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Information informing design: Information Science research with implications for the design of digital information environments

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Abstract

This debut curated 'virtual special issue' of JASIST is on the theme of 'information informing design.' It comprises several excellent scholarly research articles previously published in JASIST with important implications for the design of digital information environments. It covers articles that motivate the need for Information Science research to inform design and those that have empirically examined information-related concepts such as information behavior, practices, interaction and experience and, based on their findings, proposed recommendations or posed questions for design. This article argues that as JASIST exists at the intersection between information, systems and users, it is natural to want to understand how people engage with information to inform design and, by doing so, Information Science research can build bridges between Information Science and computing disciplines and make contributions that transcend its discipline boundaries. It argues that Information Science research not only has the potential, but also the duty to inform the design of future digital information environments.

Introduction: Why inform design?

Why study information-related concepts such as needs, behavior, practices, interaction and experience? Sometimes it is to better understand how and why people engage with information for its own sake, serving to enrich the Information Science theory base, or to inform policy or information professionals' practice. Other times, particularly for Information Science researchers with an interest in technology (such as those at the intersection of computing disciplines such as Human-Computer Interaction (HCI) and Information Retrieval (IR)), it is for the primary purpose of informing the design of digital information environments – information-rich desktop, Web and mobile environments such as search and discovery engines, social networking and online community platforms, library catalogs and Intranets.

Information Science provides a strong theoretical and methodological foundation for understanding what information people need and how people actively seek, passively encounter, make sense of, use, share and communicate information. This can help drive the evolutionary (incremental) or revolutionary (disruptive) improvement of digital information environments. In turn, new technological interventions provide new functionality which, in turn, can spark new needs, support new behavior, practices and types of information interactions and engender new, more enriching and engaging experiences with information.

JASIST exists at the intersection between information, systems and users. It is therefore natural to want to understand how people engage with information to inform the design of digital information environments. A people-centred approach to understanding information is important to ensure the information we create and communicate serves those who consume it. Similarly, a human-centred approach to designing digital information environments ensures those environments support peoples' information needs, behaviors, practices etc., and continuously evolve to support their changing needs, behaviors, practices etc.

When informing design, there is great opportunity for contributions and approaches that are not only interdisciplinary (bridging Information Science and design disciplines, such as HCI by integrating theoretical and methodological approaches from those disciplines), but also *trans-disciplinary* – making theoretical, practical and methodological contributions that permeate discipline boundaries to address common research issues. These are issues such as how we can best support the information needs, behavior, practices etc. of particular groups of people (e.g. certain professions such as knowledge workers or creative professionals), demographic groups (such as older adults, or those with disabilities) and work and everyday information practices (such as information sharing or knowledge creation). By

tackling these issues, we are essentially asking the perpetually important research question 'how can we ensure information creators and consumers have the most productive, engaging and enriching experience possible?' The metaphors of building bridges and weaving webs between disciplines are powerful for conveying the promise of informing design – to achieve a true synthesis between disciplines *"rather than degenerating to a case where one disciplinary is essentially in service to the other"* (Dourish, 2006, p.545).

Informing design, however, is not the only worthy contribution Information Science research can or should make. Dourish (2006) has argued against the need for HCI ethnographies to have direct design implications and this argument can be extended to all research that involves gaining a detailed understanding of human behavior. But that does not mean this research cannot inform the design space, such as by posing *questions* for design, or shedding light on what should *not* be designed (Dourish, 2006). Furthermore, one might argue that an analysis of the role information plays in a particular social, cultural or organizational context may be *"best articulated independently of specific systems, technologies or design briefs"* (Dourish, 2006, p.545). Therefore, it is important to note that Information Science research is not *only* valuable if it informs design; understanding information-related concepts for its own sake is not a second-class research outcome, but often a deliberate research decision to more deeply inform theory, policy or practice in other ways. That said, this virtual special issue aims to convey that informing design is a particularly useful contribution that Information Science researchers can and should choose to make.

When assessing quality of design implications, it is not necessarily the breadth (i.e. volume) of recommendations made that matters most, but the depth (i.e. insightfulness) of those recommendations. Also, the goodness-of-fit between research findings and design recommendations is paramount; *"what matters is not simply what those implications are,"* but *"why, and how they were arrived at…"* (Dourish 2006, p.547). The articles in this special issue are notable not solely because they inform design, but for the insightfulness of the design recommendations they propose and the strong link they forge between findings and design implications.

In this introductory piece, I summarize and discuss the key research findings of each article in this special issue and highlight important implications for design raised by the authors. The scope of this special issue includes articles that make *explicit* rather than *implicit* recommendations to inform design. This is not to say that research that does not explicitly discuss design implications cannot inform design. But the focus of this special issue is on research that has made the conscious choice to do so.

This article begins by discussing seminal JASIST research from the 20th century that motivates the need to inform design, then turns to focus on more recent research from the 21st century that informs design by empirically examining a variety of different types of information-related concepts. This includes research that informs design by examining: specific types of *information behavior*, the *information behavior and practices of specific groups* and particular *information contexts*. This special issue also includes work that informs design by examining the *sociomateriality* of information environments, the *role of information in everyday experiences* and peoples' *information experience* more broadly. This article ends with a discussion on how JASIST research can continue inform the design of future digital information environments.

Learning from the past: Seminal JASIST research from the 20th century that motivates the need to inform design

Information Scientists have sought to understand information-related concepts (e.g. information needs and behavior) to inform design for as long as digital information environments have existed (i.e. since the introduction of online library catalogs and bibliographic databases). In the seminal JASIST articles *why are online catalogs hard to use?: Lessons learned from information-retrieval studies* and *why are online catalogs still hard to use?*, Borgman (1986; 1996) asserted that online catalogues were and persisted to be difficult to use because they did "*not incorporate sufficient understanding of searching behavior*" (Borgman, 1996, p.493) and made recommendations for how they could be designed to be more intuitive, by more closely aligning them to information-seeking behavior. Borgman suggested this could be achieved by recognising different types of search goals (e.g. to obtain an answer, refine a question) and by recognising that searches often extend across multiple sessions and systems. Both are still formidable research challenges today; the former has been embraced as an AI challenge in contemporary search engines such as Google and WolframAlpha (i.e. using Machine Learning

techniques to support answer-focused search). The latter has encouraged decades of research into multi-session search and a persistent need to support information-seekers in resuming, reconstructing and revisiting their searches.

Models of information-related concepts to inform design have also existed ever since digital became an important channel of information access. For example, in *subject access in online catalogs: A design model*, Bates (1986) proposed a design-focused conceptual model to inform the design of online library catalogs based on a series of information search phases: *access* (comprising *entry* and *orientation*), *hunting* and *selection*. She suggests *"our thinking for design purposes will be clarified if we identify and work with"* these phases. This approach not only illustrates the ethos that digital information environments should be designed to support human needs, behavior and practices, but also that they should be designed based on fundamental Information Science theory rather than based on first principles. If successful, this technology may then shape future needs/behavior/practices, creating further opportunity for technology to be shaped by those new practices through new design interventions.

Bates highlighted there was much room for improvement in online library catalogs, just as there still is today in all types of digital information environments. For example, her work highlighted the need for search query formulation support before the worldwide web and widespread adoption of search. The need to *"generate as much variety in a search formulation as there is variety in the indexing of the topic of interest"* signals the need for automated query formulation support, such as search suggestions and query autocompletion. Bates (1986) explicitly suggests providing related query terms and topics, as well as similar books – staple functionality of contemporary recommender systems. Providing *"searchers with links and associations between terms that may be surprising or stimulating"* foreshadows the later importance of (serendipitous) information encountering.

The continued relevance of early human-centred Information Science research highlights an opportunity to continue to learn from past, particularly by embracing a human-centred ethos towards the design of digital information environments and, within that ethos, respecting the importance of informing design based on a conceptual or empirical understanding of information-related concepts. This, in turn, serves to value the strong contribution Information Science research can make to informing design.

Embracing the recent past and present: JASIST research from the 21st century that informs design

Pioneering human-centred Information Science research published in JASIST, such as that by Borgman (1986; 1996) and Bates (1986) paved the way for two decades of Information Science research that has informed design – by making design recommendations or posing design-focused questions aimed at improving existing or designing new digital information environments.

Information Science research that has informed design is wide in scope and has examined a variety of information-related concepts for the purpose of informing design, such as information needs, behavior, interaction, practices and experience. This virtual special issue showcases selected excellent scholarly work published in JASIST that demonstrates this variety, although much more superb research that informs design can be found in JASIST's back catalog.

Some of the work featured in this special issue informs design by examining *specific types of information behavior*. For example, Xie (2000) investigated shifts in information interaction intentions when finding information, McKay et al. (2019) examined browsing behavior in physical libraries to inform the design of digital information environments and McCay-Peet and Toms (2015) examined serendipity in the context of information acquisition. Other work in this special issue informs design by examining or comparing the information behavior and practices of specific groups, such as Korean immigrants in the US (Suh and Hsieh, 2019), LGBTQ+ millennials (Kitzie, 2019), visually impaired and sighted people (Sahib et al., 2012) and domain experts and novices (Liu and Zhang, 2019).

Work showcased in this special issue also informs design by examining *specific information contexts*. These contexts include the *user* context; Mohammad Arif et al. (2015) examined tourists' collaborative information-seeking behavior, the *use* context; Laing and Masoodian (2015) examined the role of visual information-seeking in visual design practice, the *environment* context; Zhao et al. (2018) examined the phenomenon of user exodus on social networking sites, the *device* context; Goyal et al. (2018) examined the impact of mobile ad design decisions on peoples' mobile information interaction

experience, the *social* context; Worrall (2019) examined the sociotechnical infrastructure surrounding information sharing in online communities and social digital libraries and the *privacy* context; Vasalou et al. (2014) examined how digital information environments could encourage user engagement with the privacy domain. Finally, this special issue features work that informs design by examining: the *sociomateriality* of information environments (Vienot and Pierce, 2019), the *role of information in everyday experiences* (specifically peoples' experiences of gratitude in online communities; Makri and Turner, 2020) and *information experience* in personally meaningful activities (Gorichanaz, 2019).

Collectively, this work demonstrates that many types of Information Science research, examining a variety of information-related concepts such as information behavior, interaction, practices and experience, can inform design. It also illustrates the types of useful and often inspirational design insights this research can provide.

Informing design by examining specific types of information behavior

Shifts in information interaction intentions

In *shifts of interactive intentions and information-seeking strategies in interactive information retrieval*, Xie (2000) examined how people shift between different *interactive intentions* during information acquisition; intentions such as finding specific information, identifying additional information to search for and evaluating the usefulness of information. By identifying patterns of frequent or important shifts of interactive intentions (e.g. from 'evaluating' to 'finding' to indicate a unsuccessful or dynamic search), or what Xie (2000) terms *opportunistic* (i.e. serendipitous) shifts, this research suggests the potential for digital information environments to support these shifts in meaningful ways.

This research has continued relevance; we still need to support fluid, seamless transition between interactive intentions to allow user interaction with the environment to evolve organically. Xie (2000) suggests the potential for *adaptive* environments to guide users through different shifts. She suggests this can be achieved by embedding the most frequent shifts into systems as default settings, allowing users to explore opportunistic shifts (i.e. information encountered serendipitously) and return to where they were in their information-seeking before they digressed, and facilitating assisted shifts - such as from narrow to broad information-seeking goals, or from searching to browsing. Contemporary machine learning approaches may be able to usefully support a variety of these types of shifts.

Browsing

In *the things we talk about when we talk about browsing: An empirical typology of library browsing behavior*, McKay et al. (2019) examined browsing behavior in physical libraries to understand how to support this behavior in digital information environments. Therefore, this work examined browsing in a physical information environment to inform digital design. McKay et al. present a typography of types of shelf browsing and explain how each might be supported through design. These include *satisficing* (settling on a 'good enough' alternative to an unavailable book), *opportunism* (ad-hoc browsing during a search for a specific book), *seeding by search* (using a search for a specific book or keyword to find a location on the library shelves that may contain useful information, then browsing that location), *seeding by location* (returning to a known part of the library to browse the books again) and *wandering* (loosely-directed browsing, using the entire library).

They suggest digital *satisficing* can be better supported by allowing people to examine semantic features of surrogate information (e.g. for books, tone, length and presentation), *seeding by search* by allowing users to examine an item in detail while maintaining a sense of their other choices (e.g. through within-item recommendations), *seeding by location* by allowing users to easily return to previously visited locations (e.g. through persistent place marking) and *wandering* by allowing users to see an overview of topics or collections, then 'zoom' into and 'pan' across items on the topic or within the collection. Despite recognition as an important form of information-seeking and encountering (Makri et al., 2019), browsing is still poorly supported in digital information environments. There is much scope for developing novel browsing functionality, and for better supporting smooth, dynamic transitioning from searching to browsing and vice versa.

Information encountering

In *investigating serendipity: How it unfolds and what may influence it*, McCay-Peet and Toms (2015) examined peoples' work-based experiences of serendipity. Many of these were examples of serendipity in the context of information acquisition – known, in contrast to active information-seeking, as passive

information encountering (Erdelez and Makri, 2020). Patterns in these examples gave rise to a process model of serendipity where an informational *trigger* sparks a *connection* to a person's knowledge or experience. The person then takes *follow-up* action to caplitalize on the connection and obtain a *valuable outcome*. *Unexpectedness* is a thread that runs through serendipitous experiences.

McCay-Peet and Toms (2015) identified several environmental factors that facilitated serendipity they suggest can be designed into digital information environments; they suggest digital information environments might be designed to be *trigger-rich* by allowing people to *"brush up against information and ideas they might not otherwise encountered that have the potential to spark serendipity"* (p.9), to *highlight triggers* (e.g. by making them more salient), to *enable connections* by supporting creative thinking and to *enable capturing* of encountered information considered useful or potentially useful. Despite increasing research interest in understanding and designing to facilitate unexpected information encounters, how best to design for serendipity in digital information environments is still very much an open research question.

Informing design by examining the information behavior and practices of specific groups

Korean immigrants

In the *"had mores": Exploring Korean immigrants' information behavior and ICT usage when settling in the United States*, Suh and Hsieh (2019) interviewed 16 recent Korean immigrants to the US to understand their settlement-related information behaviors. The immigrants used digital information environments to create a *local* identity and maintain a *global* identity. To create a *local* identity (in order to manage everyday life in the US and avoid feelings of 'lostness'), they used search engines, online maps and online communities. They also used specific online communities for Korean immigrants in the US to obtain tailored local advice, such as where in America to purchase substitutes for Korean medicine brands. To maintain a *global* identity, they kept abreast of Korean news and communicated with friends and family in Korea. However, many struggled to adapt to digital information environments in the US, which Suh and Hsieh were concerned might limit the degree to which they could establish local identity and integrate into American life.

To support creating a local identity, Suh and Hsieh suggest designing mentoring systems that match immigrants with others (from different ethnic groups) at a similar settlement stage, to encourage mutual advice-giving and support. They also suggest designing Q&A or resource-sharing systems so immigrants can offer and ask for help from each other, while promoting societal integration.

LGBTQ+ millennials

In *"that looks like me or something I can do": Affordances and constraints in the online identity work of US LGBTQ+ millennials*, Kitzie (2019) interviewed lesbian, gay, bisexual, transgender and queer millennials to examine how their identity-related information practices are supported and constrained by search engines and social networking sites. Kitzie identified three affordances that enabled and constrained their practices: *visibility* (comprising both the amount of effort required to locate information and the ability to make non-hetero or non-cisnormative identify expressions), *anonymity* (non-identifiability) and *association* (between people and people and their context in digital information environments).

The ability to perform natural language search *supported visibility* to identity-related information, by supporting free expression (unconstrained, for example, by controlled vocabularies which were noted to exacerbate difficulties in expressing LGBTQ+ identify). However, search engines also *constrained visibility* by making visible results that often stigmatized LGBTQ+ identities (e.g. news about a queer person being murdered). Some social networking sites *supported anonymity* by not requiring identifying information, such as a profile photo. But this was double-edged, as this made it more difficult to evaluate the information credibility as anyone, particularly those who stigmatized LGBTQ+ identities, could post – *constraining anonymity*. Social tagging on social networking sites *supported association* by facilitating access to people or information that shares LGBTQ+ norms and values. But it also *constrained association* by hampering information-seeking by those who lack the language to find identity-affirming information.

Kitzie highlights these findings *"have implications for how…online technologies can support visibility, anonymity, and association in ways that engender the information practices of LGBTQ+ people"* (Kitzie, 2019, p.1347). Specifically, she suggests incorporating *stress cases* into the design process that

"highlight the processes through which dominant sociocultural discourses become embedded into technologies by focusing on unexpected and unintended outcomes of technology use among marginalized groups" (p.1348). Examples provided of these outcomes include Facebook's 'People You May Know' recommender suggesting connecting with a homophobic colleague or Google presenting results that stigmatize LGBTQ+ identities. Kitzie suggests designers reorient edge cases into stress cases by fully accounting for these outcomes rather than regarding them as unimportant exceptions.

These articles highlight an enduring research need to better understand the information needs, behavior and practices of specific groups, especially marginalized or potentially vulnerable groups, to ensure existing digital information environments adequately cater for these groups and to inform the design of novel, tailored environments especially for particular user groups.

Informing design by comparing information behavior and practices across user groups

Domain experts and novices

In *the role of domain knowledge in document selection from search results,* Liu and Zhang (2019) conducted TREC-based search experiments with 35 people with different levels of domain knowledge of genomics. Their aim was to compare the document selection behavior of domain experts and novices to inform search engine personalization based on users' domain knowledge. They found that searchers with high domain knowledge read more (and different) documents than those with low domain knowledge and gave the documents they viewed higher relevance ranking scores. They also found searchers with high domain knowledge selected longer documents, documents with more and more general MeSH (medical subject heading) terms and documents from lower down the results list than those with low domain knowledge.

They suggest using these findings to personalize the ranking and/or presentation of search results based on users' domain knowledge. For example, for domain novices, personalized search engines might provide fewer results and prioritize shorter documents and those with fewer and more specific MeSH terms. Conversely, for domain experts, they might provide more results and prioritize longer documents and those with more and more general MeSH terms.

Visually impaired and sighted people

In *a comparative analysis of the information-seeking behavior of visually impaired and sighted searchers*, Sahib et al. (2012) compared the search behavior of 15 visually impaired and 15 sighted people, driven by the motivation that *"understanding search behavior…leads to more effective interfaces that support searchers throughout the search process"* (p.377). They noted visually impaired searchers were often unaware of query formulation support features such as query and spelling suggestions, which might suggest why they reformulated queries less than sighted searchers. Visually impaired searchers also did not engage in as much search result exploration as sighted searchers, by following hyperlinks to Webpages or documents. They also noted visually impaired searchers relied heavily on notetaking to keep track of information found, whereas sighted searchers made fewer notes.

Sahib et al. (2012) propose design guidelines for designing search interfaces that are usable and accessible with screen readers. They argue it is insufficient to simply make accessible interface components designed based on visual cues. Instead, they suggest designing interface components to give off *"the right type of information scent to allow visually impaired searchers to navigate effectively through the information space"* (p.389). They also suggest clustering search results and providing auditory previews and overviews, to support visually impaired users in engaging with a greater volume of results. Finally, they suggest providing integrated support for managing information found, to reduce reliance on notetaking.

Comparing information practices across user groups can bring important contrasts into focus which, in turn, can give rise to recommendations for how digital information environments can 'level the playing field' across groups where one may experience more information disadvantage than the other. It can also help us understand how we can personalize, or design dedicated systems for user groups that could benefit from specialist informational support.

Informing design by examining specific information contexts

Articles in this section have examined how an understanding of various contexts surrounding information acquisition, interpretation and use can inform systems design. While the articles in this

special issue by no means cover all possible information contexts, they do investigate several varied contexts such as the *user* (Mohammad Arif et al., 2015), *environment* (Laing and Masoodian, 2015), *device* (Goyal et al., 2018), *social* (Worrall, 2019) and *privacy* (Vasalou et al., 2014) contexts.

User context (e.g. collaborative information-seeking behavior)

In *understanding tourists' collaborative information retrieval behavior to inform design*, Mohammad Arif et al. (2015) examined tourists' collaborative search behavior. Their findings informed a model of tourists' collaborative information-seeking which, in turn, can inform digital information environment design. Stages in the model involve *collaborative*: *planning* (of their collective search strategy), *searching* (by breaking down search tasks into subtasks and allocating them to individuals), *sharing* (useful search queries, results and links) and *decision-making* (by discussing search results together).

Mohammad Arif et al. suggest collaborative *planning* can be supported in digital trip planners by allowing users to store agreed criteria such as destination and duration, as well as planned search strategy, *searching* by providing collaborative querying, search strategy planning and query-tracking functionality and *sharing* and *decision-making* by providing a shared space for individuals to state preferences, have discussions and mitigate or resolve conflict.

Use context (e.g. information-based ideation)

In *a study of the role of visual information in supporting ideation in graphic design,* Laing and Masoodian (2015) interviewed 15 graphic designers about the role of visual information-seeking in their design ideation practices. They found images played several roles, which they state can be supported by design; encouraging designers' *personal development* (by supporting the creation of personal collections containing a variety of different media types), acting as a *cognitive aid* for expressing their ideas (by supporting making associations between images and ideas), supporting the *communication* of their ideas (through the creation and sharing of images) and supporting discovery or definition of the: *aesthetic tastes* of the design client or audience and *aesthetic language* used by competitors (by supporting the gathering and representation of images that represent those tastes/language).

Laing and Masoodian also make additional design recommendations, based on a holistic understanding of their findings rather than on findings related to specific roles. These include providing more extensive support for image-based search, providing access to collections of past design work from other designers, aggregating design images from different collections across social media platforms into a single collection and providing opportunities for designers to surround or insulate themselves from a variety of inspirational information.

This work inspired a subsequent study of games designers' information-based ideation behavior (Makri et al., 2019). This JASIST article, *ideation as an intellectual information acquisition and use context: Investigating game designers' information-based ideation behavior*, identified various information behaviors important for design ideation (e.g. immersing, unblocking and externalizing). This research highlighted the value of considering information acquisition as a means to an end to fulfil a particular intellectual purpose (in this case ideation, but also other potential knowledge-based activities such as knowledge creation and synthesis). It also suggested that, rather than supporting individual information behaviors independent of intellectual purpose, systems designers should *"place intellectual purpose at the center of design"* (p.785).

Environment context (e.g. user exodus on social networking sites)

In *understanding the determinants and dynamic process of user exodus in social networking sites: Evidence from Kaixin001*, Zhao et al. (2018) conducted interviews and network analysis to examine reasons for user exodus (large-scale, rapid abandonment) of a specific social networking site – Kaxim001. Reasons included poor *design* and *user experience*, low *content quality*, high perceived *privacy risks* and *effort cost* of participation and functionality hindering the formation of *interpersonal relationships* and a sense of *virtual community*. To mitigate for exodus based on some of these reasons, they suggest providing novel design features, fresh content, designing to address privacy concerns and monitoring lurking behavior in order to offer incentives for participation when users disengage.

Device context (e.g. mobile information interaction experience with native ads)

In *designing for mobile experience beyond the native ad click: Exploring landing page presentation style and media usage*, Goyal et al. (2018) examined the impact of two different native ad landing page design decisions on peoples' mobile information interaction experience. They explain that native ads,

often used in mobile apps, are designed to conform in format and style to the context of the application. When a user clicks on a native ad, they are taken to a landing page that may or may not reflect the consistent experience of the app they arrived from. The landing page design decisions they examined were an *advertorial* presentation style, which followed the style of the application the user came from vs. an *advertisement* style, which did not.

Goyal et al. found an advertisement style landing page resulted in higher perceived usability for some genres of ads (automobiles and education) and suggested advertisers could provide more explicit advertising content in these contexts, as this is what users had come to expect. Conversely, they found advertorials to be less useful than adverts, suggesting the need to avoid their use in a native ad context. Videos increased perceived usefulness and usability of native ad landing pages, suggesting the potential to incorporate video content to complement textual ad content.

Social context (e.g. the sociotechnical infrastructure surrounding information sharing in online communities and social digital libraries)

In *"connections above and beyond": Information, translation, and community boundaries in LibraryThing and Goodreads*, Worrall (2019) examined the sociotechnical infrastructure surrounding information sharing in digital information environments. He focused on LibraryThing and Goodreads – digital information environments that serve both as online communities and social digital libraries. They can therefore be regarded as *boundary objects*, providing access to information that can be used by different communities, such as fiction readers and authors, in different ways. To understand their sociotechnical roles as boundary objects and the impact of these roles on information sharing, Worrall conducted a content analysis of messages and a survey of and interviews with users. The analysis focused on information sharing concepts from boundary object theory; *translation* (cross-community communication and negotiation around the meanings behind their knowledge), *coherence* (across intersecting communities) and *convergence* (of communities over time).

Worrall found LibraryThing and Goodreads served three roles as boundary objects, explaining each in terms of translation, coherence and convergence; 1) They helped to establish community and organizational *structure*, for example by moderators and frequent posters establishing explicit group norms by asking users to read group rules on posting. This reflected *coherence* by them making reference to the norms of intersecting communities (e.g. LibraryThing and Goodreads themselves). LibraryThing and Goodreads also served a structure-based role through *translation*; much *"back-and-forth negotiation of meaning and understanding"* (Worrall, 2019, p.747). This negotiation helped users become better acquainted with the community. 2) They helped to support *sharing of 'information values'* (i.e. a shared sense of information importance). These values often *converged* group interests and understanding. Users' existing information values from other communities shaped *coherence* between individuals and groups. 3) They helped to support making and maintaining *social ties*. Ties were created through the *convergence* of continued behaviors, activities and values and contributed to a sense of community.

These findings suggested designers might enhance the role of digital information environments as boundary objects by *highlighting translation processes and resources* to help users negotiate and reconcile understandings; *supporting the creation and maintenance of social ties* (e.g. through user profiles and off-topic discussion spaces) *without collapsing contexts* (e.g. by providing functionality that allows users to choose whether and how to socially identify themselves); *expressing site-wide norms and rules* to facilitate coherence and reconciliation of meanings, supporting 'boundary spanners' (members of multiple communities) to *forge links between communities*, thereby creating permeable boundaries for people and information to cross and *striking a sociotechnical and infrastructural balance* by promoting appropriate functionalities to appropriate user groups.

Privacy context

In *understanding engagement with the privacy domain through design research*, Vasalou et al. (2014) present a case study both of information informing design, but also the other way around - of a design intervention informing our understanding of a specific information context (information privacy) and this understanding, in turn, informing the design of future digital information environments. Together with 12 recruited Internet users, Vasalou et al. co-designed a system aimed at helping users understand personal privacy risks and how those risks form longer-term privacy concerns. Their aim was not to design a system, per se., but *"to understand how engagement with the privacy domain could be fostered by technology through the collaborative process of designing and interacting with this tool"* (p.1265).

This system was designed to cluster Tweets about privacy-related news into categories that encapsulated a privacy risk or violation and create an interactive visual representation of the clusters, which users could explore and follow the links from to read any associated news articles.

Through interviews and observations with the co-designer users, they identified implications for understanding privacy; for example, users lacked motivation to stay abreast of privacy risks, suggesting the need for systems to develop users' intrinsic privacy motivations. Users also chose to engage with those privacy issues raised by a story they were most interested in, suggesting the need for systems to frame the concept of privacy within users' interests.

The importance of understanding the context surrounding information behavior, interaction and practices has long been argued (Courtright, 2007). The articles in this special issue illustrate an expansion of the types of information context traditionally examined in Information Science research, beyond the task context. As digital information environments become ever more sophisticated in response to increased understanding of user needs, a rich understanding of a breadth of information contexts is essential for ensuring those environments fit well within the ecosystem in which they operate.

Informing design by examining the sociomateriality of information environments

In *materiality in information environments: Objects, spaces, and bodies in three outpatient haemodialysis facilities*, Veinot and Pierce (2019) interviewed and observed 28 outpatients in haemodialysis units, focusing on the role of sociomateriality in these physical information environments. They note materiality refers to the arrangement of physical and digital materials into forms that endure across place and time (Veinot and Pierce, 2019). *Socio*materiality further clarifies that materiality is intertwined with social phenomena (Veinot and Pierce, 2019). The authors use six 'layers' to understand the role of sociomateriality in these environments; *physical*, *empiric*, *syntactic*, *semantic*, *pragmatic* and *social*. They examine how each layer enabled and constrained *information access*, *flow* and *acceptance*. For example, regarding the *physical* layer, they found ongoing proximity to clinicians supported *information access* and allowed patients to form relationships with clinicians. This often led to *information acceptance*, as some patients trusted the information clinicians provided. However, the placement of equipment (e.g. dialysis machines) constrained *information flow* by impeding conversation.

Veinot and Pierce highlight the value of information that has been materially coded in physical environments and propose sociomaterial design guidance for supporting *information access*, *flow* and *acceptance* in physical information environments that arguably has much relevance for digital information environment design. For example, to support information *access*, their findings suggest carefully considering: the presence of objects in an environment, as they can support or constrain certain information behavior, the timing and location of interactions and the ability to move freely in the environment. To support information *flow*, the findings suggest providing intermediation where information structure requires expertise to understand, creating and maintain visibility between co-located people and balancing privacy and information flow. To support information *acceptance*, the findings suggest providing regular proximity to information sources, displaying information in prominent and 'official' locations and being aware that physical and emotional experiences can dictate perceived information validity. Understanding information environments through theoretical lenses such as sociomateriality can spark unique design insights that might not have materialized otherwise.

Informing design by examining the role of information in everyday experiences (e.g. gratitude in online communities)

In *"I can't express my thanks enough": The "gratitude cycle" in online communities*, Makri and Turner (2020) interviewed 8 online community users to understand their experiences of gratitude in online communities. They integrated their findings into a process model of gratitude in online communities. The process involves a benefactor *acting kindly* (e.g. providing information, advice or support) and a beneficiary *noticing* the kind act, *recognising* the good in it and *feeling grateful*. The beneficiary may then *express* gratitude and the benefactor might receive and *acknowledge* the expression of gratitude. When the acknowledgement is received, this can reinforce future prosocial behavior among the beneficiary, benefactor or other community members, thereby encouraging sustained participation and a 'cycle' of gratitude-driven prosocial behavior.

They suggest designers of online community platforms can support individual stages or the overall gratitude process and prevent process breakdown to encourage reinforcement of prosocial behavior.

For example, awareness functionality such as feeds and alerts can support *noticing* and *recognising* the good in kind acts. Rewarding quality over quantity of contribution can support gratitude *expression*, as can encouraging expression 'while the iron's hot.' Gratitude acknowledgement can be semi-automated by providing customizable templates. Understanding the role information plays in everyday experiences can inform the design of digital information environments that engender those experiences.

Informing design by examining information experience

In *information experience in personally meaningful activities,* Gorichanaz (2019) used interpretive phenomenological analysis (IPA) to examine how people experience information in personally meaningful activities; bible reading, ultramarathon running and artmaking. He identified several themes that characterized the information experience across these activities; *identity*, *central practice*, *curiosity* and *presence*. Gorichanaz (2019) states these themes *"provide a locus for developing technologies that encourage the cultivation of meaning"* (p.1309) but, rather than make specific design recommendations, emphasises that the aim of IPA is to spark rather than address questions. One such (design-focused) question is *"how particular technological interventions contribute to or detract from opportunities for meaning"* (p.1309). He notes, somewhat counterintuitively, that rather than simplifying users' interactions with information, digital information environments may need to encourage users to *"slow down and undergo struggle to cultivate deep personal meaning"* (p.1309). This work illustrates that Information Science research can usefully inform design by posing design questions rather than proposing design recommendations. An understanding of information experience can complement a human-centred design ethos, which places emphasis on designing an engaging and enriching user experience.

Shaping the future: How JASIST research can continue to inform design

The world will always be filled with information and there will always be a need to support people in creating, consuming and communicating it. Therefore, it will always be important for Information Science research to inform design. By doing so, Information Science research can help ensure insights gained from understanding how people engage with information are put to good use – creating as much impact as possible by feeding into design interventions that will shape the next generation of digital information environments which will, in turn, shape peoples' future information engagement. Therefore, our understanding of peoples' information needs, behavior, practices, interactions and experience not only has the potential to shape design, but also to be *shaped by* it.

There is scope for Information Science research to play even more of an active role in informing design, to avoid over-dominance from disciplines that have a strong design and development underpinning but lack a strong informational underpinning (e.g. HCI, IR and computing disciplines more broadly). This should not, however, be a competition over which discipline can exert most influence on the design of future digital information environments. Instead, it should be an opportunity to build bridges between Information Science and computing disciplines, so Information Science research can make contributions that transcend its discipline boundaries. By doing so, it can also bridge the three fundamental dimensions of JASIST - information, systems and users. Systems design should, in turn, be informed by all three of these dimensions, with the information and the systems that facilitate engagement with it serving the people who it is designed for, and want to use it as a means to an end (such as to create new knowledge or understand or effect a change in their lives, or the lives of others).

Information is power, bestowed through technology to enrich peoples' lives. Information Science research not only has the potential, but also the *duty* to continue to inform the design of the digital information environments that aim to empower users to create insights. I hope you enjoy reading the articles in this special issue.

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