Digital Libraries for Open Science: Using a Socio-Technical Interaction Network Approach

Jennifer E. Beamer[1,2](✉)

[1] University of Hawaii at Manoa, Honolulu, HI, USA
jbeamer@hawaii.edu
[2] The Claremont Colleges Library, Claremont, CA, USA

Abstract. This paper argues that using Socio-Technical Interaction Networks to build on extensively-used Digital Library infrastructures for supporting Open Science knowledge environments. Using a more social -technical approach could lead to an *evolutionary* reconceptualization of Digital Libraries. Digital Libraries being used as knowledge environments, built upon on the document repositories, will also emphasize the importance of user interaction and collaboration in carrying out those activities. That is to say, the primary goal of Digital Libraries is to help users convert information into knowledge; therefore, Digital Libraries examined in light of socio-technical interaction networks have the potential to shift Digital Libraries from individual, isolated collections to more interoperable, interconnected knowledge-creating repositories that support an evolving relationship between open science users and the Digital Library environment.

Keywords: Digital libraries · Open science · Socio-Technical Interaction Networks

1 Digital Libraries as Socio-Technical Systems

The purpose of this short paper is to suggest that the use of a social informatics framework could be helpful in examining the potential ways in which Digital Libraries (DLs) may support the practices of open science. DLs have become increasingly fundamental to conducting research [1, 2], and there is a corresponding need for them to not only support intellectual work, but also to transform into sites of collaborative knowledge production. The structure of this paper is as follows: First, it argues that DLs are socio-technical systems that deserve study as such. Next, there is a brief introduction to the underlying premise of social informatics (SI) and the strategy of socio-technical interaction networks (STIN) for examining how DLs can be examined. This is followed by a concise analysis, concluding with what may be some outcomes of using this underutilized strategy for open science. It should be noted that this paper is introductory in nature. Its objective is to argue for the refocusing of technical infrastructure to include more socio-technical elements. Thus, this short paper only presents a preliminary framework, and does not include specific evidence; future work will include research questions, data, and findings.

P. Manghi et al. (Eds.): IRCDL 2019, CCIS 988, pp. 122–129, 2019.
https://doi.org/10.1007/978-3-030-11226-4_10

DLs can be thought of as "socio-technical systems" composed of an "interrelated and interdependent combination of people, their social and work practices, the norms of use, hardware and software, the support systems that help users, the maintenance systems that keep them operating" [3]. That is to say, technical systems are interacting within an institutional and cultural context, and as such the technology informs the social and vice versa. Furthermore, these socio-technical processes essentially demonstrate collaboration between human and nonhuman actors, as they are assembled and reassembled in different ways to different ends [4].

In contrast, open science and the researchers engaging in the practices of open science operate in a similar socio-technical knowledge ecosystem. Open science practices may vary with the individual, but nevertheless rely heavily on collaboration within communities of practicing researchers. This collaboration among themselves is facilitated by the dependence upon an ever-improving and advancing digital infrastructure—often to the point of success or failure of their entire projects [5]. Researchers may practice in communities or groups, or teams, embracing the groundwork created by those before them, or be a pioneer themselves incorporating flexible (or sometimes work-around) features of DLs. Open science relies on DLs to support, construct, and build these different kinds of knowledge communities that use their content and services [6].

While prior DL research has thoroughly explored social-community practices, or the technical-system features of DLs, a comprehensive search of the literature shows that it has rarely intersected to include both the social and the technical. The socio-technical exploration, i.e., the mutual, concurrent, and reciprocal shaping of technology and society [7], has largely been under researched. This paper is proposing that this intersection is precisely what should be considered for future exploration. DLs have an opportunity to contribute to open science by improving already existing DL platforms and tools, thereby enhancing their open science practices, and their interconnected communities and collaborations.

Already in the past few decades, DLs and their architects have largely transformed and modernized scholarly publishing, the philosophy behind academic and research libraries and universities, the methods of access to information resources, intellectual property practices, and the very relationships between authors, libraries, publishers and readers [3]. Thus, it is argued that *by conducting a holistic examination into the relationship between the social and technical, the outcome will provide more* ***meaningful*** *data on the implications for DLs to generate more support for open science communities and collaborative practices.* The socio-technical approach I propose is not new (it is in fact an underutilized social informatics approach), and it is a strategy for identifying, organizing and comparatively analyzing (a) the patterns of social interaction within a system's development, and (b) the configuration of components that constitute an information system [8].

2 Social Informatics and the Emergence of Socio-Technical Interaction Networks

The premise of SI is that it focuses upon the relationships between information and communication technologies (ICTs) and the larger social context in which they exist [9]. For decades, DL programmers, librarians, systems specialists, users, scientists, researchers, and institutions have already been working collaboratively to build, innovate and sustain DLs. Specifically, conducting SI research means a shift to reframe the focus on understanding “the interdisciplinary study of the design, uses and consequences of information technologies that take into account their interaction with institutional and cultural contexts” [10]. SI researchers hold several premises. First, CTs and the social and organizational settings in which they are embedded are in a relationship of mutual shaping [10]. Second, their analyses frequently challenge commonly-held assumptions about information technologies, and often attempt to improve the lives of the people who work and play with ICTs [10].

Designed to provide a specific tool for understanding socio-technical systems in a way that advantages neither the social nor the technical aspects of a system, the STIN strategy was proposed as a framework for SI analysis [413]. In the early 2000s STIN was used to examine topics in which we are concerned with today DLs and the advancement of open; scholarly communication forums [ibid], democratization of scholarly publishing [12], web information systems [13], online communities [14], and DLs [15].

The most extensive study was conducted by Kling et al. in 2003 [9], where they conducted one of the most extensive analysis using their STIN strategy. They examined what they called electronic scholar communication forums (eSCFs). At the time these might have been considered to be DLs in their own right: arXiv.org, Flybase, ISWORLD, and CONVEX. One of their conclusions was that “technological developments themselves will not overcome issues embedded in the social contexts into which the technologies are introduced” [9]. Another important finding was that an understanding of the business models of the supporting organizations was necessary to understand the STIN, and that an understanding of the social relationships imbedded in the STIN was helpful in understanding how the technological innovations of electronic publishing were used and sustained. Their findings highlight the interconnected nature of knowledge creation, i.e., the many stakeholders and the interactions, organizations, systems and relationships that support the eSCFs.

Philosophically, there are two main rationales for embracing a SI approach. First, the goals and achievements of SI are congruent with the researchers’ objectives and motivations. Second, a holistic method of investigation assumed by SI research provides more meaningful data. SI researchers aim to develop “reliable knowledge about information technology and social change based on systematic empirical research, in order to inform both public policy issues and professional practice” [16].

Kling et al. established a series of theoretical models and frameworks for supporting the transition between descriptive data, interviews, observations, and results that would be useful to wider communities [11]. The STIN strategy drew from other established SI theories such as the Social Construction of Technology (SCOT) [17] and in parallel to, but independently of, Actor Network Theory [18, 19].

3 Using STIN Strategy to Examine Digital Libraries

STIN is not traditionally referred to as a theory because it doesn’t lead to strong predictions [11]. Instead, it is typically referred to as a framework or a strategy [20]. For the purposes of examining DLs, the elements used in conducting a STIN study may form a theoretical viewpoint, in that they are arranged in a way that implies a pattern of relations among concepts or even possibly the basis of a theory. The elements could define how the researcher perceives the issue and then how the researcher could address the challenge of answering the research questions.

All of the various elements involved in a network are considered nodes. These nodes are likely to include people, groups, organizations, devices, infrastructures, resources, processes, content, and policies. The nodes are not static elements, but interactors. The networks are dynamic, and the focus is on the relationships between elements.

STIN research is implemented by following the eight heuristics and include:

H1. Identify interactors (likely actors, their roles, and their needs);
H2. Identify core interactor groups;
H3. Identify incentive structures (such as a business model or motivation);
H4. Identify excluded actors and undesired interactions;
H5. Identify existing communication forums (communications systems or ecologies) and their relationships to this STIN;
H6. Identify resource flows (following the money);
H7. Map architectural choice points (technological features or social arrangement in which the designer has historically selected alternatives);
H8. Describe viable configurations and trade-offs.

From the eight heuristics above, a standard model is built and then subsequently disassembled. Its purpose is to abstract a series of underlying commonly-held assumptions about the information system's design of study. For example, for Kling [11], the standard model was built from literature about electronic scholarly communication forums. By building a standard model, researchers can incorporate conceptions that are incomplete or left out of the standard models. "What is left out of the standard models are important features of very specific technologies and settings in which people try to use them, the organizational complexity in which IT-based services are provided and embedded" [11: 49]. In contrast to the standard model, the alternative STIN model helps "to map some of the key relationships between people and people, between people and technologies, between technologies and their infrastructures and between technologies" [11: 49].

4 STIN Analysis for DLs

The usefulness of the STIN heuristics is entrenched in thirty years of technology analysis. First, H1 interactors are understood to include both human and non-human actors [11: 66], as well as non-material elements such as standards [21] and processes and traditions, potentially including dispositifs [21: 61]. Instructing the researcher to group these interactors as evident in H2 draws attention to their interactions. The organizational relationships between groups of people may have a greater impact within the STIN than dyadic human-computer interactions [21, 22].

Incentive structures H3 are identified as business models at a macro level, while at a more micro-, personal level, they need to be considered in terms of motivations.

For example, open science researchers adopting a new technology for open publishing need to consider how time spent on this will have an impact on the time available for activities which traditionally further their career, such as publishing papers in closed high-tier journals for promotion or tenure. Kling et al. [11: 57-8] use the term "communications systems" for H5, communication ecologies and existing communication forums to describe the participant's communications systems, including non-digital systems. These are predominantly understood as networks of people, rather than devices and wires [13, 21].

One of the strengths of the STIN approach for studying systems is the direction to look beyond the network [24]—first by identifying those who are the excluded actors under H4, and then by identifying the wider communication ecologies in H5 which interact with the STIN. The external elements can reveal vital perspectives, both in terms of the impacts of a system and influences on its development and use. These attentions are important where exclusion is a concern and successful participation requires the interaction of diverse stakeholder group in DLs and open science communities. Identifying undesired interactions within H4 draws attention to the experiences supported by the system. Interactions should also be considered in terms of privacy and surveillance [11: 57].

While it is useful to consider resource flows H6 in terms of following the money, the researcher is also reminded to think in terms of "resource dependencies" and "account-taking dependencies" [11, 13]. "Resource dependencies" relate to interactions which need funding, knowledge, skills, prestige or trust; "account-taking dependencies" relate to links or interactions based upon some kind of social rating [13: 102]. Resource flows also draw attention to infrastructural elements, as sooner or later these need skilled attention and financial investment.

Mapping architectural choice points under H7 relates to technical systems, but it can also refer to social processes. The researcher is directed towards the history of the system, to look at the points where choices have been made which may be considered as forks in the path of the development of the system.

Finally, H8 describes viable configurations and trade-offs. This step supports the researcher to think beyond the present system and consider potential changes (alternative configurations).

The data on which STIN models are based may be gathered through various methods, including interviews, observation, and studying materials associated with the network [9: 66]. If a STIN approach is established before data collection, the eight heuristics can be used to inform the design of instruments, such as the interview protocols.

There are several limitations that are worthy of awareness with STIN and with SI research in general. The first stems from STINs use of a variety of data collection methods: "combining the need for extensive data collection with the complex conceptualizing of socio-technical phenomena means it is a difficult methodological toolkit for many scholars" [23: 12]. A second STIN limitation is the talent to successfully identify and analyze STINs, which is deeply dependent on the interview skills of the researcher and their ability to obtain information from respondents, not to mention gaining access to individuals and organizations.

5 Can STIN Help Us Build Better Digital Libraries for Open Science?

As the goal of using SI and STIN strategy is understanding more thoroughly the relationships between social and DL design (ultimately to provide more meaningful support and facilitate open science communities and collaborative practices), there is much diversity within the different DL and open science communities. There are even more ways of collaborating, and the considerable numbers of stakeholders in both communities emphasize the need for a more holistic approach to supporting and understating how the two can work together. For example, computer scientists may see DLs as relative to databases, networks, retrieval engines, and other empowering technologies. Librarians might view DLs as extensions of the library, or as a tool for energizing and accessing information and knowledge. Policymakers often regard DLs as tools for lessening digital divides and providing equal access. Open scientists may wish for DLs to play a central role in providing access to information—tools that may assist them in developing and expanding human knowledge and sharing that knowledge.

Nevertheless, after more than a decade of research, there is some scholarly acknowledgement [6, 19, 22] that the capabilities of DLs to achieve a role advancing open science has, in large part, been constrained by its current social and technological state. Since DLs were initially intended and built to curate, search, and act as networked repositories of digital resources, they have largely remained in this form. This is not to suggest that these goals are not well-intentioned. DLs were mainly influenced by their traditional library counterparts (both humans and library systems) as they selected, collected, organized, managed, stored, preserved, and facilitated access to information. These activities remain important, and they emphasize developing, maintaining, and improving a collection of digital resources. However, if we wish to support the practices of open sciences, the next phase of DL development must include an emphasis on how people *work* with DL resources to pursue various knowledge-related goals.

In examining and practicing STIN DLs, we consider what people do, i.e., how they interact with digital resources and each other, and with organizations; and also, who is excluded. By doing this, DLs can transform into more than just searchable document repositories of knowledge; they become ecosystems that help people *create* knowledge. DLs are workspaces with rich content and tools, where people can work independently or collaborate with others to learn and to solve their problems within the interfaces of the DL.

Using STIN to build on already existing DLs, particularly those that are extensively used as a successful knowledge environment, will increase the kinds of activities that DLs support. This in turn could lead to an *evolutionary* reconceptualization of DLs. DLs as knowledge environments, built upon the document repositories, will broaden the kinds of activities that DLs support, and emphasize the importance of interaction in carrying out those activities. The primary goal of DLs is helping users convert information into knowledge. DLs examined in light of STIN have the potential to shift DLs from individual, isolated collections to more interoperable, interconnected repositories that support an evolving relationship between open science users and the digital library environment.

Acknowledgements. Thank you to my fellow Ph.D. colleagues for their advice and collegial discussions about theory and methodology. Thanks especially to Rich Gazan, D.B. and Wiebke Reile.

References

1. Blandford, A., Buchanan, G., Jones, M.: Usability of digital libraries. Int. J. Digit. Libr. **4**(2), 69–70 (2004)
2. Borgman, C.L., et al.: Knowledge infrastructures in science: data, diversity, and digital libraries. Int. J. Digit. Libr. **16**(3–4), 207–227 (2015)
3. Borgman, C.: What are digital libraries? Competing visions. Inf. Process. Manage. **35**, 227–243 (1999)
4. Bearman, D.: Digital libraries. Ann. Rev. Inf. Sci. Technol. **41**, 223–272 (2007)
5. Latour, B.: Reassembling the Social: An Introduction to Actor-network Theory. Oxford University Press, New York (2005)
6. Munafò, M.R., et al.: A manifesto for reproducible science. Nat. Hum. Behav. **1**(1), 0021 (2017)
7. Kling, R., Scacchi, W.: The web of computing: computer technology as social organization. Adv. Comput. **21**, 1–90 (1982)
8. Scacchi, W.: Socio-technical interaction networks in free/open source software development processes. In: Acuna, S.T., Juristo, N. (eds.) Software Process Modeling, pp. 1–27. Springer Science & Business Media Inc., New York (2005). https://doi.org/10.1007/0-387-24262-7_1
9. Kling, R., Rosenbaum, H.: Social informatics in information science: an introduction. J. Am. Soc. Inf. Sci. **49**, 1047–1052 (1998)
10. Lamb, R., Sawyer, S., Kling, R.: A social informatics perspective on soc10- technical networks. In: Chung, H.M. (ed.) Proceedings of the Americas Conference on Information Systems. Long Beach, CA (2000)
11. Kling, R., McKim, G., King, A.: A bit more to IT: scholarly communication forums as socio-technical interaction networks. J. Am. Soc. Inform. Sci. Technol. **54**(1), 46–67 (2003)
12. Meyer, E., Kling, R.: Leveling the playing field, or expanding the bleachers? Socio-Technical Interaction Networks and arXiv.org (Center for Social Informatics Working Paper Series WP-02-10) (2002)
13. Eschenfelder, K., Chase, L.: Socio-technical networks of large, post- implementation web information systems: tracing effects and influences. In: 35th Hawaii International Conference on System Sciences. Big Island, Hawaii (2002)
14. Barab, S., Schatz, S., Scheckler, R.: Using activity theory to conceptualize online community and using online community to conceptualize activity theory. Mind Culture Activity **11**(1), 25–47 (2004)
15. Joung, K., Rosenbaum, H.: Digital libraries as socio-technical interaction networks: A study of the American Memory Project. In Paper presented at the ASIST 2004 Annual Meeting; 'Managing and Enhancing Information: Cultures and Conflicts' (ASIST AM 04), Providence, Rhode Island (2004)
16. Williams, R., Edge, D.: The social shaping of technology. Res. Policy **25**, 856–899 (1996)
17. Pinch, T., Bijker, W.: The social construction of facts and artifacts: or how the sociology of science and the sociology of technology might benefit each other. In: Bijker, W., Hughes, T., Pinch, T. (eds.) The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology, pp. 17–50. MIT Press, Cambridge (1987)

18. Law, J.: After ANT: complexity, naming and topology. In: Law, J., Hassard, J. (eds.) Actor Network Theory and After, pp. 1–14. Maiden, Blackwell. (1999)
19. Meyer, E.T.: Socio-Technical Perspectives on Digital Photography: Scientific Digital Photography Use by Marine Mammal Researchers. Indiana University, Bloomington (2007)
20. Star, S.L.: This is not a boundary object: reflections on the origin of a concept. Sci. Technol. Hum. Values **35**(5), 601–617 (2010)
21. Contractor, N., Monge, P., Leonardi, P.: Multidimensional networks and the dynamics of sociomateriality: bringing technology inside the network. Int. J. Commun. **5**(39), 682–720 (2011)
22. Lamb, R., Kling, R.: Reconceptualizing users and social actors m information systems research. MIS Q. **27**(2), 197–235 (2003)
23. Meyer, E.T.: Examining the hyphen: the value of social informatics for research and teaching. In: Fichman, P., Rosenbaum, H. (eds.) Social Informatics: Past, Present and Future, pp. 56–73. Cambridge Scholars Publishing, Cambridge (2014)
24. Sawyer, S.: Social informatics: overview, principles and opportunities. Bull. Am. Soc. Inf. Sci. Technol. **31**(5), 9–12 (2005)