2014

Modeling Information Diffusion in University Libraries: Assessing Peer Interaction Patterns as a Complex Dynamic System

W. Michael Johnson
CUNY City College

Danuta A. Nitecki
Drexel University

Modeling Information Diffusion in Academic Libraries: Managing Peer Engagement as a Complex Dynamic System

W. Michael Johnson, Adjunct Professor, The Bernard and Anne Spitzer School of Architecture, The City College of New York. mjohnson3@ccny.cuny.edu
Danuta Nitecki, Dean of Libraries and Professor, College of Computing and Informatics, Drexel University

This paper was presented on June 6, 2014, at a City University of New York conference entitled: *Reinventing Libraries/ Reinventing Assessment: Innovative Practices and Ideas that Challenge the Status Quo,* held at The William and Anita Newman Conference Center, Baruch College.

Peer Engagement in Context

A growing group of practitioners and researchers are now exploring relationships between human learning behavior and physical space. We describe a study to research information diffusion as a complex system of face-to-face exchange. The proposed research describes a quantitative method and predictive model to identify specific physical mechanisms that contribute to information diffusion and cooperative information sharing behaviors among students. The work studies the dynamic patterns of naturally occurring, spontaneous learning that occur among peers outside of classrooms, believing that this informal peer-based learning provides essential reinforcement of ideas presented within classrooms. We focus on understanding the physical structure of interrelated conditions that afford peer engagement, seeking to maximize opportunities for peers to engage and share knowledge.

The physical structures of institutions have long been understood to play central roles in shaping academic communities. [1] Determining which specific attributes serve to support student learning and engagement has proven to be an unexpectedly difficult problem. Yet, there are compelling financial and pedagogical needs among institutions to identify the specific physical mechanisms which influence direct student interaction. Recent studies in behavioral economics, neuroscience, and ecology have helped form answers to this question, allowing us to understand the social conditions that frame varied learning processes.[2345] Our ability to learn, and by extension our cognition, are deeply influenced by social

[1] "The physical attributes of a resource always play a central role in shaping the community." Hess, Charlotte, Ostrom,Elinor. "Analyzing the Knowledge Commons". *Understanding Knowledge as a Commons*. Eds. Hess, Charlotte., Ostrom, Elinor. Cambridge: MIT Press. 2007. 45.

[2] Mani, Anandi et al. "Poverty Impedes Cognitive Function." *Science* 341.6149 (2013).

[3] Niwa, Minae et al. "Adolescent Stress-Induced Epigenetic Control of Dopaminergic Neurons via Glucocorticoids." *Science* 339.6117 (2013).

environments. Physical resources interact with the social contexts that frame peer engagement behaviors. Thus, physical factors affecting behavior cannot be evaluated in isolation. We posit that as with studies of natural ecosystems, the social behaviors in educational ecosystems must be studied together *en situ* as an integral dynamic system.

Human behavior in learning environments is subject to diverse factors, ranging from psychological, sensory, and environmental variables. Within this universe of possibility, individual learning styles also vary significantly across any given population.[6] It is therefore understandable that social learning environments are now often referred to as ecosystems of learning. Natural ecosystems define sets of relationships among species and physical environments so varied that they defy individual understanding. Educational institutions are similarly composed of interacting populations with diverse social and physical interrelationships. These educational ecosystems have proven difficult to study. Given these complex relationships, scholars have not studied how different learning styles interact in the field, nor how varying proportions of learning behaviors may broadly affect a large population.[78] But in an ecosystem proportion among elements matters, and in a social group consisting of diverse behavioral phenotypes, the proportion of types of learning behavior may have far-reaching effects on an overall student population.

Our research builds upon two central premises. First, the flow of information within face-to-face networks is dependent upon proximity. The amount and accuracy of information transfer depends upon close physical distance. This is important because close physical distance between peers can be observed and measured. Physical proximity can be used as a direct proxy for the *process* of information diffusion. Second, libraries are network hubs of unusual importance. Academic libraries are the physical nexus of information

---

[4] Graziano, Michael. *Consciousness and the Social Brain*. New York: Oxford University Press. 2013. 89.

[5] Laland, Kevin N. "Social Learning Strategies." *Learning & Behavior* 32.1 (2004): 4–14.

[6] Nisbett, Richard. *The Geography of Thought: How Asians and Westerners Think Differently… and Why*. New York: Free Press. 2003. 123.

[7] Shultz, Susanne. Dunbar, Robin. "Bondedness and Sociality." *Behaviour* 147.7 (2010): 775–803.

[8] Figueredo, Aurelio, Wolf, Pedro, et. al. "Ecological Approaches to Personality". *The Evolution of Personality and Individual Differences*. Eds. Buss, David, Hawley, Patricia. New York. Oxford University Press. 2011. 227-233.

distributed throughout a campus. These dense centers of face-to-face information exchange offer exceptionally valuable opportunities for institutions to understand and cultivate peer engagement behaviors.

Proximity and the Process of Information Diffusion

Any clear understanding of how a physical structure may alter a population of behaviors must also address the central question of agency. If one cannot quantify the conscious experience of a single student, how would the behavior of a population of students be studied? Yet, while the *content* of student interactions may defy meaningful quantification, the physical *process* of face-to-face information exchange is dependent on a specific range of physical distance among peers. Rather than suggesting that general knowledge originates outside of classrooms, we assert that face-to-face peer networks provide the robust structure to intentionally distribute, reinforce, and solidify student knowledge.[9]

The process of information exchange is dependent on patterns of engagement that may be clearly seen, recorded, and analyzed. In libraries and other dense areas of peer interaction, collective patterns of proximate physical distance describe patterns of face-to-face information exchange. These patterns of dense transfer are an essential, if not well understood, institutional resource that can be quantified through observation and cultivated. The number, timing, and duration of these physical interactions may be directly sampled visually over time, and on a mass scale these measurements reflect key aspects of an institution's ability to transfer knowledge among students. The pattern of peer interaction is a dynamic record of shared learning cooperation among students. The spatial pattern of interaction becomes a record of the *cooperation dynamic* of information exchange in a student population.

Libraries as Hubs of Engagement

Institutions have long valued the high volume of student peer interaction associated with academic libraries. They recognize these places as essential common resources. Libraries and similar areas of dense peer engagement are settings that enable high-volume information exchange. These

[9] Anastasia, Thomas. Ehrenberger, Kristen Ann. *Individual and Collective Memory Formation.* Cambridge: MIT Press. 2012. 62.

places are the settings for information networks of disproportionately high connectedness. It is the density and proximity of social resources available to students, *together* with universal access to information content available through the Internet that changes our understanding of the volume of knowledge available to students. For each student's past experience allows them to access very different on-line information sources. Access to diverse information from cooperative peers is a disproportionately valuable and dominant resource within these settings.[10] Further, the potential volume of trusted information accessible through peer engagement increases geometrically as the diversity of the group increases.[11] Students are acutely aware of the depth of these peer resources particularly at the end of terms when time is limited. The physical spaces within libraries that house these dense networks of repetitive interaction form highly efficient knowledge commons.[12]

Knowledge commons within libraries are network nodes of unusual value. Occupying privileged positions within networks, these hubs funnel information distributed throughout a campus. These centers are the foci of intentional learning behaviors that many institutions actively seek to promote. Andrew Delbanco has noted that these are the places where academic institutions expose students to three foundational missions: unencumbered access to opportunities for personal achievement, the analytical tools necessary for sustaining a full and examined life, and a "rehearsal space" for developing dialogues critical to sustaining democratic traditions. It is not by accident that the development of each of these foundational values depends on repetitive face-to-face interaction. Collectively these interactions provide a deep multi-sensory context for undergraduates to learn a process that enables trust and promotes the open and reasoned exchange of ideas. These are the spaces where cooperative behaviors are vetted, tested and learned, creating natural laboratories where the missions of educational institutions are inculcated among peers. [13]

---

[10] boyd, danah. *Its Complicated: The Social Life of Networked Teens*. New Haven, Yale University Press. 2014.

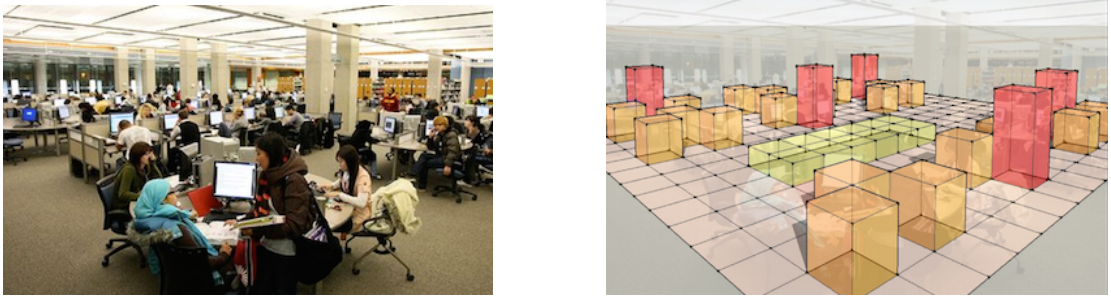
[11] Page, Scott. *Diversity and Complexity.* Princeton: Princeton University Press. 2011. 190.

[12] Levine, Peter. "Collective Action, Civic Engagement, and the Knowledge Commons". *Understanding Knowledge as a Commons*. Eds. Hess, Charlotte., Ostrom, Elinor . Cambridge: MIT Press. 2007. 252.

[13] Delbanco, Andrew. *College: What it Was, Is and Should Be.* Princeton: Princeton University Press. 2012. 177.

Experimental Method and Predictive Model

We employ an inductive observational method using time-lapse photography with smart phones to correlate specific physical and sensory factors with the probability of peer interactions within library settings. Quantitative photographic data are used to refine the predictive social actor model that in turn reflects the specific physical conditions at each institution. Time-lapse data and a predictive model are used together to determine specific small-scale incremental changes in physical accommodation. The resulting peer engagement behaviors are then sampled and compared with baseline engagement behaviors. The diagnostic system allows institutions in this way to manage peer engagement as a common resource within their existing facilities.



An open learning environment at the University of Toronto on the left, showing conditions affording peer engagement in the foreground and carrels in the middle ground that do not. A diagnostic perspective of the same condition is shown on the right. The model simplifies the information in the photograph to emphasize the shape of the learning ecosystem, proximity, and density of engagement choices. The diagnostic system integrates field data with a predictive computational social actor model.

The predictive model is a computational model that describes the probability of interaction among student peers. It consists of social actors interacting within a landscape of accommodations derived from specific site conditions. This social actor model is a type of agent-based model (ABM), a non-linear model that examines the influence of related factors, rather than the direct cause between factors. We employ an existing ABM social actor model that over time records and updates the disposition of socially connected agents moving in specific landscapes of accommodation. Each agent's disposition to engage or not is governed by an algorithm summing three factors: each actor's history, her present condition, and the current disposition of her social network. [14]

[14] Epstein, Joshua. *Agent_Zero: Towards Neurocognitive Foundations for Generative Social Science*. Princeton: Princeton University Press. 2014.

The time-lapse data collection method proposed is minimally intrusive, following the 2014 National Academies of Sciences "Not human-subjects" protocol. (Students are objects of the research but they are not controlled or subject to manipulation.) Individual sample areas include control areas with physical conditions that remain unchanged throughout. Recording areas are also analyzed for contributing sensory factors that may influence peer behaviors. The experimental method is a diagnostic to directly measure the dynamic of peer engagement and document the *cooperation dynamics* of a student population.

A Diagnostic System Measuring Peer Engagement

The method, model, and framework together establish a three-part diagnostic system integrating empirical information, predictive modeling and a experimental design that can be applied in diverse contexts, and enable independent verification and information sharing among institutions. The method establishes a common language, experimental design, and metric of analysis to compare, evaluate, and verify quantitative information from different sites at separate institutions, quickly and at very low cost. The model provides the theoretical base to guide empirical studies, and allows the research to connect with a large body of interdisciplinary work studying the dynamics of cooperation in the field. Together, the analytical framework identifies links between common engagement behaviors and specific physical factors, while establishing a database to inform and refine an important set of social modeling applications.

The framework allows institutions to study, share relevant findings, and identify key individual factors that affect peer engagement by establishing a common experimental approach. Without a common framework, isolated independent knowledge does not accumulate.[15] This approach provides a common methodology, predictive model, and analytical framework to fill a gap separating well-documented work studying student behavior and assessment and more recent ethnographic efforts studying intentional learning in higher education. [16] The cooperation dynamics framework we describe complements these approaches by directly studying the individual physical parameters that promote

[15] Ostrom. Elinor. "A General Framework for Analyzing Sustainability of Social-Ecological Systems." *Science* July 24 2009: 420.

[16] The National Survey of Student Engagement, The Australian Survey for Student Engagement and the Higher Education Academy in the United Kingdom.

dense cooperative peer engagement within specific physical contexts.

Conclusion and Directions for Future Work

Our aim in this paper has been to describe a simple model to quantitatively evaluate and cultivate peer engagement behaviors in academic libraries. Our approach looks at the process of peer cooperation as a dynamic record of face-to-face information diffusion. The model is based on two premises: close physical distance is required for information diffusion, and libraries are the natural focal points for studying the networked learning behaviors that matter most to institutions. With these two premises, we are able model the complex dynamic of information flowing through academic libraries and maximize opportunities to transfer information through trial and error experimentation, thereby increasing the bulk amount of information available to peers on a potentially massive scale. Our approach seeks to increase the overall efficiency of information exchange within each institution.

Studying cooperation dynamics allows institutions to quantify, assess, and cultivate peer engagement behaviors in libraries. But further, it allows us to assess and devote resources where it matters most, in libraries that can dynamically adapt and promote peer engagement to serve an increasingly broad spectrum of students. As institutions seek to engage more diverse populations, the ability to dynamically increase peer engagement will become of central importance. Institutions need reliable predictive systems supporting adaptive management that promotes widespread and equitable access to information. Understanding the cooperation dynamics of a student population enables institutions to integrate the management of resources and peer engagement in libraries, at the nexus of information flow on campuses. Libraries dynamically and proactively managed to adapt to rapid technological and social change.[17]

[17] We look forward to implement this study soon and invite identification of additional venues to test the methodology and contribute evidence for building greater understanding of information diffusion in academic libraries. Please contact mjohnson3@ccny.cuny.edu for further information.