Collaborative Improvements in the Discoverability of Scholarly Content

Accomplishments, Aspirations, and Opportunities

A SAGE White Paper

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Executive Summary

The life cycle of academic works is supported by extensive cross-sector collaboration throughout the scholarly communications ecosystem. In recent years, traditional codes of practice have been disturbed. In response, in 2012, SAGE published a white paper that offered conversation starters for reinventing conventions and relationships among libraries, publishers, and service providers.

To carry on the investigation of the first white paper, *Improving Discoverability of Scholarly Content in the Twentieth Century: Collaboration Opportunities for Librarians, Publishers, and Vendors*,[1] this paper explores the latest accomplishments, aspirations, opportunities, and challenges for improved discoverability of scholarly content. As the discovery landscape is rapidly shifting, this paper demonstrates that progress continues to depend on core principles of cross-sector collaboration, taking the form of these actionable recommendations for anyone in scholarly communications:

- Standards: When relevant, all sectors should participate in ratified standards to ensure that cooperation is part of business-as-usual routines.
- Transparency: Standards compliance is critical for successful discovery, and the development, implementation, and enforcement of these standards require open relationships across the industry focused on reaching our shared goals.
- Metadata: Quality metadata, observing ratified standards, enables successful discovery of scholarly content, products, and services.
- Partnerships: Opportunities exist for new discovery innovations across the industry, such as linked open data and cross-publisher discovery tools.

Introduction

Discoverability has become an increasingly popular focus of discussion in recent years because discovery facilitates core functions of research and scholarship—it is the critical precursor to fundamental academic activities, such as reading and citation. As one publisher pointed out, "If we can't find it, as readers, we certainly won't be using it. Meanwhile, our authors want their work to be read, and librarians who make it available to readers want to know it's useful."[2] Therefore, across the scholarly ecosystem, making high-quality research results and other academic work findable and accessible continues to assume heightened importance.

In the short two-year period since the first SAGE study,[3] notable progress has been made. Newly commissioned studies, research reports, and standards initiatives have heightened awareness among the scholarly community of the vital importance of discoverability. During this same period, new research findings and proven best practices have created growing appreciation for researchers' nuanced workflows, and information literacy initiatives have connected scholarly communication and research education.[4]

In addition, related technologies have significantly matured, and new products have launched. Predictive of further changes ahead, both established academic publishers and new entrepreneurial start-ups now offer reader-oriented discovery acceleration tools, oftentimes enhanced by social media tools, semantic data, and open source software—such as ReadCube (www.readcube.com/) and Mendeley (www.mendeley.com/). These movements in the scholarly ecosystem acknowledge evolving novice and expert researcher workflows and anticipate new business models and customer bases. Such new value-added scholarly services and online environments—amid increasing availability of open access and multimedia content—accelerate expectations for improved discoverability of the scholarly corpus, as well as its creation, dissemination, navigation, visibility, and usage, on the open web and within library services.

In response to these new realities, SAGE commissioned this second study in 2013 to explore new accomplishments, aspirations, opportunities, and challenges for improved discoverability of scholarly content. Industry experts were asked to reflect on which recent developments aid discoverability of scholarly materials, what else is needed to achieve optimum discovery experiences for readers, and how cross-sector initiatives can achieve these collaborative goals (see the appendix).

As with SAGE's 2012 discoverability white paper, research results aim to benefit the community of libraries, intermediaries, service providers, researchers, authors, and publishers who produce, deliver, and consume the scholarly corpus. Therefore, contributions to this study by sixteen academic supply chain experts offer viewpoints representative of (1) *academic libraries*, as well as their campus communities and technology vendors; (2) *primary content publishers*, as well as their published authors, journal editors, and technology partners; and (3) *secondary content publishers* of abstracting and indexing (A&I) services, as well as their technology partners. These experts are extensively quoted throughout this paper.

This white paper begins by providing a review of recent developments in the scholarly ecosystem since the first SAGE discoverability white paper was released in 2012. This foundation supports the exploration of both mature and evolving phenomena and allows examination of aspirations to enhance discovery tools and processes—thereby improving scholarly discoverability and accelerating related cross-sector initiatives. Concluding recommendations identify promising collaborative opportunities to drive scholarly discovery.

What Is Discoverability?

Notably, definitions have evolved in the past two years within this community-wide conversation. Now, a distinction is commonly made between

- *discovery*, or the process and infrastructure required for *a user* to find an appropriate item, and

- *discoverability*, or the description or measure of *an item's level of* successful integration into appropriate infrastructure maximizing its likelihood of being found by appropriate users.[5]

Community perspectives have also evolved in recent years. Ideal discovery is increasingly acknowledged as involving diverse users' abilities to identify appropriate information at or before the point of need. Ideal discovery is envisioned as highly efficient, saving the time of the user and occurring fluidly within the research workflow. Ideal discovery incorporates the complete relevant literature, including non-published materials, such as conference proceedings, archives, and special collections; non-text formats including images, multimedia, and data sets; and statistical or other non-English language materials. Ideal discovery provides result sets and rankings that are unbiased by either political perspective or commercial interests.[6]

Ideal discoverability (see Figure 1) also provides every item with at least a fair chance to be discovered, by every conceivable reader, maximizing the usage of that item and, by extension, maintaining or increasing its value. Therefore, a persistent concern for many academic libraries and content providers concerns current discoverability practices that potentially include greater visibility of content based on indexing limitations or competitive advantage.[7]

Heightened recognition of discoverability emerged as a significant new trend characterized by a "no wrong door" philosophy,[8] which recognizes that the variety of discovery channels needs to be more fully realized. This will necessarily involve stakeholders throughout the supply chain in order to "broaden the 'entry points' for scholarly content so that authoritative information is visible wherever users happen to

Figure 1　Survey answers to "What does ideal discoverability look like, from your perspective?"
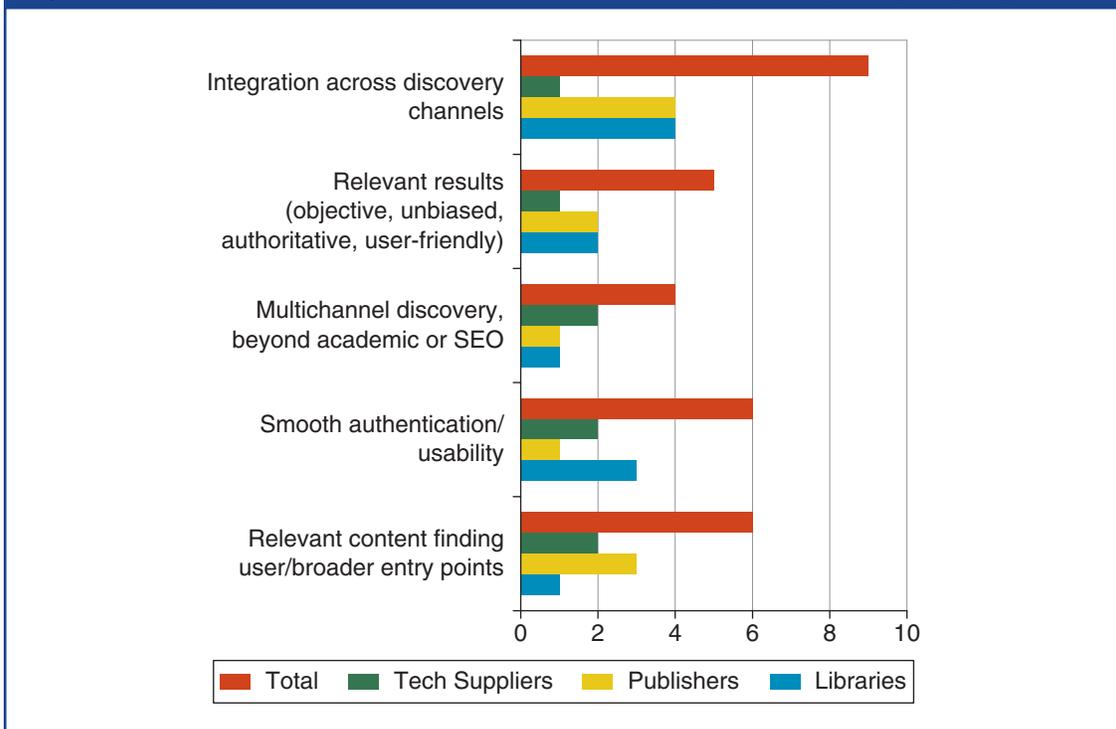
be searching, whatever they're searching for."[9] Significant improvements, so "information I need finds me,"[10] requires enriched "workflows that are seamless and transparent."[11] As one expert observed, "ideal discovery would involve seamless cycles of content discovery with search, filtering, acquisition, references, further acquisition, etc., that puts minimal to no burden of understanding underlying technology on the researchers themselves,"[12] to enable "content finding us."[13]

Also significant during the last two years, a differentiation between *search* and *discovery* has emerged, which permits further precision in cross-sector conversations. "Search is the identification of potential objects to read or view in either a known item retrieval scenario or—more importantly—an immersion environment where choices are made."[14] Thinking about immersion environments, which until recently were understood in the context of defined subsets of content such as a single database, has also shifted. Now, researchers can move more swiftly to *find* resources through *search* of all curated library content, including databases, in a "single search box" web-scale library discovery service. Easy identification of resources worth reading within a customizable immersive search environment addresses the vexing problem of knowing where, as well as how, to search in order to discover.[15]

Such progress in user environments has in turn permitted broader consideration of researcher context. For instance, *pre-search* readiness for finding appropriate resources requires sufficient "big picture" understanding to formulate research queries, including term identification and interpretation. It follows that "finding context" constitutes "searching for meaning that facilitates interpretation so that results may be had"[16] through discovery processes. In response, seamless interoperability, systems integration, common standards, and licensing practices can now support the development of new discovery products.

Collaborative Discoverability Accomplishments

In the SAGE baseline study[17] conducted in 2011, cross-sector experts recognized a variety of discoverability starting points and search catalysts. These include specialist bibliographic databases; library web pages, including discovery layer services that offer Google-like search across all curated library collection content; publisher websites, including journal homepages, publication archives, RSS and other alerting services; web search engines, such as Google Scholar; scholarly society web pages and other affinity sites; and referrals from colleagues, blogs, and other trusted networks, including social media contacts.[18]

Experts surveyed in 2013 acknowledged a significantly changed discoverability environment. This has also been corroborated in recent studies, which have shown that users' behaviors are changing.[19] As adoption of new channels for academic discovery are rapidly diversifying, libraries and publishers alike are working to make products and services visible via multiple channels simultaneously. Aiming to reach users through whatever channels they choose in their research requires working with traditional discovery methods, such as citations and A&I products, as well as new pathways, such as social media and mobile devices.

In recalling recent discoverability accomplishments, one library expert noted, "The biggest accomplishment for libraries has been to get publishers to understand how vital discovery is. Publishers finally understand that they need to provide robust metadata, and are actually supplying it."[20] This cross-sector trend signals that discoverability is increasingly expected by researchers, is valued by publishers, and is explored by libraries. Consequently, improved commercial search products and interface enhancements now enrich users' content discovery experiences. In large part, this is due to a shift in perspective throughout the scholarly community. As one expert stated, the scholarly community has "historically spent all of our time on the content side of the equation, not the user side. You need both to enable discovery."[21]

Advances are catalyzed by collaborations engaging value-added combinations of technologies, standards, and practices that produce more effective, efficient, and global solutions. Several initiatives driven by organizations, such as the National Information Standards Organization (NISO) and CrossRef, further technological and standards development and exemplify how the academic supply chain has come together "to dramatically improve the 'plumbing' of the digital information infrastructure."[22] Each

effort aims to create a smoother experience of discovery across library and publisher systems, thereby improving discoverability. As a result, "[t]here is more of a readiness by the academic community to view scholarly contributions in a more open way. This has led to expectations that this content will 'be' more discoverable."[23]

Many new products leverage collaborative standards—such as Open URL (link resolver) and Knowledge Bases and Related Tools (KBART) —enable the delivery of full text for target content via academic affiliation and library holdings. As one expert noted, "Going back a few years, the creation of the digital object identifier and the CrossRef initiative have made discoverability easier."[24] Subsequently, other initiatives offer "best practices with the intent to provide greater content to users, ensure linking and useful access points to enhance discoverability, and remove barriers within the information supply chain."[25]

Search Landscape

Publishers and libraries alike have come to acknowledge that they serve a diverse body of researchers and readers with diverse discovery habits and needs. Therefore, it is increasingly understood that successful discovery depends on a multi-channel approach.[26] Publishers understand that "it is incumbent on those of us who seek to serve busy users to . . . use different strategies to be discoverable where people want to look."[27] Librarians are finding innovative ways to use Wikipedia to drive discovery of licensed resources,[28] and they are placing content experiences in learning management systems and social media networks.

In order to ensure that content is discoverable through multiple byways, there is also growing recognition across the ecosystem that discoverability through any search engine requires content to be well indexed and well represented. Therefore, academic supply chain contributors increasingly share a common goal to ensure high-quality, accurate data that facilitate search precision and relevance, and, ultimately, content discoverability and accessibility. Consequently, scholarly metadata standards have received significant attention recently, in an effort to address the uneven protocols for product data (such as title, author, and ISBN) and semantic data elements (such as keywords, relationships, and subject categorization). Additionally, discoverability functions, such as reference citation links with built-in authentication, have significant potential to appreciably further discoverability. These researcher-experience developments depend on standards compliance, systems development and maintenance, and open business models, which in turn rely on collaboration among publishers, authors, and library vendors.

Meanwhile, indexing rules set by mainstream search engines continue to evolve and require constant vigilance.[29] For example, in 2013, academic content providers around the world were forced to consider alternate methods of open-web discoverability when Google's primary web search ceased its special treatment of access-controlled scholarly materials.[30] Google and Google Scholar do not openly discuss their development road map or any technical, professional, or commercial considerations that drive the way that literature is collected and represented to searchers.[31]

The academically oriented Google Scholar product presents both opportunities and challenges for libraries, publishers, and their service providers. Scholar is primarily indexing journal content, including popular indexing databases such as Science Direct and Scopus, but it has not yet achieved full text indexing of scholarly e-books, multimedia, or statistical products with direct linkages into publisher platforms. However, Google is invested in partnering with libraries and publishers to enable discovery and access to licensed content, as demonstrated by the subscriber link program, whereby local holdings can be highlighted in search results generated within an institutional network.[32] In addition, Google Scholar Library, which enables saving articles directly from the search page in Google Scholar, organizing them by topic, and searching full-text documents within a personal MyLibrary space, is setting heightened expectations for workflow integration solutions.[33]

Collaborative efforts toward semantic enrichment to drive discovery have evolved rapidly. Schema.org (http://schema.org/Dataset) and ScholarlyArticle (http://schema.org/ScholarlyArticle) offer recommended data structures to enable improved discoverability via unique properties. These include, but are not limited to, publisher, editor, reviewer, genre, reviews, ratings, institution, location, creation date, and modification date, as well as author, title, and source—all value-added signifiers of provenance and authority.

Similarly, two notable initiatives leverage structured metadata to improve discovery, among other benefits. The FundRef initiative (http://www.crossref.org/fundref/) will streamline discovery of open-access content through providing a standard way to report funding sources for published scholarly research. Publishers deposit funding information from articles and other content using a standard taxonomy of funder names. Then, through CorssRef's search interfaces, this funding data are made publicly available for funders and other interested parties for analysis.[34]

The second initiative, Open Researcher and Contributor ID (ORCID),[35] which celebrated its first-year launch anniversary in November 2013,[36] assigns unique identifiers to researchers in order to associate scholars or entities with research outputs, whether technical papers, grant awards, patent applications, journal articles, or conference papers, across multiple hosts or databases. To address the researcher name ambiguity problem, ORCID provides a registry of persistent unique identifiers for published researchers and scholars. Widespread adoption and usage by the research community at key workflow and dissemination points—manuscript submissions, data set deposits, grant applications, patent applications, and faculty records—support cross-disciplinary, cross-sector linkages across multiple grant awards, clinical trials, scholarly publications, patents, and data sets. Toward that end, 350,000 researchers registered and ninety organizations joined in the first year, and more than fifty organizations have already integrated ORCID identifiers into workflows, including CrossRef, Researcher ID, PubMed Central, and Scopus.

Meanwhile, webmasters are increasingly adopting industry-standard XML schemas and web standards, such as EPUB 3 and HTML5, to encode content and construct web pages in ways recognized by major search engines and discoverable via many devices. When these search providers index content and databases with standardized structures, they are better able to point users to discovery of relevant web-based resources.

To standardize the metadata embedded in electronic presentations of an article, a number of cross-sector initiatives are gaining participation and advancing discovery. For example, e-journal mark-up routines championed by the National Library of Medicine have now been formalized by NISO as the Journal Article Tag Suite (JATS; http://www.niso.org/workrooms/journalmarkup). Emerging standards, such as Recommended Practices for the Presentation and Identification of E-Journals (Pie-J; http://www.niso.org/workrooms/piej), continue to drive normalization for improved discovery.

Standard metadata schemas enable cooperative efforts across the industry. This is especially important in text and/or data-mining (TDM) platforms. Without standardization, researchers struggle with hundreds of publishers, databases, and institutional resources, all using different formats and protocols. Recognizing that automating TDM for scientific data can speed progress and innovation, in 2013, CrossRef launched Prospect (http://prospectsupport.labs.crossref.org/), a pilot program using a cross-publisher Application Programming Interface (API) that leverages its Digital Object Identifier (doi) database for text and data mining.

Standards for semantic markup, such as Dublin Core, schema.org, and ScholarlyArticle, enable scalable, more precise discovery by revealing the meaning of and relationships between appropriate content. In response, libraries, publishers, and their technology service providers are leveraging semantic enrichment to deliver search-by-concept functionality and other navigational features that enable efficient discovery of relevant materials.[37] Going one step further, Linked Open Data[38] (opening structured metadata to any user) promises new ways to connect and enrich users' search experience so that different representations of the same content can be found and links made between related resources. Through increased uptake of these semantic standards, the scholarly community moves closer to the vision of the semantic web, where related content is interconnected and supports greater serendipitous discovery.

In Europe, for instance, Europeana[39] offers multilingual discoverability of the digital resources in Europe's museums, libraries, archives, and audio-visual collections. The metadata for all the objects in the Europeana portal is open, licensed under the Creative Commons Public Domain Dedication under the terms of the Data Exchange Agreement (DEA), and can be freely downloaded to mobile and other devices via the API. In October 2012, a large subset of these data was transformed with structured, linked data.[40] The data are represented in the European Data Model (EDM), which intends to provide context by connecting objects (such as a paintings) with information from different domains (such as geography) via cross-vocabulary links.[41]

In North America, the Digital Public Library of America (DPLA)[42] provides multiple entry points to search or browse rich collections of primary-source material, including scientific papers, audio recordings, and photographic images. The discovery interface supports browsing digital records through a map or a timeline. Metadata serves as a key part of the DPLA discovery framework, describing content and resources in the DPLA, enabling users to find them, and connecting holdings in the United States to holdings in other countries as part of a global linked data environment.[43]

At the same time, publishers, libraries, and their technology partners are notably increasing resource investments to measure and optimize scholarly content for open-web discovery. Routines are in place for developing and testing online products designed for search engine optimization (SEO). With user behavior continuing to evolve and discovery channels continuing to proliferate, many sectors in the supply chain leverage web analytics and observational research to reveal insights that will accelerate document retrieval and enable researcher browsing. This includes maximizing SEO for mainstream search engines, such as Google or Bing, as well as social media exposure. Many publisher platform providers further discovery through content architecture, quality assurance, and usability testing, with the goal of hosting online content that is easily found and well presented—whether on a publisher's website or in a library catalog, via a user's laptop or smartphone, and/or from a user's home or work.

Library Discovery Tools

The introduction of web-scale discovery in 2009 represents a significant accomplishment in discoverability. Although libraries have been moving toward unified search with developments in Online Public Access Catalogues (OPACs) and in various federated search tools for some time, today's web-scale discovery services significantly advance user experiences by leveraging expectations set by open-web search engines. "Web-scale discovery removed barriers to discovery and access of content in library's collections by overcoming past deficiencies in user experience (too confusing, too slow to return results, too many search interfaces that required specialized knowledge of controlled vocabularies and advanced searching techniques) and revolutionized the way researchers discover and interact with the library, librarians and library collections."[44] As a consequence, libraries can now replicate the centralized, yet flexible model of Google's search interface, with its customary speed, content breadth, and quality. Thus, it comes as little surprise that two recent studies suggest that increased library website traffic is likely attributable to the presence of web-scale discovery services.[45]

NISO defines discovery services as those library applications that provide a single search box to access a central, pre-indexed database of institutional holdings. Since release of the SAGE white paper in 2012, adoption of web-scale library discovery services offering single search box solutions has grown steadily.[46] Industry forecasts predict continued—and even accelerated—adoption rates of this "must have" discovery tool.[47]

In recent years, the four major web-scale discovery products (OCLC's WorldCat Local, EBSCO Discovery Service, Serials Solutions Summon, and Ex Libris Primo Central) have all achieved a level of maturity. They have expanded the quantity and quality of content represented within their indexes, have continued to refine their interfaces, have enabled greater interoperability with the library's integrated library system (ILS), and have continued to improve the algorithms for calculating the relevancy ordering of search results.[48] However, none can claim complete, comprehensive coverage. Gaps remain because not all publishers contribute metadata to discovery products. Some

are concerned with intellectual property and competitive interests. Others are uncomfortable with the presentation, branding, and general lack of assurance that their content will be used only for the benefit of the libraries with current subscriptions. Regardless, as library uptake of discovery services grows into the majority, library user experiences are increasingly limited by searching incomplete holdings.

In response to these developments, the NISO Open Discovery Initiative (ODI) was charged in 2011 with recommending standards to improve discovery of information services mediated through index-based discovery services. Its driving mission is to advance cross-sector transparency and creation of an environment that broadens stakeholder participation and ensures confidence through fostering development of best practices. To further trust among all ecosystem contributors, ODI conducted a study and issued findings in 2013.[49] Soon it will be publishing guidelines for index-based discovery services, including fair linking models, metadata workflows, and usage statistics for shared assessment routines.

The cross-sector benefits for this ODI initiative are numerous. Libraries, for instance, can offer their users as wide a range of content as possible via a discovery service of choice, as well as offer better evaluate discovery services to address their local needs. Content providers can have confidence that the discovery service providers are handling their content in an appropriate manner. They will thereby be encouraged to make available the widest range of content—in terms of breadth and depth—for indexing by discovery service providers. In turn, discovery service providers will receive more standardized and efficient integration with the information providers through common industry definitions and communications.

During consideration of a range of protocols for discovery services, the ODI proposes a permanent collaborative mechanism to broaden the discussion among all stakeholders, implement ODI working group recommendations, and formalize discovery service standards. Practical next steps will provide educational opportunities to promote adoption of ODI recommended practices, support for content providers and discovery providers during adoption, and open dialogue to address ongoing issues related to all aspects of discovery platforms.

In a complementary fashion, in 2013, the National Federation of Abstracting and Indexes Services (NFAIS) produced a code of practice[50] that establishes best practices for the business agreements and cross-sector relationships within production and purchase activities for discovery services. Whereas the NISO ODI findings cover recommendations for related technologies and metadata, the NFAIS guidelines inform interactions between the creators of these services and the content providers whose resources they represent. This range of activities includes data exchanges, content coverage and display, and product identification.

It is also important that discovery service suppliers and academic content providers deliver data that allow libraries to fully understand and assess the value of web-scale discovery systems and the indexed resources. To further this effort, the "Impact of Library Discovery Technologies" report commissioned by the United Kingdom Serials Group (UKSG) recommends working toward "open communication with interested parties (libraries and content owners/providers)."[51] The report also addresses specific needs for all sectors to better understand how individual discovery systems work, their affect on usage of resources provided by individual publishers and content providers, the construction of relevancy rankings, and the application of metadata within an international cross-sector ecosystem context.

In another notable cross-sector collaboration, a UKSG/NISO initiative known as KBART (Knowledge Bases and Related Tools) was launched in 2008 to standardize data and practices for electronic resources management (ERM) knowledge bases that populate library website A–Z lists, link resolvers, and web-scale discovery services. These initiatives illustrate wide-ranging interests and activities across the scholarly information community—libraries, publishers, ERM providers, standards organizations, and platform vendors, among others—in successful discovery as well as access and retrieval.

The KBART standards also suggest the complexity of coordinated efforts required to attain current levels of reliability and quality across multiple information flows. In recognition of the need to effect smoother transitions between members of the scholarly supply chain, KBART Phase II recommendations were released in fall of 2013 for public comment.[52] The goal of this updated standard is to enable more precise, higher-quality data by content providers. In a related effort, in April 2013, the NISO IOTA (Improving OpenURLs through Analytics) initiative was approved for a two-year data analysis exercise. IOTA's aim is to assess the feasibility of industry-wide, transparent, and scalable metrics to monitor the quality of OpenURL links across providers.

Innovative uses of technology by libraries to champion content discovery are illustrated across the globe. For example, Virginia Tech libraries developed a unique real-time visualization of data from institutional usage of their Summon installation.[53] Also, QR codes are being regularly employed to raise awareness of licensed resources.[54] Open-source applications are mashed-up both to promote web-scale library search tools across campuses[55] and to enable assessment of such installations. In addition, via their participation in the Digital Public Library of America,[56] countless libraries are now leveraging social media, mobile applications (apps), and other devices to advance discovery and usage of library holdings.

For growing numbers of libraries, earlier investment in ERM systems and associated technologies, such as OpenURL software, paves the way for web-scale discovery services that enable researchers to search across vast quantities of locally hosted library information silos. Furthermore, discovery and content retrieval via institutional accounts can occur by mobile access through apps, such as BrowZine (http://browzine.com), or sites optimized for smartphones, some of which issue vouchers for off-campus mobile access:

> When viewed within the larger framework of the scholarly ecosystem, the shift in collections from "p" to "e," the advent of new technologies for discovery and management of collections, and increasing adoption of "just in time" collection development strategies coupled with availability of creative acquisitions models . . . and short-term loans all present opportunities for stakeholders across the scholarly ecosystem to find ways to work together to optimize discoverability, shorten the timeframe from when content is available to when it is discoverable, and allow each stakeholder to focus on their core competencies.[57]

Researcher Workflows

A small but important body of literature has produced new insights into academic researcher behaviors, preferences, attitudes, habits, and methods. In addition to results of four longitudinal studies, the research literature now contains some significant reports on specific aspects of academic research behavior, including user experiences in web-scale discovery services.

In 2012, the British Library and JISC released the *Researchers of Tomorrow* study, which found that Gen Y doctoral students are highly competent and ubiquitous users of information technologies generally—although, when it comes to their academic research, they tend not to be early adopters. Rather, they use applications mainly if they are easily absorbed into their existing research work practices.[58]

Since 2008, Project Information Literacy (PIL) has conducted six national studies of undergraduate students' digital research processes throughout the United States. The conclusion is that "the abundance of information technology devices and the proliferation of digital information resources have made conducting research paradoxical"[59]—in which students have an overabundance of information resources, yet have limited information literacy. In response, most students use strategies, techniques, and workarounds driven by perceived efficiency and comfortable predictability in order to manage and control the staggering amount of information that is available.[60]

In another study, conducted between 2008 and 2010, the Ethnographic Research in Illinois Academic Libraries (ERIAL) project found that students struggled with all aspects of the search process. Most tended to use Google first for course-related research, instead of the constellation of library resources.[61]
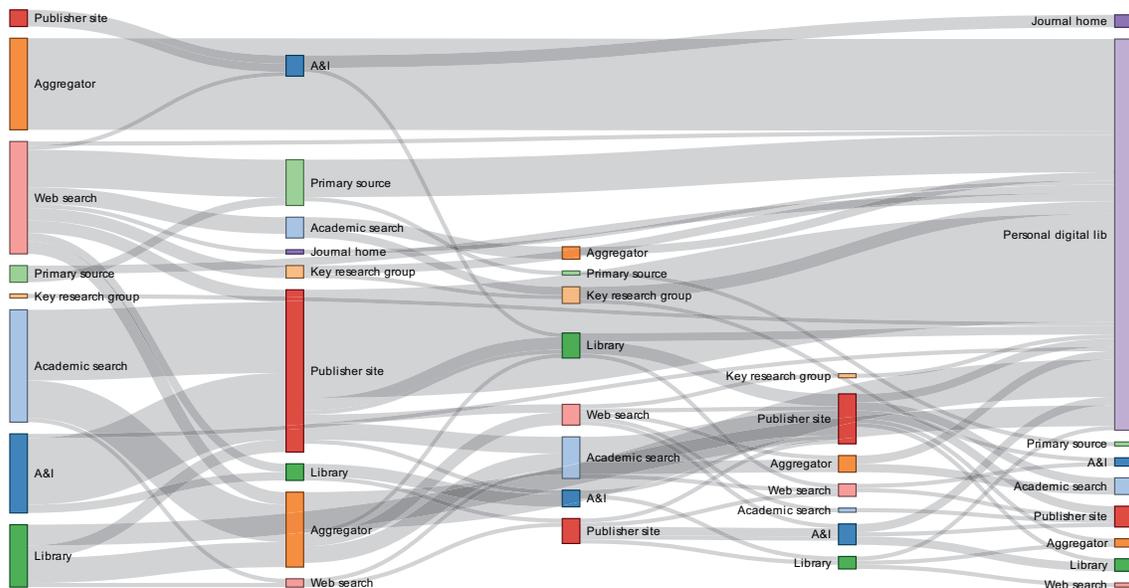
Moreover, most students lacked knowledge about how search engines worked and results were returned, which prevented them from applying search logic for conducting "good research."[62]

Additionally, a recent publication offers a "second look"[63] on studying students, based on research at the University of Rochester's River Campus Libraries. Corroborating previous findings that underscored students' reliance on "whatever works,"[64] researchers found that students, librarians, and faculty members all use similar approaches to discovering trusted information. Characterized as iterative processes of trial and error, drawing on personal sets of tools and resources acquired over time and applied when needed, researcher workflows not only depend heavily on the electronic environment but also include print resources, human connection, and real-world activities. Of particular value, this reflective volume offers novel insights into how librarians can enable students' progression "from searching to researching to the more sustained building of knowledge through library-based research and the browsing and reading and connecting it entails, researcher to researcher,"[65] thereby advancing both discovery of resources and ideas.

These studies offer a larger context of appreciation for researcher behavior and experience, motivating a growing majority of value-chain stakeholders to embrace and respond to dynamically evolving user-driven realities. As a result, libraries and publishers alike are now adopting usability testing and other practices aimed at optimizing the researcher experience.[66] Libraries, publishers, and service providers are even leveraging platforms such as Twitter and Facebook for "social search" of library holdings and academic publications.

Institutions have also begun to study discovery services' user experience. For instance, contrasting web-scale discovery with open-web options such as Google Scholar, one study highlighted the importance of relevancy ranking to students: "it seems that one of the most important—and perhaps the single most important—factor in determining which resources students will utilize is the default way in which a particular search system ranks and returns results."[67] The research also noted the variability among discovery services' proprietary search algorithms, which—lacking transparency—disallows local customization, which libraries and end users expect. Another study noted that a small number of the most popular search queries account for a disproportionate amount of the overall queries, suggesting the merits of ongoing evaluation of library-user search behavior to inform discovery layer customization.[68]

Complementing other user-focused studies that depend on self-reported perceptions and observational researcher data, a SAGE-sponsored study charted user pathways in content discovery during completion of graduate-level literature reviews. Findings highlighted opportunities for more nuanced collaborations

among scholarly ecosystem contributors, such as developing citation and document management systems *with researchers* "to evolve available products, further workflow integration, and advance researcher adoption."[69] The study also recommended additional research to further deeper insight into researchers' thoughts and judgments, because "data about the user (whether supplied by them or inferred from their activity) [are] a critical component"[70] for understanding researchers' desired outcomes and associated workflows, including "how learning, research, decision making happens."[71]

Beyond user testing and ethnographic research, most sectors largely depend on usage metrics and web analytics to generate notions about user satisfaction. However, these data are only clues: so far, no measures are available to indicate whether users truly discovered what they needed,[72] as reflected by their finding and evaluating content to make an informed decision about whether to read it in full[73] and thereby increasing the likelihood of their using it to produce new knowledge.

Ultimately, holistic assessment approaches must also recognize the qualitative aspect of user experience. Because adequate discovery cannot be exclusively measured by usage data, "successful discovery would be defined with two metrics: first, the share of needed items that are discovered, where 100% is optimal. Second, the ration of items discovered that are needed to those that are not needed, where a higher ratio is better."[74] However, at the moment, many stakeholders in scholarly communications leverage a combination of user-centered evaluation exercises and economic performance analysis.

New Discovery Products

These user-focused aspirations coincide with increasing adoption of "software as a service" discovery solutions that have catalyzed interest in user behavior across the scholarly value chain. Notably, both established academic publishers and software entrepreneurs are anticipating market demand for end-to-end researcher tools that facilitate tasks throughout the scholarly workflow. Organizations such as Digital Science (http://www.digital-science.com/), part of the Macmillan family, are developing products with the full research workflow in mind, with the aim of serving individuals at every stage of their process. Document discovery and management products, such as Mendeley (http://www.mendeley.com/), ReadCube (http://www.digital-science.com/products/readcube), and Papers (http://www.mekentosj.com/papers/) provide a number of tools that seamlessly integrate with institutional networks and personal digital libraries alike. Some focus on content discovery and retrieval via simple, low-cost document rental or purchase (DeepDyve, www.deepdyve.com, and Udini, http://udini.proquest.com/); some mainly aim to serve collection, storage, and sharing of resources (Mendeley; Zotero, http://www.zotero.org/, and ARTstor Shared Shelf, http://www.artstor.org/shared-shelf/s-html/shared-shelf-home.shtml); others support discovery and storage as well as custom approaches to organizing e-texts or digital images (Papers; Colwiz, http://www.colwiz.com/); and still others try to cover all of these plus offer unique approaches to PDF and desktop integration (ReadCube and Utopia Documents, http://getutopia.com).

Other new initiatives introduced since 2011 chart new territory. ARTstor Shared Shelf offers media management software that enables institutions to manage, store, use, and publish their institutional and faculty media collections within their institution or publicly on the web. Digital Science offers Figshare (http://www.digital-science.com/products/figshare), a community-driven open data project that hosts all formats of research outputs: graphs, images, videos, and data sets, among others. Each upload receives its own identifier, making the data citable. "Proof of concept" was demonstrated when, in a new partnership with the Public Library of Science (PLoS), visualizations of different types of data were added across the PLoS journals, making the data more widely visible and accessible. Digital Science recently announced another new product, SureChem (http://www.digital-science.com/products/surechem), which permits search of U.S., European, and world patents by chemical structure, keyword, or both. Whether employing established technology (like the Open URL) or new content (like chemical structures), old and new players in the scholarly ecosystem continue to enhance discoverability in the dynamically changing landscape.

These products compete with the "need to know" strategies currently employed by publishers, including alerting services from journal websites, widgets that highlight related or recommended content on related

sites, and discipline-specific discussion forums and blogs. All these discoverability strategies serve to enhance visibility, promote discovery, and, ultimately, drive usage—attempting to meet a range of user needs and ever-evolving habits. And diagramed search tools such as Visual Explorer in Microsoft Academic Search (http://academic.research.microsoft.com/VisualExplorer) and Google's Knowledge Graph (http://www.google.com/insidesearch/features/search/knowledge.html) are beginning to set user expectations and raise discovery standards among libraries and publishers.

Innovative academic products support a "job to be done" approach to supplementing researcher workflows with smart tools built into primary platforms and aggregated databases. This type of approach can be seen where publishers are offering visual browsing of authors (e.g., Springer Author Mapper, http://www.authormapper.com/); delivering authoritative topical discussions and cross-publisher literature review references (e.g., Oxford Bibliographies, http://www.oxfordbibliographies.com/, and SAGE Navigator, http://www.sagepub.com/navigator.sp); and contextualizing pre-search of authoritative reference source content (e.g., Credo Reference, http://corp.credoreference.com/, and Literati by Credo, http://literati.credoreference.com/). In addition, library websites and publisher platforms are enabling easier integration with researcher tools, such as Zotero and Mendeley.

Further innovation of this kind depends on vigilantly monitoring changing researcher needs and habits, which will inevitably change as discovery and delivery functions evolve, to improve the connections between readers and knowledge. In the words of one expert, "It boils down to two things: not trying to dictate where the user should start the process of discoverability (so enabling them to work their way into the scholarly corpus from anywhere) and keeping out of their way once the process is underway (connecting up systems so that transition between them is 'friction-free)— removing as many obstacles as possible from their journey, whatever route it takes."[75] Researcher workflows continue to evolve as users are influenced by rapid technology advancement and new product offerings. Given changes in information-seeking behavior and preferences, cross-sector experts agreed that the community must be vigilant, responsive, and collaborative to address user needs.

The Discovery Economy

From new revenue-generating product lines that promote academic discovery and sharing to fundamental disruptions in traditional revenue streams, the act of discovering scholarly material today has clear economic implications. Publishers are increasing investments in discovery-enabling resources and software. Libraries have invested heavily in services and systems that facilitate content discovery and retrieval. Publishers and libraries alike are required to assume new costs for information technology and associated staff expertise.[76] As a result, discovery services and new products are now key sources of investment—and, increasingly, revenue—for library technology suppliers[77] as increasing numbers of libraries adopt web-scale search services.

Rates of e-resource usage have long been a key factor in library budget decisions and return-on-investment (ROI) metrics for licensed materials—and therefore serve as important currency all along the

information supply chain as well. The majority of experts surveyed for this study agreed that resource usage data and other economic metrics remain important tools in understanding the success or failure of discovery initiatives (see Figure 2). As one publishing expert stated, "Not surprisingly, the most important measurement of whether our content is discoverable is usage. Commercially speaking, you could also take it one step further: Discoverability works well, if our online subscriptions are being renewed (based on high usage)."[78]

Figure 2   Survey responses to "How do you determine/measure successful discoverability?"
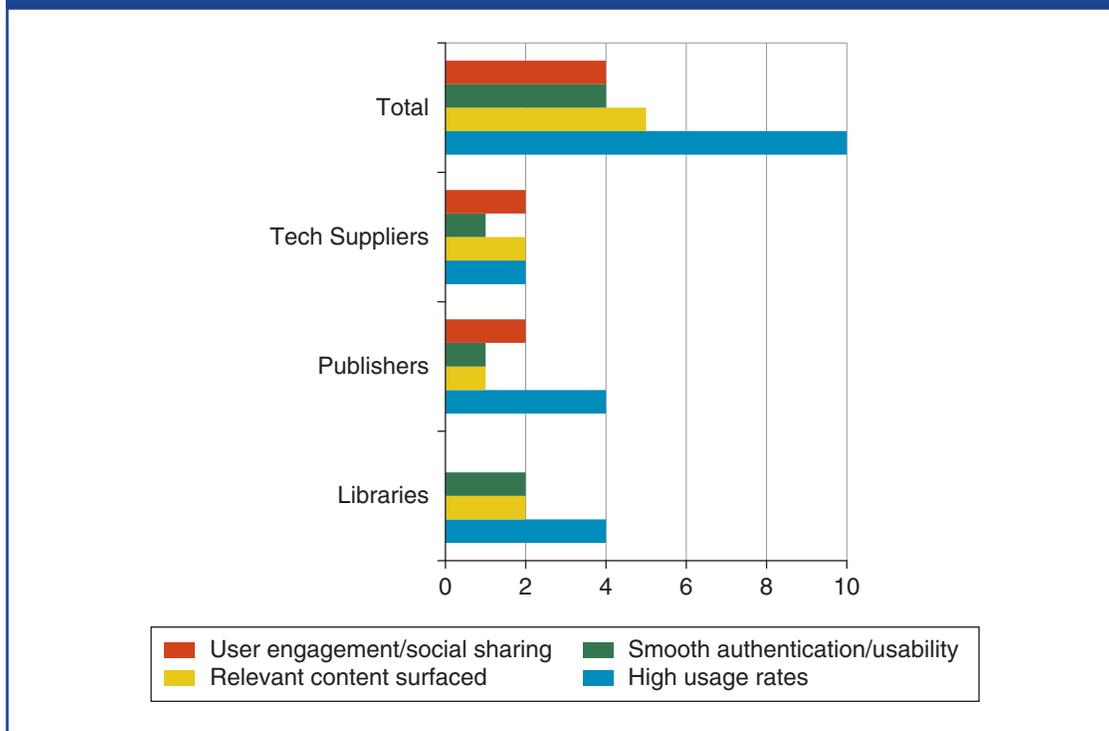
Persistent and pervasive uncertainties across sectors have recently motivated more in-depth studies of usage and other economic issues surrounding scholarly discovery. Three large-scale longitudinal studies have investigated the effect of discovery systems by examining pre- and post-implementation publisher-hosted journal usage. Although one focused on the institutional perspective, one concentrated on publisher viewpoint, and one studied library and publisher perspectives together, they agree that as the traditional pathways by which researchers discover and access scholarly content are disrupted and new pathways are forged, all sectors in the scholarly communications supply chain experience potential financial impact. However, none of these studies has yet produced clear conclusions about the impact of new discovery tools on library resource usage.

In the libraries study, general trends revealed no web-scale discovery service increased or decreased usage across all publications. In addition, findings varied by institution and by publisher, with each discovery service tool. Some publishers saw overall net increase, and some experienced a decrease in usage. Statistical analysis was used to determine which of the three factors—library, publisher, or discovery service—contribute to differences in usage rates at the journal level. Results show that the combination of discovery tool and institution (but not necessarily publisher) has a significant impact on changing usage patterns after implementation.[79]

In a second study representing the publisher perspective, JSTOR researchers asked the question, "Do different combinations of discovery services and link resolvers in different institutions produce journal usage differences?" Similarly, researchers analyzed institutional journal usage data before and after discovery service implementation. Because JSTOR sends only metadata—not full text—to discovery services, findings emphasized the importance of rich subject-specific metadata and its influence on search relevancy rankings, as well as the importance of customizing discovery service software rather than of depending on the default features.[80] Other findings supported ODI recommendations for improved cross-sector metadata exchanges and assessment metrics.

Third, a multi-phase UKSG/JISC study conducted library and publisher surveys alongside institutional case studies, which included analysis of data from usage of all licensed content (journals, e-books, and databases).[81] Overall, conclusions suggest some positive impact for journals and a definite positive

In addition to the "73 things publishers do,"[96] many content providers are experimenting with alternative publishing models, both to promote greater access to scholarly research results and to generate new revenue streams within an ever-changing environment. As the open-access movement poses promising new opportunities for discovery—in which the traditional challenges to sufficiently index content restricted to paying users is no longer a limiting factor, libraries are, in turn, expanding curation efforts to include free content, including open-access (OA) publications.[97]

Just as discovery opportunities abound for open access content, so too are there new discoverability challenges. OA products are often handled completely outside customary workflows. Publishers do not always provide sufficient metadata for OA content, indexers may not include OA publications out of concern for their peer-review quality, and institutions await inclusion of OA content requests in discovery services. So while the vision for OA forges new pathways for users to discover freely available online resources[98] and for all contributors in the scholarly communications space to reinvent the supply chain, it also heightens the necessity of cross-sector collaboration. In that spirit, the Open Access Scholarly Publishers Association recently released "Principles of Transparency and Best Practice in Scholarly Publishing,"[99] which derive from criteria developed by the Directory of Open Access Journals.[100]

impact for e-books at the 77% of institutions in the United Kingdom with library discovery technologies. However, given the challenges of interpreting aggregated data, researchers could not assess database usage impact, nor could they identify common impact patterns by type of resources, except for e-books. In sum, these exploratory research projects conducted to date have yet to reveal firm conclusions about the overall impact of new discovery technologies, because some data indicate increased usage in some cases and decreased usage in others.

At the same time, there is growing recognition within the community that quantitative usage data alone are insufficient in measuring the value of licensed scholarly content. In reframing the question to one of perceived value within a return-on-investment (ROI) framework, a recent study built on earlier research into university return on library investment[82] and library value to grants processes[83] to investigate the institutional value of library resources used by faculty in their research. The study produced a multi-campus ROI model with the potential for demonstrating how library collections support research outcomes or, alternatively, how results can support a transition to new acquisition and access strategies.[83]

Increasingly robust measures of successful discoverability would surely also examine the positive impacts of discovery technologies on libraries, librarians, and end users. For instance, consideration of web-scale discovery services could investigate how to increase library ROI across their licensed holdings. As one expert asked, "Since adopting a discovery service, is user satisfaction increasing and perception of the library's value growing?"[85] Especially promising future directions would necessarily incorporate both "outside-in" and "inside-out" resource discoverability strategies, the former connoting owned and licensed academic content and the latter institutional assets and special collections.[86] Discovery would also encompass full library destinations and services, including library facilities, resources, and expertise—including thesis, dissertations, and patents—and discoverability would make resources discoverable wherever use occurs in the researcher workflow.

Such a unified discovery and integrated system experience would enable more research to be completed within the library system environment, including fulfillment,[87] and therefore would transition users from pre-search to search to find through the set of information "prioritized, personalized, current,"[88] whether through buy, borrow, connect, Demand Driven Acquisitions (DDA), or Patron Driven Acquisitions (PDA) at the point of need.[89] Furthermore, it could be "social, networked, collaborative, and shared . . . What I receive would be filtered and organized and stored so I can get back to it."[90] Further discovery service enhancements would not only rank related resources but would also offer recommendations customized to the institution and the user, thereby progressively moving from "strings to things."[91]

To achieve such desired futures, all experts agreed that publishers, libraries, and service providers must work together and behave transparently in order to progress scholarly discoverability. As publishers freely distribute metadata and libraries promote their services via social networks,

organizations must expand their investments in staff training and hiring,[92] even as they further invest in initiatives for research education,[93] user experience,[94] or systems customization.[95] This requires vigilance and effort to monitor changing user habits, new product releases, and rapid technological advancements, which might inform progressive refinement of impact measures and associated analytics. The increase in studies about the economic impact of discovery services and associated innovations attests to the widening interest in discoverability innovations and predicts further cross-sector investigations amid uncertain and evolving researcher demands and escalating financial investments, within a widening scope of inquiry.

Collaborative Discoverability Recommendations

In this study, cross-sector experts revealed significant progress in establishing common standards for information organization, resource presentation, and performance metrics, which were fortified by recent research reports and standards initiatives. Actual improvements and continued progress in discoverability require, of course, that online product interfaces and institutional website designs conform to these industry standards and associated behaviors. Additionally, experts recommended monitoring evolving researcher behaviors and applying findings to publisher and library systems, to interface redesigns, and to new products and services. Therefore, these aspirational outcomes require foundational changes, and future opportunities are summarized as the following recommendations for libraries, publishers, and our shared technology service providers.

Standards

When relevant, all sectors should participate in ratified standards. That means we advocate that publishers integrate ORCIDs into their platforms and encourage authors to register their works. Libraries should insist on standards fulfillment from content providers—for example, assurance that KBART-compliant metadata will be delivered on subscription. Also, service providers should make observance of metadata standards status quo—in which all platform providers would include schema.org metatags in site architecture.

Transparency

With the understanding that standards compliance requires collaborative industry efforts, the type of cross-sector transparency promoted by NISO's Open Discovery Initiative is critical for the development of discoverability best practices. All players in scholarly communications should heed the ODI recommendations, in particular, clear statements of non-biased indices and algorithms by all library discovery technology suppliers.

In the spirit of cross-sector collaboration and cooperative standards compliance, further research is needed into the economic and productivity impacts of new discovery technologies. Without an appropriate level of cross-sector transparency, we cannot adequately access the success of discovery tools, and we cannot see where discovery is breaking down. Vigorous support of efforts such as the NISO's IOTA is needed from libraries, publishers, and technologists alike because initiatives like this are important moves toward an accurate shared understanding of our collective discovery successes and limitations.

Metadata

Plainly, quality metadata supports successful discovery of scholarly content. Therefore, that we must all come together to ensure we are exchanging data of the highest quality and value to end users is clear. Publishers must invest in clean, accurate, and standards-compliant metadata about their publications licensed by libraries. Libraries and their technology suppliers should openly share with publishers how their metadata performs in local institutional systems and, ultimately, how it has an impact on users. Many small-scale opportunities exist for leveraging existing cross-sector relationships

for more routine co-development, testing, and evaluation of publication metadata that would drive lasting corrections and enhancements—such as better automation for metadata exchanges—with the benefit of improved discovery. For example, vigorous cross-sector participation in NISO's Bibliographic Roadmap will contribute to enhanced metadata for improved discovery.[101]

Partnerships

In addition to collaborative efforts toward iterative metadata enhancements, a multitude of opportunities exists for partnerships across the industry around new discovery innovations. Proof-of-concept experiments with linked open data could be forged by publishers and technology suppliers, which might limit commercial risks and further connectivity between concepts and content. As publishers and libraries increase their resource and investment in research and development, we can look at ways of building upon these experiments with new ideas and sources of funding. For example, the data visualization development at Virginia Tech[102] could be extended in affiliation with one or more content providers, who could contribute resource and cost/use data, which might produce new ways of measuring the economic impact of discovery service investments.

There are also opportunities for new models of partnership across the scholarly communications supply chain. Removing the silos of publisher-centric products and databases requires new modes of collaboration across content providers and new business models for libraries. For example, Credo Reference partners with publishers to provide links from their topic pages to other relevant materials within institutional holdings.[103] As publishers experiment with new product and licensing models, ongoing, open communications with libraries and technology suppliers are critical. Many publishers are accelerating investments in library advisory boards and market research, which inform future strategies informed by successful cross-sector communication and transparency.

Conclusion

Ultimately, "despite increasingly challenging scholarly ecosystem circumstances exacerbated by economic uncertainty and disruptive technologies, the driving missions of academic publishing and librarianship have not changed."[104] Therefore, continued progress in cross-sector collaboration and, thereby, enhanced scholarship discoverability exercise cross-sector community goodwill,[105] which is motivated by common goals.

Quite simply, the shared goal remains furthering discovery, access, and usage of scholarly publications and creative work. As library, publisher, service, and researcher roles evolve and as more sophisticated discovery and discoverability strategies emerge, robust and sustainable progress very much depends on continued, heightened cross-sector collaborations. Such shared aspirations depend on exercising and extending traditional expertise to achieve boundary-crossing innovations that enable successful scholarly content discovery—through enhanced discoverability—for all current and potential users.

Appendix: Study Participants

- Marshall Breeding, Independent Consultant and Co-Chair, Open Discovery Initiative, National Information Standards Association

- Gillian Harrison Cain, Senior Marketing Manager, Discovery Services, ProQuest

- Maria Collins, Head, Acquisitions and Discovery, North Carolina State University

- Simon Inger, Owner, Simon Inger Consulting

- Phill Jones, Head of External Collaborations, ReadCube, Academic Software/Online Platform, Macmillian Science and Education

- Ove Kähler, Head of Marketing & Sales Support, Brill Publishing

- Judy Luther, President, Informed Strategies

- Michael Levin-Clark, Associate Dean for Scholarly Communication and Collections Services, University of Denver

- Ann Michael, Principal, Delta Think

- Charlie Rapple, Co-Founder and Director, Kudos

- John Sack, Associate Director and Publisher, HighWire Press, Stanford University

- Katie Sayers, Digital Marketing Lead, SAGE Publishing Ltd.

- Albert Schoenmaker, Senior Editor, Online Resources, Brill Publishing

- Roger C. Schonfeld, Program Director for Libraries, Users, and Scholarly Practices, Ithaka S+R

- James Shulman, President, ARTstor

- Jenny Walker, Independent Consultant and Co-Chair, Open Discovery Initiative, National Information Standards Association

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