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Project management as information management in interdisciplinary research: "Lots of different pieces working together"

Deborah A. Garwood*, Alex H. Poole

Drexel University, College of Computing and Informatics, 3141 Chestnut Street, Philadelphia, PA 19104, United States

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ABSTRACT

Project Management (PM)[1] in publicly funded interdisciplinary research (IDR)[2] is an emerging practice for academic scholars, one that derives from PM's origins in the industrial sector. The naturalistic paradigm that guided this case study of the third Digging Into Data Challenge (2014–2016) relied upon qualitative methods, a case study reporting mode, purposive sampling, and inductive, grounded data analysis. Fifty-three researchers representing eleven projects were interviewed. Results suggest that the grant's PM requirement provided researchers with a mechanism of information management. Project managers, whether externally hired or internally designated, were instrumental in coordinating project resources in light of governance issues, data handling, and data sharing across international boundaries. In conclusion, optimizing PM documentation from project inception through closure is recommended to facilitate communications among funders, researchers, and stakeholders. PM documentation is a mechanism for ensuring data integrity and its readiness for valuation metrics at project's end. Future research may explore the merits of mandating formally trained project managers versus supporting academic mentoring trends for project-based training, which apply domain-specific expertise to the role and enable IDR teams to exercise autonomy.

1. Introduction

Digital humanities involves "the application of computational or digital methods to humanities research, or…the application of humanities methods to research into digital objects or phenomena" (Warwick, Terras, & Nyhan, 2012, pp. xiv–xv). It involves addressing research questions that transcend genres, media, disciplines, and institutions (Burdick, Drucker, & Lunenfeld, 2012) and "involves representation, analysis, manipulation, interpretation, and investigation of humanistic knowledge while using computational media ranging from databases and digital archives in literature, visualization or sonification in art of music history, or GPS in archaeology" (Davidson, 2017, p. 207).

Work in digital humanities has been propelled by such path-breaking initiatives as the Digging Into Data Challenges (DID), an international e-research initiative that began in 2009. Its goal is a "coherent amalgam" of the networked sciences and humanities (Williford & Henry, 2012, pp. 1–2). Awarding a total of $5.1 million, DID's third challenge (2014–2016) featured ten funding organizations based in the United States, United Kingdom, Canada, and the Netherlands (Appendix A). The 14 awardees proposed to harness large corpora of existing, combined, or newly created data to develop innovative tools for sophisticated Digital Humanities research. A further challenge for teams, as in the first two rounds, was to refine these tools for open access and sustainability in the networked environment.

The expansion of IDR projects across the social scientific and humanities disciplines suggests that project management as well as data management plans facilitate IDR research (Williford & Henry, 2012). Indeed, the computationally intensive DID3 grant mandated both (Digging Into Data Challenge, 2012). Furthermore, DID organizers strongly encouraged researchers to collaborate with Information & Library Science professionals, while also recommending that research libraries become active partners in IDR projects (Williford, Henry, & Friedlander, 2012, p. 3). The range of expertise anticipated for DID3 projects, across domain, computation, and information science, attests to the important role of soft skills such as collaboration in IDR initiatives.

This qualitative case study of 53 researchers who participated in 11 of the 14 DID3 projects proposes the following three research questions. First, what is the role of project management (PM)[3] in IDR? Second,

* Corresponding author at: Drexel University, College of Computing and Informatics, 3141 Chestnut Street, Philadelphia, PA 19104, United States.
E-mail addresses: dgarwood@drexel.edu (D.A. Garwood), ahp56@drexel.edu (A.H. Poole).

[1] Project Management is abbreviated as PM.

[2] Interdisciplinary Research is abbreviated as IDR.

[3] In the case study, "PM" refers to "project management," while "the PM" or "PMs" indicates "project manager(s)."

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how did researchers and PMs fulfill the project management requirement in their work? Third, can project management facilitate long-term sustainability of publicly funded research? These questions highlight the interplay of the grant's PM requirement and researchers' articulation of its three phases, from the planning stage to work plan implementation and finally packaging deliverables for sustainable open access over the long term. The article considers these questions in light of PM literature and IDR.

Three perspectives derive from the source data: that of the PIs interpreting the grant's PM requirement for the proposal; that of the researchers implementing PM during the active research lifecycle; and that of scholars post-project assessing PM as an integrative mechanism for collaboration and, potentially, for project sustainability. In exploring these perspectives, the case study illuminates the PM requirement's influence on researchers' options and strategies, on one hand, and how researchers' actual practice of PM propelled collaborations toward deliverables, on the other.

A theory section explores how the field of Information & Library Science (ILS)[4] adapted PM's methodologies to information management and knowledge production, with particular attention to the emergence of PM in data-driven IDR collaborations. A methods section describes the rationale for a qualitative study situated in the naturalistic paradigm based on interviews with 53 DID3 researchers. Points on limitations in this section treat the study's boundaries and qualifications. Results are grouped in three subsections that tie to the PM requirement: first, the project planning phase in which PIs and key staff outlined the project goals, assembled staff expertise, and proposed a work plan; second, the implementation phase in which team members leveraged PM techniques during the active research lifecycle; and third, the project completion phase, in which researchers commented on the role of PM in packaging and disseminating project deliverables. The discussion section explores four points that connect theory and results: first, PM in the ILS setting; second, the question of formal training versus academic mentoring or ad hoc learning for PM; third, the dual utility of PM for coordination and documentation of IDR projects; and fourth, the potential for PM documentation to facilitate long-term sustainability of research outcomes. The conclusion presents a summary and suggests directions for future research.

2. Theory

2.1. IDR Research as Project-based Initiatives

2.1.1. What is IDR research?

IDR's emergence may be traced in literature that explored interdisciplinary, computationally intensive scientific research during the 2000 s using terms such as "e-Research" and "cyberinfrastructure" (Friedlander, 2006; Lawrence, 2006; Ray, 2012; Steinhart, 2006). Collaborative practices, data sharing techniques, and data repositories necessary to e-Research gained momentum (Choudhury, 2008; Gold, 2007; Higgins, 2007; Nielsen & Hjørland, 2014; Lee & Tibbo, 2011; Ray, 2012). Concomitantly, international funders' expectations for data management plans (DMPs) became increasingly stringent, and were mandated in the US in 2011 (Parham & Doty, 2012; Sallans & Donnelly, 2012). In line with IDR's instantiation as a new mechanism of knowledge production (Knorr-Cetina, 1999), the Digging Into Data Challenge (launched in 2009) proposed that collaborative research based on combinatory data sets exploded disciplinary silos and converged in "one culture" of knowledge (Williford & Henry, 2012, p. 7).

The vantage point of DID3 projects as a "coherent amalgam" of the humanities and sciences thus opened a wide field for researchers to explore (Williford et al., 2012, pp. 1–2). Interdisciplinary domains that coalesced in the case study were indeed unprecedented. Yet *as* IDR research, they shared a common origin as DID3 grants. The melding of international funding sources and institutional governance resulted in unique management procedures for each project. These complexities constituted a preeminent rationale for the PM requirement in DID3 grants.

2.1.2. What is a project?

Note (2015) defines "project" as "a series of unique, multifaceted, and related activities with a purpose that must be accomplished at a particular time, within cost constraints, and according to specifications" (Note, 2015, p. 1). Projects accomplish specific objectives in environments of rapid change (Note, 2015, p. xii). In such an environment, a flattened hierarchical structure permits communication and decision-making techniques that conform to a project's unique constraints (Note, 2015, p. 9). The flexibility for shared authority also distinguishes projects from vertical management procedures that are optimal for routine, ongoing operations (Note, 2015; Strauss, 1988). Flexible decision-making allows teams to balance resources and constraints as contingencies arise (Note, 2015, pp. xii–xvi).

2.1.3. What is project management?

In ILS literature, PM entails planning, tracking, and evaluating the key phases of discrete projects that contribute to organizational goals (Winston & Hoffman, 2005, p. 52). Those key project phases may be partitioned four or more ways (Feeney & Sult, 2011; Leon, 2017; Maron & Pickle, 2014). Note (2015) articulated five "Project Life-Cycle Phases," namely "Initiating, Planning, Executing, Monitoring, and Closing" the project. Because PM techniques oriented toward organizational goals, per Winston and Hoffman (2005), may be categorically different from project-based research, the introduction of PM to the library setting and refinement of its techniques for IDR merits further discussion.

2.2. Project management in industry and in the library environment

Initially modeled on Taylor's scientific analysis of early 20th century manufacturing processes, PM in industry acquired greater sophistication by mid-century (Winston & Hoffman, 2005). The Project Management Institute, established in 1965 as means to promote standards and confer certifications of expertise, exemplified the pervasive utility of PM for the industrial sector (Note, 2015, p. xviii). More recently, PM's application in business and industry has been associated with information systems development (ISD) techniques that integrate the computational dimension of ISD tools with a firm's research and development objectives (Windeler, Maruping, & Venkatesh, 2017).

By contrast, PM entered the library environment via IT systems during the latter part of the 20th century (Winston & Hoffman, 2005). Interestingly, information professionals already employed PM principles and tools, and refined them while conducting digitization projects over a period of two decades (Note, 2015; Nowviskie, n.d.). Applied to library operations and research services, PM techniques introduced resource accountability as part of project documentation (Feeney & Sult, 2011; Jahnke, Asher , Keralis, & Henry, 2012; Note, 2015). PM documentation thus provided a vehicle for recording funds expended throughout a project, so that valuation formulas could be applied *in medias res* as well as on the occasion of a project's closing (Note, 2015, p. 115). This has propitious implications for the role of PM in IDR.

2.3. Interdisciplinary research and project management

Given the size of data in DID3 projects, in tandem with team collaborations on the international level, the literature on project management most relevant to the case study concerns IDR. The DID Challenge's aims ride on the presumption that IDR drives innovation (Williford & Henry, 2012). However, distributed collaborations demand a high degree of communication and coordination (Lawrence, 2006;

[4] "Information and Library Science" is hereafter abbreviated as ILS.

Malone & Crowston, 1994, p. 103; Spencer, Zimmerman, & Abramson, 2011). PM tools and techniques have therefore assisted researchers engaged in IDR projects (Jahnke et al., 2012; Lawrence, 2006; Leon, 2017; Maron & Pickle, 2014; Spencer et al., 2011). Notably, PM may facilitate IDR through management-based soft skills rather than technologically-based hard skills (Lawrence, 2006, p. 407).

PM has been identified with expertise critical to handling the complexity and volume of research data that IDR initiatives create, use, and reuse (Jahnke et al., 2012; Leon, 2017; Maron & Pickle, 2014; Spencer et al., 2011; Williford & Henry, 2012). The data-driven research process tends to be nonlinear (Jahnke et al., 2012, p. 10). Indeed, Williford & Henry (2012) described DID projects as "structures built with continually moving parts" (Williford & Henry, 2012, p. 4), alluding to the iterative data protocols IDR researchers develop as project phases unfold. Aligning scholarly data modeled iteratively and from diverse domains tends to introduce unpredictability, particularly during the active research life cycle (Jahnke et al., 2012, p. 9). To that end, the literature calls for more in-depth study of researcher behavior and motivations during collaborations (Benardou, Constantopoulos, & Dallas, 2013; Borgman, 2010; Borgman, Wallis, & Mayernik, 2012).

The question of IDR deliverables' sustainability over the long term pertains to PM skills as well as curation skills (Jahnke et al., 2012; Leon, 2017; Maron & Pickle, 2014; Reed, 2014). Yet researchers face time constraints that often preclude training for IDR best practices such as PM (Jahnke et al., 2012; Leon, 2017; Maron & Pickle, 2014). Even those who are aware of and who do seek training may find options lacking (Cummings & Kiesler, 2005; Note, 2015; Winston & Hoffman, 2005). Regarding curation and digital preservation, institutions must responsibly delegate their role in supporting a project's long-term trajectory (Jahnke et al., 2012; Maron & Pickle, 2014; Reed, 2014). Thus the substantial benefits projected for IDR outcomes raises the stakes for researchers and stakeholders alike to facilitate the IDR research process through PM best practices (Spencer et al., 2011).

3. Methods

3.1. The naturalistic paradigm

The naturalistic paradigm guided this study. It accommodates heterogeneity, ambiguity, and reflexivity, ideal for examining the actual working practices of scholars. It relies upon qualitative methods, a case study reporting mode, purposive sampling, and inductive, grounded data analysis (Lincoln, 1985).

First, qualitative research integrates iterative inquiry, data collection, and representation and legitimation. It focuses on exploration, description, and comparison (Bernard & Ryan, 2010; Taylor & Bogdan, 1998). Second, case studies are "interpretive instrument[s] for an idiographic construal of what was found" (Lincoln, 1985, p. 189). "The more complex and contextualized the objects of research, the more valuable the case study approach is regarded to be" (Scholz & Tietje, 2002, p. 4). Third, interviews allow an investigator to account for multiple perspectives and processes, and to develop holistic descriptions (Weiss, 1994). Semistructured interviews combine flexibility and control; the interviewer and the participant co-construct the conversation (Charmaz, 2014).

Qualitative inquiry often employs purposive sampling. Sample selection proceeds based on the type of study conducted, the research questions asked, and the type of evidence needed (Pickard, 2013). Snowball sampling allows a researcher to find participants where they are few in number, difficult to locate, or when higher levels of trust are needed to encourage participation (Atkinson & Flint, 2004, p. 1044). In this case, we first contacted project PIs, whose names were released with the announcement of the DID3 award, and either interviewed them, asked for referrals to those project participants the PIs thought would be helpful given our study's focus, or both. In each interview, in fact, we requested referrals and stopped our sampling only when interviewees themselves thought we had contacted all of the relevant parties. Embracing PIs, PMs, researchers, postdocs, librarians, and both PhD and Master's students, this "chain referral" process permitted us to get a robust, multifaceted perspective on the project work these teams undertook.

Finally, this study borrows strategically from grounded theory. Proponents of grounded theory "share a conviction with many other qualitative researchers that the usual canons of 'good science'…require redefinition in order to fit the realities of qualitative research and the complexities of social phenomena" (Corbin & Strauss, 1990, p. 4). Grounded theory researchers reject determinism and appreciate flexibility. Grounded theory methods embrace the agency of the researcher and the study participants alike; they explain as well as describe. They also capture the contextual relationships inherent in their interactions. A strategy of iterative data collection, coding, and analysis is thus fruitful (Charmaz, 2014).

3.2. The collection and processing of case study resource data

Interviews with 53 individuals who participated in 11 of the 14 DID3 projects were conducted from September to December of 2016 by phone and through the virtual platforms Skype and Google Hangout. Interviewees included key staff such as Principal Investigators who often performed other roles such as project management, and faculty, postdoctoral scholars, and PhD students. Transcripts were coded by hand and with NVivo software.

The resource data was sufficiently heterogeneous for the case study's purpose of exploring researcher behavior. Of the total participants, 19 out of 53 (36%) were PIs (Table 1). The ratio of PIs to staff members was thus slightly more than one-third. The number of PMs is not applicable, as the tasks of that function were often distributed. Table 1 tabulates the composition of team sizes, which varied from one to eight persons, and from one to three PIs per project. Table 1 also shows that five teams had seven to eight members, five teams had three members, and one team was represented by a PI only.

Considering interdisciplinary content for the 11 projects, domain topics varied from archaeology and linguistics to political science and biodiversity. Computational science techniques were collaboratively developed for each project during the active research cycle. Participant responses to interview questions remained the salient unit of analysis.

The 53 participants in the study were anonymized with an alphanumeric code that associated their names with the corresponding project team. For example, "P47-08" indicates Participant #47 who worked on Project 08. These alphanumeric codes are used throughout the study. Extensive comparisons of participant responses were made to preserve the context of responses, which formed the basis for themes in the case study analysis.

Two limitations may be noted. This case study eschewed statistical

Table 1
Composition of case study projects 01-11, tabulated to indicate the number of PIs per project, the number of staff per project, and the total team size.

	Project # (case study)	PIs per project (case study)	Staff per project (case study)	Team size (case study)
	01	2	5	7
	02	1	2	3
	03	2	1	3
	04	2	1	3
	05	1	2	3
	06	1	0	1
	07	2	6	8
	08	2	5	7
	09	3	4	7
	10	2	6	8
	11	1	2	3
Totals	11	19	34	53

verification in favor of triangulation, which yields holistic work rooted in thick description (Jick, 1979). First, the selection of interview participants via the snowball sampling technique represents a challenge to the data's internal validity. To combat this, more than one person from each project was interviewed whenever possible in order to illuminate shared work practices and priorities further. Similarly, multiple document types about each project were examined and interviewees participating in the same project were asked about their work in different ways (e.g., by posing multiple questions during each interview). Second, external validity refers to the extent to which the data measure what the researcher claims. The investigator can generalize from case studies but theoretically: transferability requires case-by-case reassessment.

4. Results

4.1. DID3 grant structure, the PM requirement, and researcher response

The DID3 grant proposal was structured in ten parts, of which the ninth constituted the PM requirement (Digging Into Data Challenge, 2012).The PM Requirement acronym, PMDC, stands for "Project Management, Dissemination, and Communications Plan"[5]; (Digging Into Data Challenge, 2012). The three key phases of the requirement included: "Roles and Responsibilities" (9a), "Work Plan" (9b), and "Dissemination and Communication" (9c) (Digging Into Data Challenge, 2012, p. 10).

4.1.1. Planning the PMDC

Planning the PMDC took place while PIs and key staff formulated the proposal, prior to project funding. P12-08, a PI, described it as a collaborative process, "We worked together on that [PMDC planning]. [P51-08] was especially good with the data management plan and the budget, and P47-08 was very good with the big-picture stuff." Like P12-08, PM P39-05 described a collaborative proposal-drafting process. "Everyone was involved...I did a lot of the draft myself, mainly because I was the center point and had connections with everyone and could frame the problem appropriately. I was also the only one who had experience in the Digging Into Data framework" (P39-05). PIs and key staff utilized internal expertise and social networks in planning the PMDC.

4.1.2. PMDC part 9a: roles and responsibilities (Phase 1)

Grant structure as well as institutional mandates influenced PM practices. Not every project hired or even formally designated a project manager. Participants variously opted to delegate the role among team members, hire an external PM, or designate PIs as PMs. In another variation, post-docs and PhD students were mentored, or acted as, PMs.

4.1.2.1. Global and national PMs. P40-10, a PI, associated the PM role with global and national funding agencies that supported her project. "There are several project managers. There's a project manager on the global level; there's another one, [for] each institution and the country… It's not really the country; it's the funding institution. In our case we had one in the [home country]. They had two, I think, in [international country] and they had one or two in the [international country], in our particular project."

Similarly, PI P51-08 pointed to funding agencies' constraints on staffing and other resources, "It is always interesting when you are dealing with multiple countries and funding regulations, realizing what we could and couldn't spend money on." As an example of institutional influence on the PM's role, researcher P23-07 noted of PM P8-07's work: "Legally, I was [the summer undergraduates'] their supervisor, but in practice [P8-07] was. When I say legally it's because P8-07 as a post-doc can't hold grant money in his own right...He did all that work and the coordination of all the technical stuff with [partners overseas]."

4.1.2.2. External PMs. Funding constraints influenced whether participants hired an external PM or designated a team member for the role. P49-09, a PI, suggested that hiring a PM was not a foregone conclusion: "I was asked at the beginning of the grant process by people in my department why I was bothering [to hire a PM], because the amount of administration that it generates for the amount of money that we get they said just isn't worth it." Another PI on this project who hired a PM with supplemental grant funds supported the decision: "For a two year project, for the amount of money they are giving it's really been hard to hire someone just independently, fulltime position, which is not realistic. But having that makes a really big difference in the smoothness of the project" (P36-09).

PIs on Project 08 differed on the merits of hiring a PM. P12-08 related, "We did have a quote-unquote project manager that I think [PI P47-08] got some additional funds from [funding agency] to hire… project management is super-important, but…having a project manager from outside who didn't necessarily understand the project made things a little bit weird." As an alternative to external professionals, some PIs doubled as PMs.

4.1.2.3. PIs as PMs. P5-10 assumed a dual PI-PM role. "Project management has to be done by the principal investigator, who has technical knowhow," she argued. "And I distinguish between project management and a project manager, someone who is hired specifically to do only project management. They're different things." PM P20-08 clarified, "Not every qualified project manager is necessarily as good as every project manager, if you see what I mean."

Another PI-PM, P40-10 agreed with P5-10's preference for internal PMs. She cited logistical reasons, "It's different institutions...We coordinate…if there's somebody that doesn't have the students, the work doesn't get done until the students come in. The project starts later and things aren't going to be done until much later, so you have to adapt." Likewise PI P53-07 framed the issue in terms of optimizing resources, "the mix of skills that was required meant that…we got better value for money by involving three or four people part-time than appointing a completely new person."

4.1.2.4. Formal training and Ad Hoc learning for PM. P14-07's Master's degree program in information management included two courses on PM. When asked what skills people entering the field of digital humanities need to have, P14-07 recalled, "The first thing that came to my mind was project management skills." PM P28-08, who holds a Master's in Information and Library Science, lamented that none of her team members appreciated the existence of standards for preserving data: a concept that she picked up as an ILS student. P28-08's comment points to the relevance of ILS services for IDR researchers, and more broadly to the need for early career training (Jahnke et al., 2012).

Among those PMs with informal training, P39-05 initially gained experience on a similar project. "I was thrown into the deep end when I moved here…so I had to learn on my feet pretty quick." To refine her skills, P39-05 found PM leadership training to be helpful for "difficult discussions when people aren't performing where they should be, or understanding weaknesses in your management style."

P25-01 associated her PM experience with informal training, commenting, "It's kind of a mentor-mentee relationship or apprentice model." P52-02 also alluded to this type of training: "We kept meeting to direct and train my skills how to manage things, how to work with helpers, how to combine different kinds of knowledge together." These comments attest to Leon's (2017) assertion that most graduates in the humanities lack formal training for managing IDR projects.

[5] "Project Management, Dissemination, and Communications Plan" is abbreviated as PMDC.

4.1.2.5. PhD students and post-doctoral researchers as PMs. Supporting the informal acquisition of PM skills, PI P43-09 commented, "I expect of postdocs that they can also handle the project management aspects quite well. This is how they prove that they can be assistants, first, and then so up the ladder." PMs seemed to favor this arrangement. Post-doctoral researcher P7-10 recalled a project PI saying, "'Okay, you will be the one working on this project.' It was a great experience from the beginning." Similarly, PI P36-09 welcomed the opportunity to serve as PM on her project. But she confessed that she had "No formal training whatsoever. It is the same way when we get a PhD we are often undertrained as teachers. We are definitely undertrained as managers."

Unfazed by a lack of formal training, P17-04 described melding domain expertise with her skills as a developer during her PhD work, which subsequently proved useful in her DID3 project. "I am essentially the project manager. [PI P6-04] has a high-level management role, but I make the on-the-ground decisions of what is going to be built" (P17-04). The PM exercised data-intensive skills in this case. Similarly, on a different project, PM P34-03 characterized data management skills as inextricable from project management skills.

In contrast to P17-04, P33-11 felt ambivalent about acquiring PM skills through her PhD work. "I didn't find it that useful at the time. Such big projects are very different and even much more complex than a PhD, so maybe [formal training is] something that might be useful."

4.1.3. PMDC 9b: the work plan and its implementation (Phase 2)

The work plan corresponded to Part 9b of the PMDC. Some researchers had little knowledge of the work plan beyond their immediate responsibilities. P23-07 reflected, "The [overseas partner] coordinated the work plan and did most of it. Personally, my part of the project was a little bit off to the side from everybody else's." P35-01 encountered a similar situation: "I wasn't exposed to an official work plan...I see the tips of many icebergs, but I don't know the overall flow of the project outside of the tiny bit that I contributed."

In fact, PMs described the preliminary work plan as schematic. P14-07, a PI-PM, noted, "We had a list of expected deliverables that we were supposed to produce for our subgroup for our work package. Some of them were open for interpretation." PM P4-09 first created training data as a means to fine-tune the work plan. Then she adjusted the work plan to the schedule. Notably, she took deliverables into account, thus balancing feasibility and desirability; her PI, P36-09, remarked, "What was working and what was proving fruitful and interesting is what we ended up going with."

P20-08 also found the work plan to be a high-level guide at best, "It wasn't super-duper clear…when I came in, I did look at the planning that had been done so far, what was in place, what was not… and also the relationship with the developer and how that was shaping up." Pointedly, PM P20-08 recalled that negotiating work plan implementation with the developer entailed the coordination of a series of interdependent tasks. "It was difficult to assess the quality of some of the pieces, and it was difficult to assess when they would be delivered...That…made judging development progress and completion difficult, and it made testing difficult." As this turned into "a little bit of a power struggle," P20-08 admitted, "I stepped back a lot and just did observation, rather than try to actively manage."

The PM's equanimity in this case reflects Note's (2015) recommendations on handling conflict, such as remaining professional when problems arise and assessing the causes of the conflict. On a different project, PI P43-09 said of her PM's potential to mediate, "It's really handy to have a project manager, who, in a neutral way, can say something about the project plan and practical things."

Project implementation prompted participants to incorporate planning tools and tracking mechanisms. According to P51-08, "It helped us to have done some initial project planning with a project manager and then it helped us to have someone tracking. We literally started taking minutes of our meetings in our weekly Google Hangouts." The PM then enhanced collaborative implementation of the work plan, "In the next meetings [meeting minutes from previous meetings] really helped us and allowed us to see what balls we had in the air that were maybe not being juggled appropriately" (P51-08). P51-08's team's tracking efforts led to a productive change in the work plan, "We realized a change in what problem we were actually able to address as the project moved forward. So…we planned effectively, but in that execution we realized additional functionality."

4.1.3.1. Communication and the work plan. Other participants discussed the PM's communications in relation to the work plan. P6-04, a PM who managed coders recalled, "I touched base once every week, and mostly it was to get them to tell me what they were doing...Let's say it was an interface issue: 'We need the search button to work right; we had a bunch of bugs in terms of loading up the databases.'" Regarding routine tasks, P6-04 added, "we had an agreed-upon laundry list of duties that would be done, and they would just mostly consult with me." Researchers reliably provided P6-04 with valuable insights on planning work phases.

On coordinating an entire team at the global level, PI P40-10 said of the PM's communication patterns, "[P7-10] kept us informed; we kept her informed. There was always someone that you could go up or down to look for to get answers or get orientation." The PM's initiative in this instance fostered the reciprocal exchange of information on the team.

4.1.3.2. Contingencies and the work plan. PMs spoke in depth of contingencies that arose during the active research cycle. P16-06, a PI-PM, said of a prototype, "We saw quite quickly that wasn't going to work, so we dealt with it and it was OK. It wasn't something that we had originally envisioned." PM P29-05 reflected on project implementation and work plan changes within the timeframe. "There were times when we had to drop features because we weren't going to make it on time, but because those features weren't actually included in the work plan, it was quite easy just to come up with a core that we needed to have for the functionality."

Linking PM contingencies to risk management, PI P40-10 related, "We tried to arrange to avoid the show stoppers, tried to see which ones are the critical points where if this fails the whole project is going to have problems and be delayed." Managing risk was also central to P34-03, who remarked, "I try to have a series of fallbacks so that if one thing doesn't work you know you can do it another way...It's an experiment, it's a build, that does some things well, maybe not anticipated; other things, not as well." In fact, P40-10 documented project challenges because "not everything came out perfectly." P5-10, one of this project's PI-PMs, reflected of the timeframe constraint, "Things are never sequential in a project, because some people leave or move, etc., and certain parts might take longer, especially if you're collaborating."

4.1.3.3. Data volume, contingencies, and the work plan. Participants referred more specifically to data volume as a project contingency. PM P21-11 explained, "We all needed to skill up in some sense, because [P33-11] and I had never worked with such big corpora." P33-11 related, "There were so many interesting questions that arose while we were working on the data," and P26-11 maintained, "The challenges of the data were just more than we thought."

P32-03 also hinted at data volume as an unexpectedly intriguing phenomenon. Her PM remained on the project even after getting another job because "it was really quite an adventure in the sense that the amount of data we were getting back was just huge." Numerous participants expressed intense interest in data as project work progressed, not least because its sheer volume altered research questions and techniques and thus the work plan. As P40-10 noted, "We're working with big data and that implies certain knowledge…the estimation of times, the results, the tryouts. All that has to be considered with…how we manage."

By way of illustration, P10-07 remarked on the need for a flexible work plan. "The research side of things was a lot more unpredictable… we didn't know what we were going to find." On reporting work plan

changes to the funding agency, P10-07 added, "I don't think that the grant body made us over specify, literally to every month, exactly what we were going to be doing."

PI P43-09 mused on PM for routine versus data-centric, exploratory ventures. On one hand, "The paradigmatic example is building a bridge. You know how to build a bridge, and you have a project manager for the bridge building and then things go all right." Alluding to Big Data, on the other hand, P43-09 continued, "Then you have the other type of projects where you really delve into the unknown. What we did in this project was not done by anyone before."

Considering the requisite technical expertise for DID3 data management, PI P6-04 stressed the salience of her PM's skills as a post-doctoral researcher. "There's a lot of research projects that fail at the beginning just because they don't have these types of people to get it started, or these people join the project too late."

4.1.3.4. Project constraints and their interplay. In their discussion of PM, Feeney and Sult (2011) characterize the constraints of a project as "scope, schedule, and resources" (Feeney & Sult, 2011, p. 754). P53-07 spoke to resources as a constraint on project staffing in her comment on the expense of computational expertise, "The people from a computer science background, it's starting to be on the boundary of budget that's really not worth doing the project for." As participants reflected more particularly on their project's constraints, however, they tended to home in on researcher interactions. P40-10 remarked, "Everybody has a different cycle, different timelines, different priorities. We have to make sure that we're…on the same page."

P8-07 considered researcher motivation a constraint on coordinating group expertise. "Everybody had different priorities. For some this is a way to do their PhD; for others it's a way to do some technical stuff, so it's kind of hard to see that those priorities converge." With conflicting priorities in mind, PM P36-09 mused, "You may jell with one approach versus another and that is hard for the participants as much as it is for someone managing it."

P8-07 suggested ameliorating project constraints through skills development: "A lot of the problems are constraints of the actual processes, and there's not much you can do about them. But…giving people more skills and best practices at a very granular level is how you might go about [it]." These comments suggest that PMs have a role in facilitating collaboration on their teams.

4.1.3.5. Project complexity as a constraint. PM P20-08 introduced project complexity as a constraint falling under the PM's auspices. "To have experience of running a project is helpful… But probably what's more important is, the more complexity you have, the more useful it is to have a project manager" (P20-08). In this case, she thought it "quite useful to have somebody who can raise the risk flags a bit earlier."

Interdisciplinarity as an element of project complexity figured into P14-07's belief in employing PM skills "when you're working on projects that are so interdisciplinary, that are going to require input from lots of different people, or lots of different pieces working together." With regard to mediating this complexity, P20-08 reasoned, "In terms of creating a timeline, looking at governance around decision-making and things like that, you could…give guidance to somebody…'Make sure that you do these key components.'"

P20-08 ultimately suggested that the PM's role culminates in fostering global project communications through a common conceptual lingua franca. As a result, the required interim project reports that PMs write "can refer to where you're at, and everybody in the different stakeholder groups knows what you're referring to because you have a common material and a common language around it."

4.1.3.6. The PM's role and leadership. PM leadership was foremost in P18-05's assessment of her project, "I would remind my people, 'This has to be done.' But as far as the overall project, [P39-05] really is the person who kept us on track." Noting P39-05's (informal) PM designation, P18-05 also lauded her ability to "preemptively identify problems in falling behind to make sure that we could address those issues earlier." PI P40-10 concurred, "You have to have that figure, who follows up everything from times, budgets, reporting. Someone has to be checking that out."

The payoff of a formal PM could be substantial. On a project that employed a formally trained PM, P49-09 similarly highlighted leadership skills. "I had to reallocate some of the budget to pay for project management, and that absolutely made all the difference in the world…I would go as far as to say it saved the project."

4.1.4. PMDC part 9c: disseminating, communicating, and sustaining deliverables (Phase 3)

Funders' grant requirements increasingly include a sustainability as well as a data management plan (Maron & Pickle, 2014). Part 9c of the PMDC mandated a sustainability plan, which addressed DID3's overarching goal of fostering and promoting innovative tools stemming from publicly funded research. At minimum, the sustainability plan required a project website (Digging Into Data Challenge, 2012).

Participants reported achieving the promised deliverable(s) and often more, albeit through extensions in some instances, or partners' willingness to follow through on deliverables post-project in others. Regarding sustainability, responses were somewhat mixed.

On one hand, many participants attested to the deep scholarly investment among team members. P43-09, an experienced PI, remarked, "Instead of this single shot activity, I see this as a long term process… these scholars realize that what they were doing is for the future." PI P47-08 enthused about new research directions based on project results: "We want to build the next level of coding platform…Ultimately, we're sitting on…literally life-changing trillion dollars of information."

On the other hand, researchers pointed to a gap between realizing promised deliverables and providing for project sustainability beyond the grant cycle. PI P36-09 observed, "The timeframe is very short for coordinating these multi-folks things. When you put in that many actors, you pretty much double or triple the timeframe." P30-10 declared that her project's resources were adequate for the active research cycle, but insufficient for a fully functional, client-deliverable system by a factor of two or three. Along similar lines, PI P21-11 asserted that the limitations of DID3's grant structure and scope precluded the maintenance of tools long-term. Thinking on a larger scale about the challenges of monetizing computational tools forged in academic research, PI P43-09 averred, "The problem…is that there is no business model for this yet."

P17-04, a team-designated PM with technical expertise, suggested, "It would be great if we had someone on the team who was more skilled in managing this project and taking it beyond the scope of the grant-funded academic project." PI P34-03, in fact, corroborated this view of data management and post-project sustainability as mechanisms best served through project management.

Given the recency of data collection, in some cases before projects had been completed due to no-cost extensions, we were unable to determine how successful these projects were in leveraging their project management efforts into long-term project sustainability. Nevertheless, in line with case study purposes, participant comments on the PMDC throughout Section 4: Results consistently pointed to the hard and soft skills of project management as crucial to a project's viability. Among tasks that fell to PMs, interviewees highlighted coordinating schedules, handling contingencies, documenting changes to the work plan, tracking budgets, and reporting to stakeholders. In fact, several participants attributed a leadership role to the PM function due to its comprehensive documentation and the coordination of work plans. One PM, in fact, suggested that her grant's outcomes were poised for long-term sustainability on the basis of final project management documentation – attesting to her sense of its complete and authoritative records. In all, interviewees' retrospective outlook on projects, by the

time of PMDC Part 9c, was overwhelmingly positive except for long-term sustainability. A PI addressed this concern by asserting that the DID3 grant, if not publicly-funded DH projects in general, lacked a business model.

5. Discussion

5.1. Case study results and theory: comparing four areas

5.1.1. PM in the ILS setting and in DID3

PM's utility for IDR projects in the ILS setting has been commended as an integrated process linking resources and organizational performance (Feeney & Sult, 2011; Leon, 2017; Maron & Pickle, 2014; Winston & Hoffman, 2005). The DID3 grant structure linked funders' requirements and researchers' proposals in a common purpose. Funders called for researchers to utilize standards through the PM requirement, an example of ILS expertise. Closely related to standards, practices of data management (the DMP requirement) complemented PM responsibilities for project coordination, reporting to stakeholders, and preparation of data sets for open access. In effect, the PM requirement was a mechanism for information management on the part of researchers.

5.1.2. Formal training for PM versus Ad Hoc acquisition of PM skills

Winston and Hoffman (2005) noted the need for formal PM training and other management skills in the ILS context, but scant opportunity. Note (2015) and Nowviskie (n.d.), meanwhile, pointed out that information professionals tended to develop PM skills on the job. Leon's (2017) experience garnering PM skills in the alternative-academic ("alt-ac") setting informed her views on job-related PM training.

In the case study, PMs coordinated funding agency resources at the global and national levels; PIs also found that governance at the institutional level structured the PM's role. Some teams expended funds to hire external PMs but more often, participants designated a team member for the PM role, ostensibly to conserve resources and consolidate expertise. In the latter approach, a PI might take on the role or delegate it to staff including PhD students and post-docs who had various levels of formal and informal training. Overall, PMs' comments on their on-the-job training supported Nowviskie's (n.d.), Leon's (2017), and Note's (2015) position that ad hoc learning has been an acceptable, even resourceful route to acquiring PM skills specific to IDR.

This stance differs markedly from advocacy for formal PM training at the graduate level or early career point (Jahnke et al., 2012; Leon, 2017; Maron & Pickle, 2014).[6] Spencer et al. (2011) strongly recommended placing professional PMs on research teams as a strategy for guiding IDR projects to fruition. The debate appears unsettled pending considerations such as pedagogical formulations of curricula for PM, funder requirements for PM that may mandate certification credentials, and researchers' preference for autonomy on a per-project basis.

5.1.3. PM's dual utility for coordination and documentation

Feeney & Sult's (2011) study suggested that a substantial benefit of PM lay not only in project coordination, but also in the documentation of resource allocation for complex, iterative projects. They asserted, "The ability to have an agreed-upon document to refer to serves the important function of mitigating many of the communication challenges that arise from organizational uncertainty and helps to ensure that the service stays on the right track" (Feeney & Sult, 2011, p. 761). Cummings & Kiesler's (2005) study underlined the need for coordination of tasks and communications in order for IDR to produce the desired innovative outcomes. Weighing the opportunities for innovation and the costs of coordination was a question for policymakers as well as researchers: their study found that coordination costs were neither articulated nor funded (Cummings & Kiesler, 2005, p. 720).

Corroborating this insight, the PM requirement anticipated a dual role for PMs, both to aid researchers in coordinating tasks and to foster accountability between teams and stakeholders through phase documentation reports. Participants maintained that PM documentation was useful not only in developing a common understanding of project status, but also for interpreting outcomes to audiences when it came time to disseminate deliverables.

5.1.4. PM documentation, data fitness, and sustainability

The long-term viability of IDR projects in digital humanities is a complex responsibility linking researchers, institutions, and stakeholders (Jahnke et al., 2012; Maron & Pickle, 2014; Reed, 2014). In the case study, sustainability concerns permeated participants' comments even as they enthused about new skills acquired through working collaboratively with Big Data. As discussed in Section 4:Results, participants' insights into the tasks of project management suggest that soft skills, such as coordination and communication among researchers dispersed on international teams, were as critical as the hard skills of documenting funds expenditures and work plan changes for interim reports to stakeholders dispersed globally. Interestingly, researchers perceived a leadership role for PMs, whose responsibilities culminated in complete project documentation with the potential to usher an IDR project across the threshold from grant cycle to long-term sustainability.

The literature suggests – and this study affirms – that PM is an emergent practice for the information management of IDR research. Further studies of PM's adaptation for IDR research, especially the contributions of ILS expertise for standards, are needed to provide insights useful for funders, researchers, institutions, and stakeholders.

6. Conclusions

The case study's research questions explored, first, the role of PM in IDR; second, the PM requirement in DID3 grant structure and the ways researchers articulated its three phases; and third, the potential PM documentation may hold for IDR research sustainability and public access. Project management, as information professionals have refined it for ILS over the past two decades, is an emergent mechanism for partitioning, administering, and documenting IDR research projects from their inception. Whereas the literature suggests that partitioning project phases is more conceptual aid than protocol – a heuristic at the discretion of the resource allocator – the case study found that the DID3 PM requirement's three phases powerfully impacted researchers' work.

In effect, PM was a mechanism for information management that funders required researchers to use in short-term, publicly funded IDR projects. Indeed, the complexities of governance, data volume, and other contingencies of exploratory research posed real challenges to scholars within the grant's timeframe. The documentation and valuation techniques that PM offers hold the potential to clarify management structure and rights while documenting staff responsibilities and workflows: all in the interest of ensuring data authority. The case study found that PM served information management functions in IDR research, insofar as researchers could fulfill them.

As with many aspects of IDR supported by public funding, the recommendations suggested here are most usefully understood as a shared responsibility among funders, researchers, institutions, and all stakeholders. Their combined efforts instantiate the purpose and benefits of innovative IDR research. Recommendations include promoting PM as vehicle of complete project documentation, first so that data integrity is assured; second so that outcomes can be described in accessible language appropriate to the communities of practice; and third

[6] Three resources for PM training include the Digital Humanities Summer Institute, http://www.dhsi.org; The European Summer University in Digital Humanities, https://www.clarin.eu/event/2016/european-summer-university-digital-humanities; and Development for the Digital Humanities, DevDH.org. We appreciate these suggestions from one of the peer reviewers.

so that the project in its entirety can be valued, appraised, and prepared for long-term sustainability in the public interest.

Future research may consider the potential for academic curriculum development in PM specifically for IDR; PM certification in programs that currently exist outside of academia as a credential for the PM requirement in publicly funded IDR projects; expertise ILS may contribute to best practices regarding data, ISO, and other standards; and the merits of research teams' autonomy based on domain expertise for internal PM role(s).

Declarations of interest

None.

Appendix A. Digging into Data 3

Countries involved	Canada Netherlands United Kingdom United States
Funders involved	Arts and Humanities Research Council (AHRC) (UK) Canada Foundation for Innovation (CFI) Economic and Social Research Council (ESRC) (UK) Institute of Museum and Library Services (IMLS) (USA) Joint Information Systems Committee (Jisc) (UK) National Endowment for the Humanities (NEH) (USA) National Sciences and Engineering Research Council (NSERC) (Canada) National Science Foundation (NSF) (USA) Netherlands Organisation for Scientific Research (NOW) (Netherlands) Netherlands e-Science Center (NLeSC) (Netherlands) Social Sciences and Humanities Research Council (SSHRC) (Canada)
Awardees	Automating Data Extraction from Chinese Texts Commonplace Cultures: Mining Shared Passages in the 18th Century Using Sequence Alignment and Visual Analytics Cleaning, Organizing, and Uniting Linguistic Databases (COULD) Digging Archaeology Data: Image Search And Markup (DADAISM) Project Arclight: Analytics for the Study of Twentieth-century Media Global Currents: Cultures of Literary Networks, 1050–1900 Mining Biodiversity Digging into Linked Parliamentary Data (DiLiPaD) Field Mapping: An Archival Protocol for Social Science Research Findings Digging into Signs: Developing Standard Annotation Practices for Cross-Linguistic Quantitative Analysis of Sign Language Data Trees And Tweets: Mining Billions To Understand Human Migration And Regional Linguistic Variation Legal Structures Mining Relationships Among Variables In Large Datasets From CompLEx Systems (MIRACLE) Resurrecting Early Christian Lives: Digging In Papyri In A Digital Age
Total funds awarded to DID3 projects	$5.1 million
Grant time period	2014–2016
Website, "Digging Into Data Challenge"	https://diggingintodata.org

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Deborah A. Garwood is currently a Research Assistant and doctoral student at Drexel University's College of Computing and Informatics. Her research areas are Digital Curation and Archives. Ms. Garwood participated on a panel for the Mid-Atlantic Regional Archives Conference in 2017. In 2016 she presented research at the Joint Annual Meeting of the Council of State Archivists and the Society of American Archivists in Atlanta, Georgia, and at the International Conference on Dublin Core and Metadata Applications in Copenhagen, Denmark. Ms. Garwood earned an MSLIS at Drexel University, an M.FA. at Hunter College, and a B,A. at Oberlin College.

Alex H. Poole Assistant Professor at Drexel University's College of Computing and Informatics, Alex H. Poole received his PhD from the University of North Carolina at Chapel Hill. Poole's research and teaching interests center on archives and records management, digital curation, digital humanities, pedagogy, and diversity and inclusivity. He has published in The Journal of the Association for Information Science and Technology, Digital Humanities Quarterly, The American Archivist, Archival Science, The Journal of Documentation, and The Library Quarterly (forthcoming). Poole earned a B.A. from Williams College, an M.A. from Brown University, and an MLIS from the University of North Carolina at Chapel Hill.