaterial position thus 'refutes anthropomorphic centrality of human beings and human knowledge in defining the world and its relations' (Fenwick et al. 2011, p14-15).

Significant here are spatial theories that lie within the broader sociomaterial arena (Fenwick et al. 2011). Arguing that space is produced through relational practices rather than serving as a background for educational activity (Fenwick et al. 2011), sociomaterial theory provides a useful way of thinking beyond the dominant dualisms of 'closed' and 'open', 'centralised' and 'distributed', prevalent in discussions of digital educational provision. Established education, it has been claimed, is typified by 'spaces of enclosure' (Lankshear et al. 1996, p154). Lankshear et al. suggest that '[t]he book, the classroom and the curriculum can be viewed as intermeshed fixed enclosures which operate in concert to separate educational engagement from wider spheres of social practice' (Lankshear et al. 1996, p154). It is through such closed spaces, and under the direction of the authoritative teacher that students must interpret an external world. For Lankshear et al., these enclosed spaces are part of an educational tradition that privileges singular definitive knowledge (1996). In contrast, digital networks are suggested to open new possibilities for educational practices that challenge the stability of authoritative texts, and to provide the conditions to negotiate rather than discover knowledge (Lankshear et al. 1996). It is such sentiments which have fuelled utopic views of digital networks as spaces of anti-institutional empowerment. As an early report on MOOCs claims, '[w]hile digital technologies have exponentially increased the rate at which knowledge is created and distributed, they have simultaneously reduced the barriers to creating and consuming it' (McAuley et al. 2010, p5).

The following analysis is suggested to signal caution in assuming that open or distributed spaces are inherently more pedagogically valuable, emancipatory, or democratic, than established institutional spaces of enclosure. Following Ryberg et al.'s call for more nuanced considerations of 'web 2.0' technologies in the face of technological determinist hyperbole (2012), I draw upon sociomaterial theory to challenge the simple distinctions between bounded and unrestricted space. Exploring two examples from the EDCMOOC, I will attempt to show that the course did not take place within centralised or distributed space, but rather it was a spatial practice itself. Centralisation and distribution were the effects of particular sets of relations. In this way I suggest that 'there is no inside and outside, but rather a relation set of practices and mobilities' (Fenwick et al. 2011, p152). The spaces of the EDCMOOC can thus be perceived as being produced through practices of boundary making, (im)mobilities and moorings (Edwards et al. 2011), rather than rigid distinctions between closed and open, or centralised and distributed educational space.

5. Analysis

While the Coursera domain name is registered in Ashburn, Virginia in the United States (W3snoop, 2014),

the platform is powered by the Amazon Web Services cloud infrastructure (Saeta 2014). The power and scalability of this cloud-based service is described as essential for the global provision of the organisation, and the rapid rise in users experienced during the first year of launch (Saeta 2014). The recent expansion of partnerships, claimed to be 108 at the time of writing (Coursera 2014a), therefore constitutes a considerable adoption of cloud services by a significant number of elite institutions world-wide. However, despite utilising cloud services, the Coursera platform conforms to a model that resembles existing educational practices (Rodriguez 2013), and the bounded and tightly managed Learning Management System (LMS) or Virtual learning Environments (VLEs), traditionally hosted by the educational institution. The platform is structured around three principal functions: the delivery of video lectures; automated assessment, either in the form of computer-graded multiple choice quizzes or algorithms which allocate assessors for peer-reviewed student work; and the facilitating of dialogue between participants in a threaded discussion forum. These spaces are deigned to contain the activities of engaging with course content, being assessed for the purposes of measuring course completion, and communicating and socialising with peers. In this way, the Coursera platform might be considered to emulate established classroom space, an arrangement in which pedagogy is considered to drive the deployment of technology (Cousin 2005).

However, looking beyond the categorisations of cloud computing or learning platform, the following analysis will attempt to show how the space of the EDCMOOC is produced in practice. The resource pages of the course offer a noteworthy example of the complexities engendered by combining platform and social media services. Instead of producing video lectures, the EDCMOOC embedded a range of public domain You Tube videos within the Coursera site (see fig 1 for week one), and combined with open access journal papers and articles, these constituted the primary resources for the MOOC. Utilising material that already 'existed' elsewhere on the open web meant that the Coursera platform pages became a conduit for the movement of participants to and from wider social media.

Figure 1: Section of the EDCMOOC week 1 resources page showing embedded YouTube videos.

Thus the Coursera platform might be considered to be 'just the visible surface of a large realm of software, a complex amalgam of data structures, algorithms, packages, [and] protocols' (Dodge et al. 2006). The notion of a platform or course management system containing resources appears to be an inadequate description of the EDCMOOC arrangement. Two facets are important here. Firstly, that student engagement with these resources might be better understood in terms of movement between spaces, rather than the immobile absorption of content. Secondly, that this activity is a process of co-creation through which the course space is produced by EDCMOOC participants and the algorithms which operate beneath the surface of services such as You Tube. While the Coursera forum for week one discussions contained 56 threads and a total of 1,192 posts, the links to You Tube prompted by the embedded videos encouraged many students to shift their com-

ments elsewhere. As depicted in figure 2, the public domain videos utilised by the EDCMOOC began to be populated with comments specific to the course.

The course hashtag is clearly visible in many of the comments, filtered within You Tube to show 'top comments' (see fig 2). This demonstrates how EDCMOOC participants were moving between the Coursera platform and social media. For these students, engagement with the EDCMOOC was shifting and fluid; experiencing resources in different settings and participating in discussion across and between different channels. Research which attempts to make sense of such experiences and arrangements might therefore focus on 'flow and connectivity rather than location and boundary as the organising principle' (Hine 2000, p64). What I suggest to be significant in this example is not the centralised platform or the use of public social media, but the practices of moving between them. What this calls for is a shift away from thinking about these technologies as innately location specific or inherently distributed, and towards the idea that their spatial qualities are produced in practice.

Figure 2: Section from the comments in YouTube underneath the video 'Bendito Machine III', used as a resource in the EDCMOOC.

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The idea that course space is shaped through the routines of engagement can be perceived in the structure of the You Tube page itself. Firstly, the comments section (see fig 2) is determined by a complex algorithm designed to be relevant to the individual logged in to You Tube (You Tube 2013). The algorithm determines 'relevance' according to 'the video's creator, popular personalities, engaged discussions about the video, and people in your Google+ Circles' (You Tube 2013). While providing sparse technical detail about how this algorithm actually operates, such descriptions point to complex functions that draw upon the Google plus platform, as well as a range of other You Tube users. This means that the arrangement of comments, and thus the spatial qualities of the You Tube page, are not static, but rather come together through multiple and contingent relations between the human users of Google Plus and You Tube, as well as the non-human algorithms which operate beneath the surface of the user interface. Dependent on so many variables, the precise structure of the comments will appear differently for each logged in user, and cannot thus be attributed exclusively to the intentions of the authors of the algorithm. Moreover, the 'social' and 'material' dimensions are not independent here; rather social networks and algorithms co-constitute one another. In the context of the EDC-MOOC, the comments section is a crucial part of the You Tube page, facilitating the kind of discussion promoted as the central activity of the course. However, as described here, the discussion space is not simply a display of dialogue between human participants, but also a shifting arrangement in which non-human algorithms play a significant part.

The entanglement of human user and non-human algorithm also manifests in the 'recommended videos' section of the You Tube page. This list of associated videos appears to the right of the video currently being viewed (see fig 3), and is determined using a broad range of data, including video meta-data, the previous activity of the logged-in user, as well as the previous behaviours of other You Tube users who also viewed the current video (Davidson et al. 2010).

Figure 3: Section from the 'Bendito Machine III' You Tube page showing recommended videos.

In this way, multiple contingencies structure the You Tube page differently depending on persistently shifting combinations of data and human behaviour. The overall You Tube page is thus not fixed, but produced through relations between the operation of algorithms and the activity of users. The significance of this can be seen in the 'recommended videos' section shown in figure 3. The recommended video at the bottom of the list shown is 'Inbox', a short public domain film that was also used as one of the resources for the EDC-MOOC. It is not believed that these videos were associated in any way before being included as resources in

the EDCMOOC, and therefore I suggest that the inclusion of 'Inbox' in the recommended videos of 'Bendito Machine III' demonstrates how the viewing behaviours of course participants have influenced the structure of the You Tube page. This is a salient example of the complex spatial arrangements offered by social media; structures which challenge one dimensional and reductionist views of technology (Chandler 2002), and foreground relational and sociomaterial understandings of educational space. The use of You Tube in the EDCMOOC demonstrates a notion of space, 'not as a static container into which teachers and students are poured, or a backcloth against which they act, but as a dynamic multiplicity that is constantly being produced by simultaneous practices-so-far' (Fenwick et al. 2011). The implications for education are that the use of social media de-centres human intention, and the spaces utilised for educational activity cannot be entirely controlled by teachers, students, or the authors of the software.

One of the foremost spaces of the EDCMOOC was the 'EDCMOOC News' blog aggregator (see fig 4). This bespoke system developed by the teaching team utilised a range of freely available web services to collate, combine and display posts from the personal and distributed blog sites of individual participants. Blogging was considered to be one of the primary activities in the EDCMOOC, and rather than being secondary to the teacher-curated material, participant responses were promoted as a central resource (author removed for peer review 2014). In this way, the EDCMOOC News constitutes an important space for the discussion of centralisation, distribution and aggregation.

Figure 4: The EDCMOOC News WordPress site, showing two posts aggregated from distributed EDCMOOC participant blogs.

Encouraging students to blog in public spaces was deemed important as way of distributing course content and opening the possibilities for connections with people outside of the course. This kind of distribution reflects the pedagogy of networked learning in which knowledge construction is suggested to be 'located in the connections and interactions between learners, teachers and resources, and seen as emerging from critical dialogues and enquiries' (Ryberg et al. 2012, p45). Additionally, personal blogs were thought to be important as spaces which students might feel some ownership of the writing process, outside of the confines of the Coursera platform. However the advantages of these public contributions were countered by the prospect that dispersed content would be difficult to locate amongst the plethora of personal blogs and sites on the web. For this reason a blog aggregator was developed, drawing upon successful examples from other MOOCs (see Downes et al. 2011). With such a system, the advantages of both distribution and centralisation were thought to be retained.

The EDCMOOC News utilised three principle functions: a Google spreadsheet behind a web form which allowed participants to submit the RSS feed to their blog; 48 individual Yahoo Pipes , each fetching 20 feeds from the Google spreadsheet, filtering posts according to publishing time and the presence of the course hashtag (#edcmooc), and sorting posts according to date; and a WordPress instance using the FeedWordPress plugin to display aggregated posts (see fig 4). The EDCMOOC News displayed 1,340 posts during the first instance of the course (Scott 2013). Participants submitted 931 RSS feed URLs to the Google spreadsheet, and aggregated posts came from 300 of these (Scott 2013). Google analytics indicated that the EDCMOOC News site was visited close to 1,430 times by 997 unique visitors (Scott 2013).

The purpose of this analysis of the EDCMOOC News is to counter the tendency to 'black box' technology (Mackenzie 2009, Fenwick & Edwards 2010, Edwards & Carmichael 2012), in other words to mask the relations through which technologies operate and consider them simply as objects in themselves. From this perspective the EDCMOOC News is not a static or linear broadcast of course information, but a set of dependencies and relations that entwine participants and algorithms in the production of educational space.

Significantly, a number of processes defined the order in which posts appeared on the WordPress site (see fig 4). Firstly, Yahoo pipes limited posts to those with a published date within 72 hours of the process being triggered (Scott 2013), limiting the collection of posts to the most recent. Secondly, WordPress displayed aggregated posts in pages, limited to 100 posts each. These processes meant that aggregation was hierarchical rather than egalitarian, a suggestion bolstered by a statistical analysis of EDCMOOC News visitors. Scott states '[h]alf of the visits to the site were from people who had visited before and almost everyone only visited the first page of the site' (2013). This privileging of the first page of the EDCMOOC News meant that the first 100 aggregated posts were much more likely to be viewed and commented on, thus entering into the kinds of dialogue intended for this activity. However, the processes of aggregation also excluded many posts from the prospect of interaction and dialogue by displaying them in pages not immediately visible to visiting participants. Figure 5 shows the rate at which new posts were added to the EDCMOOC News WordPress site, indicating high volumes being aggregated roughly every 48 hours, with three processes exceeding 100 posts at a time. This demonstrates the speed at which contributions to the EDCMOOC News would be relegated to lesser pages of the WordPress site, and thus away from the space of majority engagement and interaction. For an EDCMOOC participant, having your post appear on the front page of the EDCMOOC News would be significant, with Google Analytics indicating that the site was visited 1,430 times by 997 unique participants (Scott 2013), presenting many opportunities for peer engagement. However, as we have seen, there is a complex arrangement of algorithmic processes and human attention that contributes to the possibility that a post will be read. These contingencies include the time at which the post was published, the correct execution of the particular Yahoo Pipe involved, as well as its corresponding FeedWordPress RSS fetching process. Given the global distribution of EDCMOOC participants (MOOCs@Edinburgh Group 2013), the likelihood of contributions reaching the front page of the EDCMOOC News is increased if a participant is working within the same timezone as the FeedWordPress process that populates the site (in this case GMT). In this way, the geographical distribution of participants also influences the production of the EDCMOOC News front page. It is thus a complex performance of human contribution, algorithmic process, and spatial ordering.

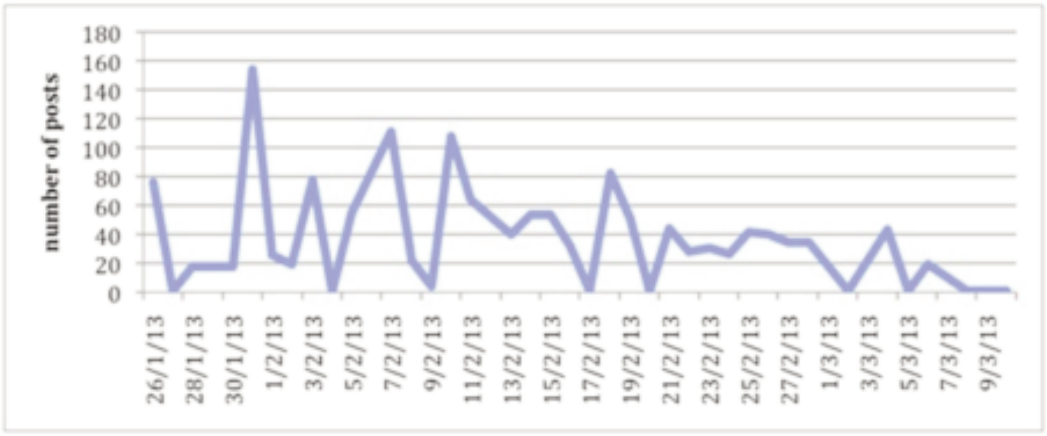

Figure 5: A graph showing (Scott 2013) http://edcmoocteam.wordpress.com/2013/04/09/nothing-new-under-the-sun/

Furthermore, considered as a central resource in the EDCMOOC, the EDCMOOC News must be perceived, not as a stable and definitive representation of course themes, but rather as a shifting space of knowledge, produced by a fluctuating body of human contributors and a bespoke mixture of non-human aggregation processes. Considered on its own, the first page of the EDCMOOC News constitutes a volatile and troublesome source of knowledge for the course. Its contents at any one time cannot be reduced exclusively to the intentions of any single individual (whether teacher or software designer), nor to the collective group of human beings involved. Rather, the body of knowledge that is the EDCMOOC News is determined by a number of interrelated and co-constitutive factors that are human and non-human, social and algorithmic. Considered as knowledge, it would be difficult to ascertain precisely what such an assemblage would therefore represent. It is suggested here that a more useful interpretation would be a non-representational, social and material enactment of knowledge (Edwards 2010). Such an interpretation reflects the call for a 'shift from epistemology to ontology, from representation to performativity, agency and emergence' (Pickering 2002, p414) in considerations of knowledge.

This analysis has demonstrated the need for a shift from 'the universal to the specific and material' (Fenwick et al. 2011, p159) when it comes to considering the implications of distributed, aggregated, centralised or networked educational spaces. It is with such approaches that I suggest continued research can identify the complex contingencies that shape and produce educational space, and acknowledge the agency and influence of code in education.

6. Conclusion

In a field where incentives for cloud computing are driven by perceived economic benefits (Mircea & Andreescu 2011, Sultan 2010), this paper calls for sociomaterial theory to explore the broader implications of digital, online and networked education. The view that technology simply generates efficiency savings is tied up with determinist perspectives on technology (Kanuka 2008), and limits how we can understand the relationships between social and material factors. The increasing use of both distributed and centralised educational content needs to be accompanied by robust theorisations and critiques of the systems used in order to highlight the agential influence of the digital. The sociomaterial perspectives outlined in this paper call into question the dominant view of technology as a 'tool' of distribution or aggregation. This instrumentalist perspective situates agency and intentionality exclusively within the domains of the human users, and denies the possibility that the complex algorithms and codes of the web shape and influence educational space. Rather than assuming that educators can unproblematically control web services and social media, we may need to recognise that the growing proliferation of algorithms and code act in ways that cannot be predicted. Referring to Mackenzie (2009) Dodge et al. describe 'spaces in flux that cannot be mapped in certain terms, but can only

be guessed at in probabilistic ways' (2006), and it is such considerations that continued educational research may need to adopt.

Fenwick et al. contend that '[c]yberspaces are therefore not merely a new educational tool, but can spatially reconfigure the forms of knowing, sociality and subjectivity enacted through educational (en)counters' (2011, p157). Distributed or aggregated educational spaces are not simply better or worse for learning. They qualitatively change the space in ways shaped by digital systems, through procedures that are irreducible to human intention or agency. The implications for education are that many social media and web services, as well as MOOC platforms such as Coursera, are being controlled, not by educators, but by large multinational for-profit companies. The educational use of such systems therefore constitutes a persistent negotiation and tension between their perceived pedagogical value, and the interests of profit. Ideas about movement and transition between different spaces is a challenge to the practices of data mining assumed to be one of the drivers behind Coursera, edX and Udacity (Watters 2013). However, shifting educational activity into the public domains of social media is not an escape from data capture, and the algorithmic properties of You Tube described previously are representative of further procedures intended to extract profit from user activity. Therefore, while Kanuka suggests that 'the debate over whether or not we need to prepare our learners for a pervasively networked world revolves around what types of persons we expect our education systems to produce' (Kanuka 2008, p92), I contend that such persons need to be able to understand and recognise the ways that technology and human, social and material, are deeply entwined.

Notes

(1) Figure 2 shows 'top comments' without a user logged in, therefore not drawing upon Google plus circles (You Tube 2013).
(2) During the first delivery of the EDCMOOC in January 2013

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