11-8-2016

What Can Social Networks Tell Us About Learning Ecologies?

Caroline A. Haythornthwaite

What Can Social Networks Tell Us About Learning Ecologies?

This work was completed in November 2016 and is to be translated into Spanish for a forthcoming book edited by Albert Sangrà Morer.

Caroline Haythornthwaite
School of Information Studies
343 Hinds Hall, Syracuse University
Syracuse, New York, USA 13244-1190

Acknowledgements:
A version of this paper was first presented at the International Seminar on Nuevos contextos, múltiples mecanismos: Ecologías de aprendizaje/New contexts, multiple mechanisms: Learning Ecologies, held at the Universitat Oberta de Catalunya, Barcelona, Spain, November 2015, organized by Albert Sangrà Morer, UOC and UNESCO Chair of Education and Technology for Social Change. http://symposium.uoc.edu/event_detail/3015/detail/ecologias-de-aprendizaje_-nuevos-contextos-multiples-mecanismos.html. The author's work was supported in part by the Social Science and Humanities Research Council of Canada through a grant for the project "Learning Analytics for the Social Media Age" (pLASMA) (PIs Anatoliy Gruzd and Caroline Haythornthwaite), and the GRAND Network of Centres of Excellence; and benefitted from collaboration and discussion with members of the pLASMA team: Anatoliy Gruzd, Drew Paulin, Sarah Gilbert, and Marc Esteve del Valle.

What Can Social Networks Tell Us About Learning Ecologies?

Abstract. The ecology metaphor is drawn from the biological sciences and refers to the "scientific study of the distribution, abundance and dynamics of organisms, their interactions with other organisms and with their physical environment" (British Ecological Society, 2016). In recent decades, the metaphor has become useful for tackling the complexity of new information and learning environments, particularly as driven by the increasing quantity of information, the growing number of available media and means of communicating, the extended reach of information technologies, and the new practices arising from these configurations. This paper brings to the discussion of learning ecologies the research and perspectives of social network analysis, where we find synergies in addressing interactions, niches, species and configurations of ecosystems. This perspective opens up some new ways of looking at and understanding learning practices in both online, offline and hybrid settings, and how these create sustainable ecosystems of information exchange and knowledge construction. The ecology and network ideas are highly synergistic, and what has been found from examination of social networks, using methods of social network analysis, can help inform the practice of individual learners, as well the practice of organizing in the service of learning. This paper draws on the literature, and studies by the author to address the network ecology of learning, suggesting ways to organize and anticipate change in order to gain the best advantage from our personal and social learning networks.

Introduction

The seminar held at the eLearn center at the Open University of Catalonia (www.uoc.edu/portal/en/elearncenter/) brought together a range of scholars to discuss how the ecology metaphor can help us understand contemporary learning both online and offline. In addressing learning ecologies, I advocate for expanding the interpretation of 'e-learning' to go beyond the classroom or educational institutional context, and beyond the technology of closed learning management systems to the practice of open learning on and through the internet (Haythornthwaite & Andrews, 2011). Contemporary learning ecologies include the open social and technical network that connects us to resources and other people in everyday learning. I strongly believe we are at a transformative stage for learning that is driven by our practices in a networked world, and that e-learning is a transformative movement driving change in who learns what, from whom, where, when, and under what circumstances. The combination is a transformation that creates and sustains new ecologies, new ecosystems of interactions, and new emergent species.

The ecology metaphor is drawn from the biological sciences and refers to the "scientific study of the distribution, abundance and dynamics of organisms, their interactions with other organisms and with their physical environment" (British Ecological Society, 2016). In recent decades, the metaphor has become useful for tackling the complexity of new information and learning environments, particularly as driven by the increasing quantity of information, the growing number of available media and means of communicating, the extended reach of information technologies, and the new practices arising from these configurations.
Writers on technology, literacy, information, knowledge and education have embraced the ecology metaphor as a way to approach the complexity of roles and relations that shape contemporary practices of information and knowledge creation, distribution and learning (e.g., Brown, 1999; Brown & Duguid, 2000; Bruce & Hogan, 1998; Davenport & Prusak, 1997; Knorr-Cetina, 1999; Luckin, 2010; Nardi & O'Day, 1999; Siemens, 2003; Star, 1995; Star & Strauss, 1999; Girard & Stark, 2007; for a review from the learning perspective, see Haythornthwaite and Andrews, 2011).

I bring to the discussion of learning ecologies the research and perspectives of social network analysis, where we find synergies in addressing interactions, niches, species and configurations of ecosystems. This perspective opens up some new ways of looking at and understanding learning practices in both online, offline and hybrid settings, and how these create sustainable ecosystems of information exchange and knowledge construction. The ecology and network ideas are highly synergistic, and what has been found from examination of social networks, using methods of social network analysis, can help inform the practice of individual learners, as well the practice of organizing in the service of learning. This paper draws on the literature, and studies by the author to address the network ecology of

learning, suggesting ways to organize and anticipate change in order to gain the best advantage from our personal and social learning networks.

The paper address these questions:

- What are the similarities between ecologies and networks?
- What can networks tell us about learning ecologies, ecosystems, and communities?
- What we can learn from networks to create or strengthen ecologies of learning?
- What is the impact of strong or weak ties in connecting different elements of our learning ecologies?
- How are the new online crowds and communities ecosystems going to affect learning?

What are the similarities between ecologies and networks?

As noted above, ecologists study organisms and their interactions with other organisms and within their physical environment. In a similar manner, social network analysts study actors (people, groups, organizations, etc.) and their interactions (known as 'relations') with other actors within their social system (the social network). An ecology is shaped by the way organisms affect and are affected by other units in the environment; so too the network is formed and reformed by the social actions of actors. Organisms interact with physical elements of their ecology, and contemporary network actors interact with social and technical aspects of their environment. Considerations of the ecology of learners and the networks of learners thus also includes study of the interaction between people and technology, in their cultural, institutional and workplace environments; this type of study is often referred to as sociotechnical studies, or social informatics. (For more on social networks and learning, see Haythornthwaite, 2014; Haythornthwaite, de Laat & Schreurs, 2016).

In ecologies we find places and niches that support particular kinds of species and/or particular kinds of cross-organism interaction: amensal, as one organism's use of resources depletes those of others; commensal, where one organism benefits from another; mutalism, where both benefit; parasitism, where one organism feeds on a host; and predation where one hunts and eats another (British Ecological Society, 2016). In social networks, such interaction patterns are identifiable by repeated patterns that emerge in network structures: cliques are like niches, with highly interconnected members; network stars disseminate information and connect actors; brokers bridge between cliques and bring resources from one part of the network to another. Interactions (relations), such as giving information, receiving advice, or providing recommendations, can be directed from one actor to another, serving the sender, receiver or network as a whole in the way this increases reputation, social capital, or knowledge to their individual or mutual advantage.

The outcome is an environment – a network – that exhibits a more-or-less persistent structure, which – in richly interacting cases – forms a community. For an ecologist, community is all species in the defined area that "interact directly, or indirectly, or share interaction links to other species in the community" (British Ecological Society, 2016, np). For a network analyst, community is that which emerges and is maintained through the types, intensity, and character of the network of interactions among actors, the way these define actor roles, and how these bind them toward common interest and goals. A caveat is that the human perception of a network as a 'community' is another layer on top of this. Where a network analysis may identify cliques and clusters that are tightly connected, thus representing a configuration of a community, the lived experience of a member of such a clique is another hypothesis to be tested. Humans require some particular social bonding to perceive their network as the kind of supportive, safe structure that gives rise to the more common meaning of the word community. To understand human community requires a deeper examination of what relations are maintained, and how these give rise to the social outcome of belonging to a community, whether a geographically based, a professional community, or a learning community (Haythornthwaite & Kazmer, 2004; Haythornthwaite, 2007; Gruzd & Haythornthwaite, 2011).

What can networks tell us about learning ecologies, ecosystems, and communities?

The first lesson we can take from ecologies – and from networks – is not to draw the boundaries from outside, but instead to examine actual interactions. What and who comprise the ecology can be surprising and not easily assessed from something like a class or team list. Actors reach out to others to learn and to transmit that learning to others. This includes reading and reviewing research literature, studies, and blogs; attending classes, seminars and workshops; taking internships and apprenticeships. Some actors sit on the very edges of the network, scanning the environment for new resources providing 'absorptive capacity' to a learning group (Cohen & Levinthal, 1990). Others sit centrally, making, modeling and enforcing rules of behavior, keeping discussion on topic or helping others learn, thereby shaping and reinforcing the structure of the network, and of the ecology (DeSanctis & Poole, 1994).

The second lesson is that there are multiple, legitimate ways to participate. Newbies and lurkers observe, acting as legitimate peripheral participants as the learn the norms of the environment (Lave & Wenger, 1991; Preece, Nonnecke & Andrews, 2004). They learn to be members of the community, and to become members of a profession, e.g., by learning 'to be' a doctor (Becker, Geer, Hughes & Strauss, 1961), to be e-learner (Haythornthwaite, 2013; Haythornthwaite & Andrews, 2011), an anthropologist (Jackson, 2015), or a networked scholar (Veletsianos, 2015). Through engagement with others, individuals come to know what constitutes community identity, their place in it, and the rules and norms for membership, recognition, and status.

And the third lesson is that there are multiple types of exchanges and contributions that make up an ecosystem. Single-threaded ecosystems have thin, non-resilient structures that crumble with one change; multi-threaded ecosystems persist even in the face of change. In learning ecosystems, we acquire more than just facts, more than just the know-what knowledge which is often the primary focus in knowledge transfer. For a learning ecosystem to function, there are more kinds of learning involved, of which the best known is professional know-how, i.e., how to apply factual knowledge. Also important within ecosystems and networks is how knowledge and tasks are allocated across people (or places): know-who (or know-where), i.e., knowing who performs what kinds of tasks, who (or where) to go to for different kinds of information or expertise, or to retrieve or deposit different kinds of knowledge or task appropriate resources (transactive memory). Members of ecologies build up mental models of cognitive social structures of who knows who, and who knows who knows what (Monge & Contractor, 2003).

Summarizing broadly from a number of studies conducted of work and information ecosystems, the relational mix has been found to include interactions directly related to work products specific to the group – e.g., computer programs, academic papers, teaching techniques, research conduct – but also relations of sociability and emotional support that sustains group belonging (Haythornthwaite, 2001, 2002, 2006, 2008; Gruzd & Haythornthwaite, 2013; Budhathoki & Haythornthwaite, 2013).

Examining single and/or multiple connections reveals the character of a network, leading to an understanding of what relations drive the interactional basis of the ecosystem, what allows for resilience in the face of changing membership or environmental conditions (e.g., changes in media use, changes from offline to online). It also shows the kinds of generic relational mechanisms that support specific kinds of ecosystems – hybrid (online and offline) learning, workplace learning, distributed learners; and what sets of relations build a sense of community (e.g., work plus emotion and sociability).

What can we learn from networks to create and strengthen ecologies of learning?

Understanding the relational mix is one part of understanding what one can learn from networks in support of learning ecologies. Another part is to consider the network structures. Social network representations of interaction patterns (sociograms) provide visual insight into how actors are connected, where the gaps exist in connectivity, who is included or excluded, and how far the ecosystem reaches.

As an illustration, Figures 1 and 2 present the network of discussion in two MOOCs (Massively Open Online Courses; both ran with the same eight week timeframe). These were produced using the Netlytic analysis system (netlytic.org), and show ties where one participant responds to or names another in their discussion board post. These are meant as illustration only and do not reflect the full interaction among

participants, but they do illustrate the use of the learning management system discussion boards. Figure 1 shows a densely connected network, reflecting active discussion with attention to others (because the tie is based on naming others). Figure 2 shows a sparsely connected network, with few posters tied to others through naming or responding. The many unconnected dots show that while posts were made, there was no conversation with others.

Such top-down views are excellent ways for instructors to create and strengthen network connections in the learning ecology. These visualizations immediately show the shape of the discussion environment and the structure of interaction among participants, by showing the density of connectivity, the presence of central and peripheral actors, and the placement of key actors. They can give a visual reflection of strategies determined for the discussion, allowing intervention in accordance with instructor goals. For example, if the instructor for the MOOC in Figure 2 intends interaction, but finds this lack of interaction is because of the technology, they can introduce another means of communication (anecdotally, from interviews with the instructor, this was the case).

In this way, instructors in a learning ecology act as a keystone species (Nardi & O'Day, 1999). The decisions they make about how group and class discussion will unfold, how they promote that, and what technologies they use all determine the communication pathways for the rest of the ecosystem. In my early studies of e-learners showed that the use of group projects created network configurations that replicated the group structure, showing tightly interconnected cliques for each team (Haythornthwaite, 2001, 2002). This is not surprising, but what was interesting was the media use associated with those with these strong in-class ties compared to those with weak in-class ties. Those with stronger ties used more means of communication: online chat, discussion boards and email. Those with weaker ties were connected only by the online class interaction, notably by the live chat sessions accompanying the real-time class interaction. Thus, the decision to use chat was equally the decision on how to connect weak ties; where such a medium disappears, no further connection persists among these individuals. Knowing that one medium creates the weak tie connectivity, and knowing that media shape interconnectivity, allows an instructor to be aware of how their ecology is connected and thus to be aware of consequences on the ecosystem of both instructional organization and of media use.

The instructor for the MOOC in Figure 1 has a different problem – too much discussion. Where an instructor wishes to be in on every conversation, this can be a problem. Many online instructors have already faced this kind of limit, and have accepted that it is not possible to be in such control of discussion. Collaborative learning perspectives provide theoretical support for accepting a more learner-managed discussion, with many practical references on how to teach online addressing this need (e.g., Rudestam & Schoenholtz-Read, 2010; Haythornthwaite & Andrews, 2011; for some cases, see Haythornthwaite & Kazmer, 2004). This is also well addressed by researchers in computer-supported collaborative learning and

the learning sciences (for reviews see Miyake, 2007; Hoadley, 2007). One area of recent development looks at collaborative course development and collaborative grading, both in response to the ecology of the Internet in supporting knowledge co-construction, and the challenge of the number of people who are participating (Paulin & Haythornthwaite, 2015).

While MOOCs are fairly bounded networks, i.e., people have to sign in to join the MOOC, open learning ecologies are more wide-ranging. There may be no authority tasked with running the discussion, monitoring conversations, helping new participants. The history of online, virtual communities has shown how roles and practices evolve to fill those positions. Members of the virtual community ecosystem come forward and become a new species of participant. So, too, in the learning ecosystem, new roles – species – have emerged. Network analysts would refer to these individuals as occupying certain roles and positions in the network. Across networks – ecologies – the same roles emerge based on giving and receiving the same kinds of resources (information, help, social support). For example, Preston (2008) found emergent roles of e-facilitators, braiders, and accomplished fellows among professional educators. E-facilitators help shape the argument, provide summaries, and influence the direction of the discussion; braiders re-interpret the debate in different styles for different audiences; and accomplished fellows set up working parties to explore a subject in more depth. Researching the experience of online learners, Montague (2006) identified the role of learner-leader; over their time online, these students took information, experiences, and opinions from inside and outside the learning context in an iterative process of learning and leading. Pollock and colleagues (2014), found e-learning teachers were acting as explainers, synthesizers and supporters who were explaining technology, synthesizing, explaining and extending content, and supporting students with their learning experience. In other contexts, Preece & Shneiderman (2014) found that new users of social media started out as readers before developing into contributors and, for some, into leaders; Gilbert & Paulin (2015) examined the role of 'most knowledgeable others', exploring how this position effected knowledge sharing across a network.

While the instructor and analyst may look top-down on interactions, seeing connectivity and network roles emerge, the individual learner may see a sea of separate elements that fail to coalesce into meaningful units for learning. The kinds of information available in top-down visualizations are also likely to be useful for participants as a way to get a better sense of the landscape of their learning ecology. At present, it is rare that development efforts focus on showing data to the learners, emphasizing much more elements of the system that an instructor can use. New dashboard implementations aimed at allowing student views are emerging, but not yet widespread (Verbert, Duval, Klerkx, Govaerts & Santos, 2013; Haythornthwaite, De Laat & Dawson, 2013). An example of using the networks for personal and network ecology learners is that of Maarten de Laat and Bieke Schreurs (De Laat & Schreurs, 2013; Schreurs & De Laat, 2014). Their analysis gather network data on teaching professionals, and then show them the networks diagrams that result.

Teachers are able to see the ecology and their place in it; and they can then take the opportunity to use this network information to reach out to others with shared interests and thereby improve their personal learning ecology.

Which is the impact of strong or weak ties in connecting different elements of our learning ecologies?

Shared interests provide the basis for creating a social network tie. Both weak and strong ties add to our network and our information ecology. Strong ties are those we hold with friends, close friends, colleagues, and in most cases with family members. Those who are strongly tied tend to be similar to each other (socioeconomically, professionally, by interest). Because of our similarity, we tend to have access to the same kinds of information, and feel motivated to share what we know or what we have. Encounters and interactions are frequent, and include both emotional and instrumental content; pairs share a high level of intimacy, and self-disclosure, reciprocity in exchanges, and the use of multiple means of communication. Strong ties form a persistent and well-travelled route in our network and ecology for exchange and connectivity.

By contrast, weak ties connect infrequently, by few means; few types of resources, information and support are exchanged and these are primarily of an instrumental, non-intimate kind. Our weak ties are with acquaintances and casual contacts, who tend to be unlike us in some way. The 'strength' of our weak tie contacts is that by not being like us, they attend to different parts of the ecosystem, and thus have connections to other people and other resources than do our strong tie partners. The downside is they have little or no obligation to share that information.

Another aspect to consider is how many strong or weak ties an individual can maintain, and thus the size of their ego-centric network. Research suggest the limit is associated with capacity of the 'social brain' and the time associated with maintaining relationships (Dunbar, 2016). Distributed learners are often faced with a whole new set of ties added into their existing ecology of ties for work, place, and family. They end up juggling multiple social worlds (Kazmer & Haythornthwaite, 2001), trying to integrate the new learning ecology – and the new information and professional practices it represents – into what Norman Jackson (2015) referred to as 'lifewide learning'. Instructors and learners are also juggling an ecology that supports many more means of communication: discussion boards, blogs, micro-blogging (e.g., twitter), social networking sites, media repositories, video, social bookmarking, virtual worlds. A recent study of the use of social media for teaching, with responses from 333 respondents, showed over two-thirds had or were using 10 different kinds of social media, and over a third were also contributors in these social media venues (Gruzd, Haythornthwaite, Paulin, Gilbert & Esteve del Valle, forthcoming; Esteve del Valle, Gruzd, Haythornthwaite, Gilbert & Paulin, 2017).

MOOC-size classes also challenge capacity with thousands of potential co-learners in the ecology. In earlier studies of e-learning classes, students across four classes

reported keeping strong ties with three others, strong to intermediate ties with three more, plus four ties from intermediate to weak. Beyond those ten ties, the view was only of 'other members of the class'. As this held across all classes, it suggests the kind a limit there is for maintaining closer ties in online class settings (Haythornthwaite, 2000). One way to increase the range of an ecology without increasing contact load is to maintain a network of network contacts. Connecting to five or ten similar others has far less information capacity than connecting to five people who themselves connect to five others. Many formal learning mechanisms make use of this means of extending learning and information capacity – from formal designation of roles for coordinated access, to use of the instructor role as connector to multiple others such as guest speakers.

As an individual, or as a learning ecology organizer, a mix of strong and weak ties is important as it provides both committed others in the personal network, e.g., those willing to explain and re-explain a concept (what Luckin, 2015, referred to as the 'zone of available assistance'), and more diverse others who can provide an opportunity to hear new ideas. Recent attention to the internet is suggesting a polarization of information access and exposure, with discussion is coalescing around similar views, e.g., dropping Facebook contacts who disagree with a political viewpoint, or reading only news that agrees with one's perspective. This polarization affects the learning ecology by all but eliminating discourse across divides, keeping only similar others in discussion with each other. A learning ecology may need to take steps to keep the information pathways open for learning, management and societal benefits.

How are the new online crowds and communities ecosystems going to affect learning?

A lot of effort has been spent to enhance the feeling and perceptions of belonging to an e-learning community; an effort that has focused on making learning ecologies that privilege strong ties over weaker ones. Now, however, both the rise of MOOCs and of crowdsourcing suggest the need for new views of learning ecologies. The rise of new ecologies of learning, such as citizen science projects, encyclopedia such as Wikipedia, and question and answer sites such as Reddit, raise questions about the organization of contemporary learning and knowledge building, and about motivations to learn and contributed to this knowledge (Rotman et al, 2014; Budhathoki & Haythornthwaite, 2013).

Two kinds of learning ecosystems seem to be emerging, each with different roles and expectations. The more familiar are community-based ecologies, which foster interaction and recognition from members who are known to each other (or getting to be known), whose contributions are attributed and visible to others; communities have an expectation of persistence and commitment, and thus often require training of varying levels in order to belong or progress, and reward structures that give greater importance to quality that matters to the community. By contrast, crowd-based initiatives coalesce around a centralized effort, based on a large and diverse set of actors who not known to each other yet who contribute to a common goal.

While some crowd tasks may be complicated, generally they are designed with little need for training or expertise before beginning to contribute, no need to interact with others, and no requirement for persistent or continued commitment; neither are these tasks designed in a way that requires evaluation, thus prioritizing quantity measures of contribution. (For more on these ideas of crowds and community structuring, see Budhathoki & Haythornthwaite, 2013).

It is perhaps typical to think of Wikipedia as a prime crowdsourced example. Anyone can modify content, with little training. However, Wikipedia is a good example of the dual nature of many instances of crowdsourcing. The 'talk' pages where contributions are evaluated and debated show the community aspect of this learning ecology. Citizen science initiatives are similarly designed for wide participation, with individuals coming to these sites because of interest in the science, whether their motivations are personal, e.g., to support career objectives, or altruistic, e.g., to contribute to knowledge. Either way, engagement with the science, and with others, perhaps particularly the opportunity to engage with experts, can be a motivating force for continued interaction and a sense of community with the subject matter. These new kinds of motivations become important areas of support for learning, and suggest directions for organizers of sites that do want to harness a crowd model in support of individual and collective knowledge, whether via an anonymous repository or a communal discussion space. It is worth applying the attention now being given to developing such spaces in the science, knowledge, and commercial spaces into application in learning spaces, and advancing new methods for promoting learning in a combined crowd-community ecosystem.

Supporting ecologies of learning

Learners sit at the nexus of multiple overlapping social worlds, each of which contains different people and demands for attention. The capacity to manage this load is limited and thus perhaps the first task for individuals in strengthening their learning ecology is to manage a network of networks that enhances their reach in finding sources and other contacts who can help in meeting their learning goals. Taking classes is, of course, a very typical way of expediting learning – gaining access to an expert and a class of like-minded individuals with whom to work on a problem. Online crowds and communities are becoming similar options, and can act as entry points for further contact and engagement.

The discussion of network aspects of learning ecologies suggests that strengthening individual ecologies also involves the work the organizer does for all learners. Effects of task choice, group work, media use and non-use each greatly affect who can and does talk to or work with whom and thus the connectivity of the organisms within the ecosystem – the learners within the network. Organizers can take a greater or lesser role in controlling those aspects, but should do so with the goals of interaction in mind, continuing to exercise the responsibility for 'presence' as the organizer ('teacher presence' in Garrison & Anderson's 2003 framing). Similarly, operators of online crowds and communities, and the hybrid versions that many

online environments exhibit, also have a need for 'presence', whether this is enacted in task design or by inclusion of community activity.

New forms of online organizing can already be seen to raise new patterns of interaction, new pathways and new ecologies. To date, education has grappled with the move from offline campus learning ecologies to online, e-learning ecologies, and the follow-on move to hybrid, online-offline ecologies. Outside education, learning ecologies have been embraced for public knowledge as shown through the multiple information sites and ecologies for knowledge exchange and personal interaction, from Wikipedia to social networking sites. In academia, learning through online document and publication sharing has shaken and reshaped the publishing ecology. The changes are not yet done, as teachers embrace social media in the classroom, as information literacy becomes more important in sorting the shifting information sands, and the knowledge production ecology undergoes further disruption with online crowds added to the already existing online communities. Every new set of interconnections shapes new networks, which in turn shape and form the basis of new learning ecologies. Networks and ecologies remain as important organizing ideas and metaphors that help in approaching and understanding change, practice and success in the design and presence of new learning environments.

References

Becker, H. S., Geer, B., Hughes, E.C. & Strauss, A.L. (1961). *Boys in White: Student Culture in Medical School.* Chicago, IL: University of Chicago Press.

British Ecological Society (2016). Glossary. Retrieved November 5, 2016 from: http://www.britishecologicalsociety.org/glossary/

Brown, J.S. (1999). Learning, Working & Playing in the Digital Age. Paper presented at the 1999 Conference on Higher Education of the American Association for Higher Education. Retrieved November 5, 2016 from: http://serendip.brynmawr.edu/sci_edu/seelybrown/seelybrown.html

Brown, J.S. & Duguid, P. (2000). *The Social Life of Information.* Boston, MA: Harvard University Press.

Bruce, B. C., & Hogan, M. P. (1998). The disappearance of technology: Toward an ecological model of literacy. In D. Reinking, M. McKenna, L. Labbo, and R. Kieffer (Eds.), *Handbook of literacy and technology: Transformations in a post-typographic world* (pp. 269-281). Hillsdale, NJ: Erlbaum.

Budhathoki, N. R. & Haythornthwaite, C. (2013). Motivation for open collaboration: Crowd and community models and the case of OpenStreetMap. *American Behavioral Scientist, 57*(5), 548-575.

Cohen, W. M. & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*, 128-152.

Davenport, T. H. & Prusak, L. (1997). *Information Ecology: Mastering the information and knowledge environment*. NY: Oxford University Press.

De Laat, M.F. & Schreurs, B. (2013). Visualizing Informal Professional Development Networks: Building a Case for Learning Analytics in the Workplace. American Behavioral Scientist 57(10), 1420-1437.

DeSanctis, G. & Poole, M. S. (1994). Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization Science, 5*(2), 121-47.
Dunbar, R.I.M. (2016). Do online social media cut through the constraints that limit the size of offline social networks? Royal Society Open Science, 3, 150292. http://dx.doi.org/10.1098/rsos.150292.
Esteve del Valle, M., Gruzd, A., Haythornthwaite, C., Gilbert, S. & Paulin, D. (2017). Social media in educational practice: Faculty present and future use of social media in teaching. *Proceedings of the 50th Hawaii International Conference on System Sciences*, Big Island, HI. Los Alamitos, CA: IEEE Computer Society.
Garrison, D. R., & Anderson, Terry. (2003). *E-learning in the 21st Century: A Framework for Research and Practice*. RoutledgeFalmer, NY.
Gilbert, S. & Paulin, D. (2015). Tweet to learn: Expertise and centrality in conference Twitter networks. *Proceedings of the 48th Hawaii International Conference on System Sciences*, Kauai, HI. Los Alamitos, CA: IEEE Computer Society
Girard, M. and Stark, D. (2007). Socio-technologies of assembly: Sense-making and demonstration in rebuilding lower Manhattan. In V. Mayer-Schönberger & D. Lazer (Eds.), *Governance and Information Technology: From Electronic Government to Information Government* (pp. 145-176). Cambridge, MA: MIT Press.
Gruzd, A. & Haythornthwaite, C. (2011). Networking online: Cybercommunities. In J. Scott & P. Carrington (Eds.), *Handbook of Social Network Analysis* (pp. 167-179). London: Sage.
Gruzd, A. & Haythornthwaite, C. (2013). Enabling community through ssocial media. *Journal of Medical Internet Research.* 2013;15(10):e248. http://www.jmir.org/2013/10/e248/. DOI: 10.2196/jmir.2796 PMID: 24176835.
Haythornthwaite, C. (2000). Online personal networks: Size, composition and media use among distance learners. *New Media and Society*, *2*(2), 195-226.
Haythornthwaite, C. (2001). Exploring multiplexity: Social network structures in a computer-supported distance learning class. *The Information Society, 17*(3), 211-226.
Haythornthwaite, C. (2002). Strong, weak and latent ties and the impact of new media. *The Information Society*, *18*(5), 385 – 401.
Haythornthwaite, C. (2006). Learning and knowledge exchanges in interdisciplinary collaborations. *Journal of the American Society for Information Science and Technology*, 57(8), 1079-1092.
Haythornthwaite, C. (2007). Social networks and online community. In A. Joinson, K. McKenna, U. Reips & T. Postmes (Eds.), *Oxford Handbook of Internet Psychology* (pp. 121-136). Oxford, UK: Oxford University Press.
Haythornthwaite, C. (2008). Learning relations and networks in web-based communities*. International Journal of Web Based Communities*, *4*(2), 140-158. DOI: 10.1504/IJWBC.2008.017669.
Haythornthwaite, C. (2013). Emergent practices for literacy, e-learners, and the digital university. In Robin Goodfellow & Mary Lea (Eds). *Literacy in the Digital University* (pp. 56-66). London: Routledge.

Haythornthwaite, C. (2014). Learning networks. In R. Alhajj & J. Rokne (Eds.) *Encyclopedia of Social Network Analysis and Mining* (pp. 785-793). Springer Science+Business Media, New York.
Haythornthwaite, C. & Andrews, R. (2011). *E-learning Theory and Practice*. London: Sage.
Haythornthwaite, C. & Kazmer, M.M. (Eds.) (2004). *Learning, Culture and Community in Online Education: Research and Practice*. NY: Peter Lang.
Haythornthwaite, C., De Laat, M. & Dawson, S. (Eds.) (2013). Learning analytics. *American Behavioral Scientist*, 57(10), whole issue.
Haythornthwaite, C., De Laat, M. & Schreurs, B. (2016). A social network analytic perspective on e-learning. In C. Haythornthwaite, R. Andrews, J. Fransman & E. Meyers, *Handbook of E-Learning Research*. (pp. 251-269). London: Sage. (7K words)
Hoadley, C. (2007). Learning sciences theories and methods for e-learning researchers. In R. Andrews and C. Haythornthwaite (Eds.), *Handbook of E-learning Research* (pp. 139-156). London: Sage.
Jackson, N. (Nov. 12, 2015). Lifewide learning. Paper presented at the "New Contexts, Multiple Mechanisms: Learning Ecologies" seminar. Universitat Oberta de Catalunya, Barcelona, Spain.
Kazmer, M.M. & Haythornthwaite, C. (2001). Juggling multiple social worlds: Distance students on and offline. *American Behavioral Scientist, 45*(3), 510-529.
Knorr-Cetina, K. (1999). *Epistemic Cultures: How the Sciences Make Knowledge*. Cambridge, MA: Harvard University Press.
Lave, J. & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge, UK: Cambridge University Press.
Luckin, R. (2010). *Re-designing Learning Contexts: Technology-rich, Learner-centred Ecologies*. Abingdon, UK: Routledge.
Luckin, R. (Nov. 12, 2015). Resources-based Ecologies. Paper presented at the "New Contexts, Multiple Mechanisms: Learning Ecologies" seminar. Universitat Oberta de Catalunya, Barcelona, Spain.
Miyake, N. (2007). Computer supported collaborative learning. In R. Andrews and C. Haythornthwaite (Eds.), *Handbook of E-learning Research* (pp. 248-265). London: Sage.
Monge, P. R. & Contractor, N. S. (2003). *Theories of Communication Networks*. Oxford, UK: Oxford University Press.
Montague, R-A. (2006). *Riding the Waves: A Case Study of Learners and Leaders in Library and Information Science Education*. Unpublished doctoral dissertation. University of Illinois at Urbana-Champaign, Champaign, IL.
Nardi, B. & O'Day, V. (1999). *Information ecologies: Using technology with heart.* Cambridge, MA: MIT Press.
Paulin, D. & Haythornthwaite, C. (2016). Crowdsourcing the curriculum: Redefining e-learning practices through peer-generated approaches. *The Information Society,* 32(2), 130–142. doi:10.1080/01972243.2016.1130501.
Pollock, M., Yonezawa, S., Gay, H., Rodriguez, L., Garcia, G., Qassimyar, M., et al. (2014). *Innovating toward equity with online courses: Testing the optimal 'blend'*

of in-person human supports with low-income youth and teachers in California. CREATE Equity Research Report, 1 March. Retrieved 14 August 2015 from https://create.ucsd.edu/research/CREATE%20Equity%20RR_1Mar2014.pdf

Preece, J. and B. Shneiderman (2009) "The Reader-to-Leader Framework: Motivating Technology-Mediated Social Participation. *AIS Transactions on Human-Computer Interaction, 1*(1), 13-32.

Preece, J., Nonnecke, B., & Andrews, D. (2004). The top five reasons for lurking: improving community experiences for everyone. *Computers in Human Behavior, 20*(2), 201–223. http://dx.doi.org/10.1016/j.chb.2003.10.015

Preston, C. J. (2008). Braided learning: an emerging process observed in e-communities of practice. *International Journal of Web Based Communities, 4*(2), 220-243.

Rotman, D., Hammock, J., Preece, J., Hansen, D., Boston, C., Bowser, A. & He, Y, (2014). Motivations affecting initial and long-term participation in citizen science projects in three countries. *Proceedings of the iConference*.

Rudestam, K.E. & Schoenholtz-Read, J. (2010). *Handbook of Online Learning, 2nd edition*. Thousand Oaks, CA: Sage.

Schreurs, B., & De Laat, M. (2014). The Network Awareness Tool: A web 2.0 tool to visualize informal networked learning in organizations. Computers in Human Behavior, 37, 383-394.

Siemens, G. (Oct. 17, 2003). Learning Ecology, Communities, and Networks: Extending the classroom. *Elearnspace.* Retrieved November 5, 2016 from: http://www.elearnspace.org/Articles/learning_communities.htm

Star, S. L. (1995). *Ecologies of Knowledge: Work and Politics in Science and Technology*. Albany, NY: SUNY.

Star, S. L. and Strauss, A. (1999). Layers of silence, arenas of voice: The ecology of visible and invisible work. *CSCW, 8* (1-2), 9-30.

Veletsianos, G. (Nov. 12, 2015). Networked scholars. Paper presented at the "New contexts, multiple mechanisms: Learning Ecologies" seminar, Universitat Oberta de Catalunya, Barcelona, Spain.

Verbert, K., Duval, E., Klerkx, J., Govaerts, S. & Santos, J.L. (2013). Learning analytics dashboard applications. *American Behavioral Scientist*, 57(10), 1500-1509. doi:10.1177/0002764213479363

Figure 1: A densely connected MOOC discussion network

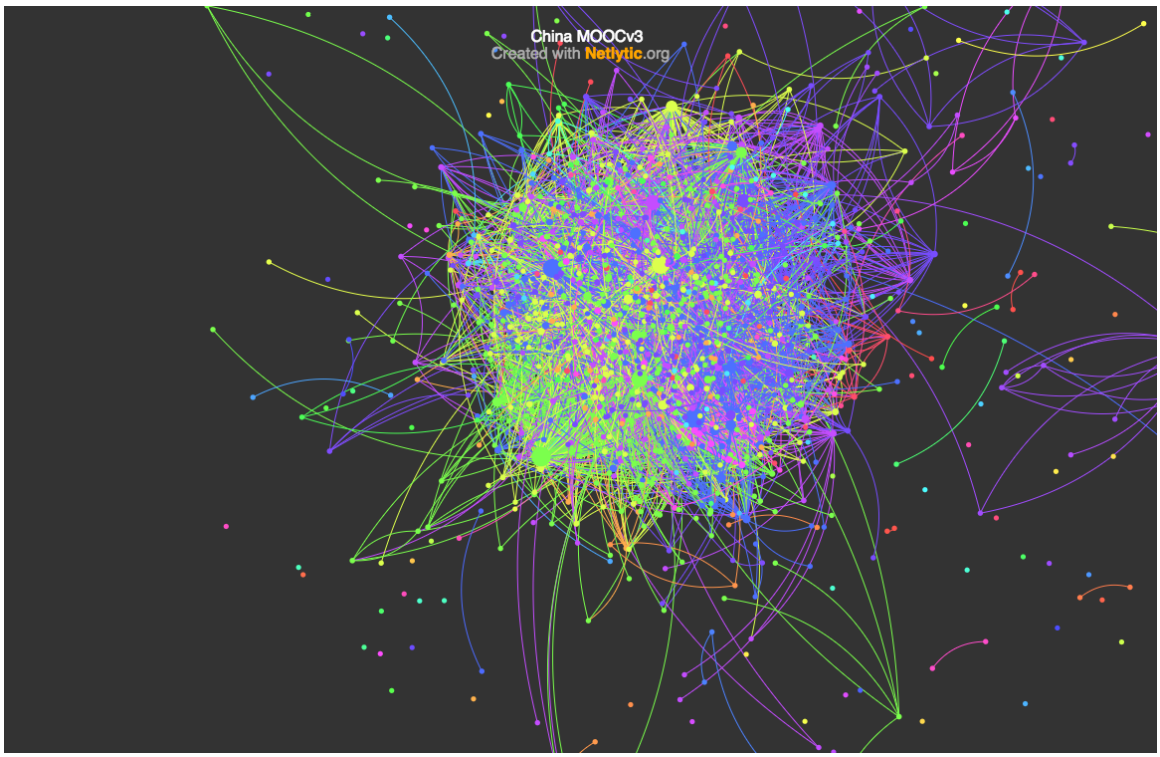

Figure 2: A sparsely connected MOOC discussion network