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Library & Administrative Support for Civil & Environmental Engineering Scholars

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Library & Administrative Support for Civil & Environmental Engineering Scholars

Abstract
As university researchers’ needs for information and research support continue to change over time, it is important for university libraries to assess how well their services fit with the current research environment. Collecting perspectives from scholars in particular fields is a key step in developing and redeveloping library support for research. The Supporting Civil and Environmental Engineering Scholars project was coordinated by Ithaka S+R and sponsored by the American Society of Civil Engineers (ASCE) to explore the research and information needs of scholars in the fields of civil and environmental engineering. All phases of the research process, from idea generation to dissemination of results, were included in the research. Teams were assembled at 11 universities (Appendix 1), including Iowa State University (ISU).

Disciplines
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INTRODUCTION

As university researchers' needs for information and research support continue to change over time, it is important for university libraries to assess how well their services fit with the current research environment. Collecting perspectives from scholars in particular fields is a key step in developing and redeveloping library support for research. The Supporting Civil and Environmental Engineering Scholars project was coordinated by Ithaka S+R and sponsored by the American Society of Civil Engineers (ASCE) to explore the research and information needs of scholars in the fields of civil and environmental engineering. All phases of the research process, from idea generation to dissemination of results, were included in the research. Teams were assembled at 11 universities (Appendix 1), including Iowa State University (ISU).

After receiving training in Ithaka S+R’s qualitative methodology, librarians from participating institutions interviewed local researchers in order to develop actionable recommendations for the local library and campus. Ithaka S+R's methodology is based in grounded theory, consisting of a series of semi-structured interviews with scholars in civil and environmental engineering which were then used to uncover underlying themes and issues rather than attempting to advance a detailed hypothesis. Identifying these themes lays a groundwork not just for improving services locally but also for future research in this area.

For the ISU phase of the project, 42 scholars were identified using the Civil, Construction and Environmental Engineering (CCEE) department’s online directory. The authors contacted each of these scholars and scheduled interviews with 11, with at least one representing each of the department’s broad research areas. Interview questions were based on a questionnaire template (Appendix 2) with some follow-up questions prompted by interviewees’ comments. The interviews were transcribed and then analyzed and coded by both librarians in an effort to identify common themes and core concepts, which were in turn developed into the following narrative and recommendations.

This report explores the information needs of researchers throughout the research life cycle and is organized based on a rough chronology of the research process. We begin by examining information needs relating to developing a team and a research question, proceed through gathering information through literature reviews and data collection and analysis, and move on to discuss the ways in which research results are shared with the wider world. Throughout this narrative we identify important
themes that emerged during the interviews, which were used to develop recommendations for the ISU Library and campus more broadly.

RESULTS

CIVIL & ENVIRONMENTAL ENGINEERING AT IOWA STATE UNIVERSITY

At ISU, civil engineering and environmental engineering are studied and researched primarily within the Department of Civil, Construction and Environmental Engineering. The department offers undergraduate majors in Civil Engineering and Construction Engineering in addition to Master of Science, Master of Engineering, and Doctor of Philosophy degrees in Civil Engineering. Graduate specializations in Civil Engineering Materials, Construction Engineering and Management, Environmental Engineering, Geotechnical Engineering, Intelligent Infrastructure Engineering, Structural Engineering, and Transportation Engineering are also available. Civil Engineering was one of the initial programs offered at Iowa State University, with the first graduating class in 1872 including three civil engineers; in 2003 the department name was updated to Civil, Construction and Environmental Engineering.

Faculty within the department are grouped into the following research areas: Construction Engineering and Management, Environmental/Water Resources Engineering, Geotechnical/Materials Engineering, Structure Engineering, and Transportation Engineering. Some research projects in this department may also be characterized as Intelligent Infrastructure Engineering. The number of faculty researchers in each area ranges from six to nine, with around 40 total faculty members currently active in research. Many of the department’s researchers are also associates of a research institute in the ISU Research Park, the Institute for Transportation (InTrans).

Because of this administrative structure, interviewees typically described their research as based in one of the five main divisions of civil and environmental engineering identified by the department. Many also situated their work within a more specific topic, such as bridge construction or public health, or referred to roles or career path designations such as faculty member, journal editor, or applied engineer. One commonality was the desire to create real-world impact for practicing engineers in the interviewees’ fields. The “Post-It note” version of one scholar’s goals could apply to some degree to all of the interviewees: “Implementing good technologies through collaboration with industry, agencies and academia.”

Researchers described many potential audiences for their research. Within academia, scholars were a primary audience. Consideration was also given to career advancement, particularly to meeting the expectations of researchers and administrators involved in the promotion and tenure process. Funders were another oft-mentioned audience, with goals and expectations that in some cases differed dramatically from those within the university. The Department of Transportation, for example, was frequently cited as preferring publications in support of practicing engineers, rather than peer-reviewed scholarly publications. In addition to scholars and funders, researchers might consider practicing engineers and industry as an audience for their research outputs. Less frequently, researchers mentioned outreach efforts to the general public, including K-12 education, and international communities.
Funding sources were as varied as the research being conducted. Government-backed funding sources included the National Science Foundation (NSF), U.S. Department of Energy (DOE), U.S. Department of Transportation (DOT) and its subdivisions, state-level DOT (Iowa or other states), and city governments within Iowa. Other sources of funding were national professional organizations, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), and other research groups and foundations, such as the National Academies or Water Environment Research Foundation. The scale of grants given and sought varied; interviewees mentioned projects requiring anywhere from $50,000 to $500,000 or more in funding.

Scholars reported using a variety of approaches to investigate their research topics, all of which were grounded in classic experimental methods and statistical analysis. Researchers incorporated sources of data, computational tools, and simulations appropriate to each research question. Testing and data collection might be done in the lab or in the field. Computational models and simulations could be written completely from scratch or based on commercially available software. The physical scale of objects studied could range from microscopic to geographic.

COLLABORATION

All interviewees described collaboration as an integral part of the research process and mentioned a variety of past, current, and potential collaborators. These included students, postdocs, faculty within and outside their research field, faculty at ISU and other institutions, research support personnel, Iowa and other state Departments of Transportation, practicing engineers, city governments and utilities, and more. In general, researchers felt that collaboration was a beneficial practice that enabled them to better leverage complementary research areas, expertise, and lab resources. Several also felt that collaboration was a benefit when applying for funding and mentioned cases where collaborating with team members in other states helped secure funding from those states’ agencies.

Working with a team required researchers to balance competing priorities, communicate effectively, and efficiently manage time. Cooperation and trust among the research group members were also described as important because group members must be willing to share information resources, data, skills, time, and outputs such as publications and presentations with one another. Several researchers focused on group organization and structure, and the ways in which having clear responsibilities and division of funding can ease the collaboration process. One researcher recommended that teams decide how to assign ownership of intellectual property early in the collaboration to avoid problems later. Publishing is also more complicated in a collaborative setting, raising questions such as which field the results will be published in, how to divide the work of writing, and how authors will be credited. One researcher mused on adding one more step to collaboration timelines, proposing that a means for collaborators to jointly reflect on the process could improve outcomes for future teams.

Researchers identified networking as a key component of collaboration. While it was important for researchers to build connections at ISU to take advantage of local resources and expertise, it was also necessary to cultivate more widespread connections in order to find future collaborators, secure funding, and further their careers. Conference attendance and participation in service-focused
committees were important forms of networking for these researchers. Despite the unique opportunities afforded by these activities, researchers reported that there is often insufficient or nonexistent financial support from funders or universities to defray the costs of travel and event registrations. Although webinars and other videoconferencing tools are now available, researchers voiced a strong preference for attending in-person meetings when possible. As one researcher described it, research areas within civil and environmental engineering tend to be small enough that it is possible to know, or at least know about, nearly everyone doing research in that area. Meeting these other researchers establishes a foundation for collaborative relationships.

INFORMATION MANAGEMENT

During the interviews, we asked the CCEE scholars about their use of published information to inform their research. In general, they shared two major reasons for undertaking a search for published information: looking for gaps or problems in the research record to find areas for new research, and to do due diligence or support their findings. One researcher also described periodically doing state-of-the-practice reviews to keep up to date. The overall scope of a literature review varied from researcher to researcher and depended on the field of study. For example, one researcher reported needing to thoroughly cover sources going back to the 1960s, 1950s, or earlier, while noting that other fields, such as computer science, may have a much more contemporary focus than civil engineering and do not need to go back so far. Another researcher shared an idea of the scope of a literature review in this field, noting that they use around 150 sources per topic when conducting a literature review.

Information sources included peer-reviewed journal articles; peer-reviewed conference papers; books and, less often, textbooks; technical reports; government reports; pre-prints and other early online sources; specifications; and theses. Scholars reported that indicators of quality, such as a journal's reputation within the field, its review criteria, and its impact factor, were major considerations when selecting sources for a literature review. Researchers in different fields perceived different types of information sources as being important. For example, in transportation, reports may provide more detailed information than peer-reviewed journal articles, while journal articles may be the gold standard in other fields.

When conducting their literature review, researchers overwhelmingly referenced Google and Google Scholar as important tools, primarily for the ease of use and the variety of formats covered. When asked about search tools, one researcher sarcastically responded, “have you heard of Google?” Despite the preference for Google, nine of the interviewees also mentioned using specialized indexes. Web of Science was the most frequently mentioned of these; one scholar considered Web of Science the best way to find journal articles and used Google and Google Scholar to find literature in other formats such as government reports. Two of the three transportation engineers interviewed used Transportation Research International Documentation (TRID) for finding information, and one of them considered TRID superior even to Google Scholar for transportation research. Elsevier’s Compendex and ScienceDirect also merited mentions by name. Only one researcher mentioned using the ISU Library website, though others may be using it to click through briefly as a gateway to specific databases and journals of interest.
Researchers reported using limited strategies when searching for literature, primarily relying on keywords to uncover useful resources. A few also described using the references cited in useful, high-quality papers as sources for their own research. Only one researcher mentioned browsing the tables of contents of their preferred journals to find papers. Similarly, only one researcher mentioned using specialized tools within databases, such as citation and similarity searching. When researchers found articles that sounded promising but were unable to access them, they described contacting the authors directly or, sometimes reluctantly, using library services such as Interlibrary Loan.

Interviewees frequently tasked one or more of their students with conducting the literature review, rather than undertaking it themselves. Both undergraduate and graduate students might be tapped for this task. Scholars described a few reasons for delegating this task to students, often as a means of teaching the students how to do a thorough literature review or to help them better understand the research topic. Others reported delegating due to a lack of time. In cases where students did the bulk of the literature review work, researchers reported advising students and performing quality checks to ensure that there were no major omissions. Several researchers reported that students were likely to rely solely on Google for finding sources, and one revealed that students may give up if a cursory search turns up only a few options.

Two scholars mentioned that librarians’ help in training students in literature review skills would be helpful. These scholars saw room for improvement at both the search stage and the filtering stage in student research. One scholar gave an extreme example:

“I had a student a few years ago where I wanted a search on a given topic. And I knew there was a boatload of stuff out there-- came back with three publications. And that was after a month's hunting. No. Go try again. And what had happened-- found a textbook, found the two references in the textbook, and given up. So help for them would be great.”

Once references were collected, some of the scholars explained their process for managing those references. Several researchers stored digital copies of articles and other references in project- or topic-based folders on their computers. However, maintaining a large collection of saved articles had become a challenge for a few interviewees. One researcher acknowledged that it could be challenging to retrieve information later when all the files were saved in a large folder with no further attempt at organization. When asked about citation management software, most researchers reported that they did not use any; however, one researcher described using Mendeley to store citations and documents, and to share those with their students. Another researcher explained that they use Excel to describe and organize files used in their literature reviews. Most relied on memory alone.

In general, scholars did not report any significant challenges to finding published information. However, they did mention frustrations arising from hurdles encountered during the search process. Several scholars mentioned being frustrated by paywalls and being obliged to pay for articles that were urgently needed, but either did not mention Interlibrary Loan as an option at all or considered it to be too slow. Scholars also reported frustration over the extra step of logging in to access library resources from off campus. One researcher specifically mentioned that it was easier to do research on campus to avoid
this. Other challenges that emerged included accessing and translating papers in languages other than English, searching pre-digital materials, finding full text of obscure publications, questions about copyright and file sharing with students, and the time-consuming nature of the literature search.

It was not uncommon to hear about use of the library’s resources only in a worst-case scenario, when all other attempts to find or acquire the needed information had failed. For example, one researcher reported sending graduate students to the library to access older materials that had not been digitized and were not available through other means. Another felt that students should use the library, but was not certain that they were even aware of the services available. Based on the interviews, it was not clear that all the interviewees were fully aware of the scope of library services available. While the interviewees generally praised the library’s collections, several noted that they would appreciate more journals, more access to dissertations and theses, or more e-books. Others, however, took a more positive view and shared their appreciation for the increasing availability of digital resources, especially journals.

### DATA MANAGEMENT

Scholars collected an enormous variety of data: quantitative and qualitative data; building, water, and traffic data; data describing the physical characteristics of materials or structures; and human subjects data, including data with personally identifiable information which must be appropriately secured. Data were collected both in the lab and in the field, often by automated sensors. Data collection might last for only a short time, or it might go on for years and result in extended datasets. File formats were most often dictated by equipment output, or by what researchers considered the easiest format to use for a given dataset. This included Excel spreadsheets; TXT, CSV, and other text-based formats; and images and videos. Other digital formats included various file types produced by different sensors, electronic lab notebooks, databases, and PowerPoint files. Some scholars reported working with relatively small datasets, which could be compiled manually, while others described their research as utilizing big data. For some simple projects, all project data was kept in a single spreadsheet, while other projects needed a more complex directory system.

Scholars put a great deal of thought into their data collection before any data had even been acquired. This is no surprise when the cost of running experiments can be up to half a million dollars for a single project. Though one researcher commented that it is impossible to acquire perfect data even under the best circumstances, scholars cited several techniques they used to ensure they collected useful and usable data. These included defining the sampling protocol in advance of data collection, adjusting the protocol if problems developed during data collection, and planning for samples that spanned time or spatial variations.

Researchers also considered the size and scope of the data being collected. One researcher referred to an expectation from NSF that the maximum amount of information be captured during data collection; such expectations from funders encourage researchers to collect as much data as possible. Some equipment produces enormous datasets, which limits the options for file types, processing techniques, and storage. Additionally, large datasets may require specialized software to manage them, in turn
requiring research groups to invest time and money in acquiring and learning to use the software effectively.

Datasets might be automatically collected by sensors or collected and assembled manually, particularly when students were available to do the data collection. In general, researchers agreed that automated data collection was easier, faster, and often more reliable than manual data collection, but was not always possible. Stumbling blocks to data collection included lack of network access at test sites, difficulties associated with collecting large amounts of data, and the number of steps required to get data from the point of collection into a storage system such as CyBox, the local implementation of Box cloud storage, where the research group could access it for analysis.

Data were not always collected locally. In some cases, collaborators or even other labs might initially collect the data, which would then be used by the entire research group. Researchers were split on the question of whether to use data produced outside the local research group, with some, especially those regularly using DOT data, being in favor and others feeling that third-party data might be less trustworthy or usable. Although one researcher made a point of only using data from within the research group or from current collaborators, most of the interviewees used data collected by others in at least some of their research projects. Reusing data eliminated some costs of data collection. It could also expand the historical or geographical scope of a project beyond what one research group could collect, or provide more context for comparisons and judgments of whether statistical outliers represented valid data points.

A scholar might decide whether to reuse data as early as the proposal stage of a research project. To successfully reuse data, scholars described looking for data sources that were consistent, in a usable format, and in a database the researcher and project team could access. If the data source was not in the public domain, scholars considered whether publications from the current project could include the reused data: “We want to make sure that they give us the rights to publish that data. Because it doesn't really do us any good when we collect it, but we can't provide it to others.” If data was obtained through a request, researchers had to carefully specify what data they needed—often there were no standards for metadata to simplify this process. The project budget might even need to include resources for digitizing non-digital data.

Scholars described a wide variety of sources of data for reuse in research. These included authors of recently published papers, who might be contacted with a request that data be shared. Data gathered by close collaborators or from earlier projects within the research group were the easiest to reuse. Several interviewees felt that becoming familiar with collaborators’ data and systems was an important part of the process. Having a personal connection with another researcher simplified actions such as coordinating access to a dataset or addressing questions on how to interpret data. Since much of civil, construction, and environmental engineering deals with public infrastructure, many of the data sources these researchers used were provided by federal or state governments. Many of these sources were databases that are publicly searchable or that can be accessed on request. Researchers in transportation engineering used data from the Departments of Transportation of Iowa and other states, and from multiple divisions and databases of the U.S. Department of Transportation. A construction engineer
mentioned using public data sets from the Energy Information Administration, and a structural engineer reported finding data using NSF’s DesignSafe hub.

Data were also obtained from private data sources; these might be clients of the research group providing data for specialized analysis, or commercial sources that sell data. For instance, businesses that provided GPS applications might also provide vehicle speed data harvested by those apps. As with other sources of data, it was crucial for scholars to understand how the data was collected and processed: “It is a black box in one regard, that you don’t really know the specific methods they use to aggregate up from the raw data.” Privacy issues could arise if the data had geographic or other identifying components, as might be the case for data measuring energy efficiency of privately-owned buildings.

There could also be challenges involved in reusing data, and our interviewees mentioned several of these. More time might be needed to interpret and analyze data collected by others, and scholars felt it was crucial to understand the metadata used by the original research team. If the data was not in the public domain, there could be limitations on how it could be used. One researcher mentioned a case where a potential client limited the amount of data shared with the research group because of patent development interests on the potential product they were being asked to help evaluate. Sometimes a partial dataset or summary included with a publication caught a researcher’s interest, but the original author was unwilling to share the data or simply did not respond to contact. Data that was publicly available might be spread among multiple potentially useful databases, mixed in with data that was not useful for a given project; gaining familiarity with the available data sources could be an important professional skill. Also, datasets that were generated by multiple sources could contain inconsistencies, such as traffic crash reports from separate states that had different thresholds for determining when a crash would be counted, or changes over several decades in which data points were recorded. Yet another challenge involved finding the questions and methods to take advantage of the vast increase in the number of devices owned by the public that can capture data:

“You are going to be bombarded with data...autonomous vehicles and connected vehicles...you have 100 million sensors out there. ... Safety research...operations research...environmental research...we are going to know everything we need to know about how drivers are reacting, how the vehicle is reacting if it was driving. ... We used to know it for a sample or for one single occasion. Now we know it for every vehicle all over the network. ... It's going to be a huge opportunity to mine that data and... help us better design, better build, better operate our infrastructure.”

Once data was collected, analysis began. Scholars analyzed their data to extract meaningful information, so trends and relationships could emerge or predictions could be made. For example, as one researcher shared, the data might be used to build or refine a model to make predictions about building performance. Cleanup was an important preliminary step to data analysis. Several researchers stressed the importance of checking data for various issues, including missing data, statistical outliers, and noise. Scholars described data analysis as a time-consuming process and one where results could be difficult to
reproduce. In cases where data were originally collected by others, researchers had to cross-check or re-analyze it carefully in a process one described as “part science, part art.”

Statistical analysis methods were used by several research groups, who described using techniques including image analysis, multiple regression, significance testing, time series trends, and non-linear statistical techniques. One researcher mentioned using mobile analysis tools, especially as the processing power of devices increased enough to allow for image analysis in the field. Others were able to use standard computing equipment for analyzing their data. These researchers had multiple options in terms of software for data analysis, including Excel, MATLAB, Abacus, various statistical packages, and even custom software. Because of their reliance on these tools, lack of expertise in computer programming or using analytical software among students on their research teams was a concern for interviewees.

Campus technical support services were available and appreciated, providing researchers with computer tech support for hardware issues and open source software expertise. Researchers expected that the IT group would be able to continue support as the computing environment changed. Administrative offices on campus, such as the College of Engineering, the office of the Vice President for Research, and the Office of Intellectual Property & Technology Transfer, provided various services to researchers.

Scholars’ day-to-day data management practices reflected the complexity and variety of their participation in research collaborations. While scholars reported using a variety of organization methods for their data, most had either already shifted or were in the process of moving to CyBox for their data storage and organization needs. CyBox allowed researchers to define the group with access to a project folder, and to assign roles and permissions appropriate to each group member. Using CyBox also solved the problem of where to find the most current version of the data among several research group members, where in the past files might have been scattered across workstations. Scholars also used CyBox to share data with non-ISU researchers who could be given the link for a file. Due to CyBox’s ease of access and sharing features, researchers felt it was anywhere from a slight improvement over previous systems to a complete game-changer for project group management.

Researchers noted that the larger the research group, the more important it was to have a clear data organization plan, a system that could be maintained as the project developed. This might start with setting clear names for folders or weekly reminders to students to update folders as they recorded data. Several interviewees pointed out the importance of enforcing good data management practices among their students, noting that some students were well organized while others required much more guidance. One interviewee noted that a post-doc's duties in the research group included monitoring data.

Most of the scholars interviewed for this project reported using the same systems for storing active data and for long-term retention or preservation of data. Researchers commonly described CyBox or a back-up copy on an office workstation, networked drive, or external hard drive as their primary means of preserving their data. With the advent of campus-wide unlimited cloud storage through CyBox, researchers reported relying less on maintaining relatively expensive local servers with limited storage.
capacity. Despite the implementation of CyBox, questions of cost and capacity for long-term storage solutions were still major concerns for scholars. While CyBox might be able to accommodate very large datasets, uploading that dataset or downloading it again later could be impractical and time consuming. For researchers who kept data in physical lab notebooks, storage of the data might be as simple as shelving the notebooks in an office or lab. Those researchers noted that although notebooks introduce storage challenges of their own, digital files are more easily lost, destroyed, or altered than paper notebooks. No researcher that we interviewed mentioned best practices and recommendations for data preservation that have been developed by libraries and archives.

In cases where data must be secured, scholars had to plan for security costs. ISU does provide server space for secure data storage which can help researchers ensure that access to the data is limited. However, this service is not free and can add considerably to the cost of a project through staff, storage, and utilities expenses.

There was no consensus as to what long-term retention of data might entail. Several scholars reported that they keep their data indefinitely, if possible. Others might keep data for 10-15 years or more before they felt that the data is no longer useful or usable. Still others stuck to whatever was mandated by their funder, often just 3-5 years. Even when data was retained this way, the members of the research group were often the only ones who were aware of the data’s existence. In some cases, where researchers worked primarily with data produced or collected outside of their own labs (such as data provided by the funder), their retention practices were dictated by the requirements of the owner of the data rather than any personal preference.

Researchers who chose to keep data for the long term most often chose to do so as a just-in-case precaution or because of funder requirements or expectations. For example, a researcher might retain their data in perpetuity because the data was expensive to create in the first place and could not be easily or affordably replicated. Data might also be retained in case something had been missed in the initial analysis or project, or because the researcher felt it might continue to be useful for future analysis. Scholars sometimes retained data from students’ projects because other students might be able to make use of the data after the original students graduated and moved on. In cases where researchers deleted data, deletion was often motivated by the need to meet IRB or funder requirements, particularly the need to certify that data containing personally identifiable information had been deleted upon completion of a project. Less frequently, since the introduction of unlimited cloud storage, researchers might delete data after a period of time in order to free up storage space on local computers.

Once data was collected, cleaned, and analyzed, it was often shared in some way. Scholars reported using their publications as the primary means of sharing their data with the wider research community. The most common forms of data presentation were numerical, through combinations of summary charts, tables, figures, and/or appendixes which served to support the analysis and conclusion being presented. Researchers frequently mentioned including data in the form of charts, graphs, histograms, and other graphics in their papers and presentations. Often data were presented as part of a statistical analysis or comparison, including before and after comparisons, comparisons of a lab’s test results with
results published elsewhere, statistical models, or time series data. In some cases, particularly in transportation engineering, the presentation of data might be enhanced with images or videos, or even maps and other geographical representations. When researchers included data of any kind in their papers and presentations, a major concern was determining how much data to present and in what form. Ultimately, researchers were interested in presenting enough data to explain their results and make their outcomes easier to understand, but not overwhelming their audience with too much irrelevant data.

Sometimes researchers shared data privately, upon request, but sharing data is increasingly a requirement set by project funders. Federal and state agencies often set data sharing polices that require open access to the data; other policies may allow for more limited ways for the shared data to be accessed. NSF and NCBI were noted by interviewees as agencies that both require and facilitate data sharing through the databases they host. One researcher described the effect of NSF foresight in this area:

“NSF put out some collaboration tools for real-time collaboration, sharing of data, expected us to upload data when the tests are done in a common database so that not just my collaborators, but anyone in the world can access. So, we basically upload the data. They review. There's a DOI... assigned to the data set. ... There’s a process that everybody was expected to do. There was an NSF expectation as a sponsor. And as a result, I think the collaborating environment was friendlier than it could have been otherwise.”

Not all project data was shared. Some federal projects had requirements for data security, or clients might specify nondisclosure agreements or otherwise restrict data sharing as a condition of a project. If personally identifiable information was used, IRB restrictions on access applied.

Data sharing could also require additional time and costs to a project, suggesting that this is an area where researchers could benefit from additional campus support. Formatting and storing data did not happen instantly or for free, and researchers might be faced with conflicting requirements from funders and data repositories or databases. Data sharing could add a new layer to project administration: “Now we really have to worry about what happens to the data that we collect, the data that we create, and who manages that and for how long it's managed.” Despite the growing prevalence of data sharing practices and requirements, one scholar wondered if anyone would ever use the vast amount of data uploaded to an NSF database.

On the other hand, some researchers saw sharing data as an opportunity to get more value from data that was expensive to collect, hard to replicate, and complex to analyze. One scholar hoped that engineering researchers would become more organized in sharing data within the field, including establishing data standards in areas such as sensor labeling. Two interviewees offered thoughts on future trends in data sharing. One mentioned the increasing role of some journals in facilitating data sharing, while another expressed a need for a robust system to share documents that did not find a home in existing databases.
The interviewees reported using a variety of information sources and forms of communication to keep up with developments in their field. They described attending events, reading and browsing the literature, and various means of interpersonal communication, some as simple as emailing colleagues within the field.

Most interviewees highlighted conferences as a means of learning and professional development. These ranged from smaller regional conferences to national and international venues with thousands of presenters. One major benefit researchers mentioned was the opportunity to learn by attending others’ sessions. Getting feedback about their own projects and methods was another important benefit. One researcher noted that organizing conferences and workshops could be a useful way to keep up with the profession while engaging in professional service, while another felt serving on a journal’s editorial board was similarly beneficial. Scholars also mentioned other workshop-scale events as useful venues for giving or attending presentations. Some of these were organized by NIST, NSF, or groups of state DOTs. Others occurred within the ISU department or between research groups. One interviewee particularly valued workshops on emerging issues in the field. While some scholars mentioned watching webinars as a means of keeping current, most felt it was more effective to participate in face-to-face discussions and presentations. Obviously, travel to multiple events adds to time pressures and costs money; one interviewee pointed out that the current university annual allotment for faculty travel was never enough to cover a full year of professional events.

In addition to professional development opportunities, several of the scholars mentioned using publications and websites to stay informed about developments in the field. Depending on the researcher, this could include browsing and reading key journals, glancing over a daily email from an industry trade organization, checking a Google news feed, or watching for new papers from other research groups working on similar topics.

Researchers made use of a variety of options for getting the word out about their own research. All the researchers reported primarily using peer-reviewed journal articles to share their research with the academic community. Transportation researchers often used Transportation Research Record for publishing articles; researchers in other disciplines preferred journals focused on their specific fields of study. One researcher shared concerns about expanding the scope of communications about research results beyond academia and reaching new, public audiences. Most researchers also made use of conference papers and presentations for sharing their research results, naming a variety of conferences in their respective fields. Transportation Research Board meetings and ASCE conferences were mentioned several times, along with many specialized or interdisciplinary conferences offered by the American Chemical Society, Institute of Electrical and Electronics Engineers, National Travel Monitoring Exposition and Conference, and more. Researchers also gave talks and presentations outside of academic conferences, including invited talks, workshops for peers and practicing engineers, short courses and other training, and webinars.
Researchers might produce technical reports and technology transfer summaries that they considered useful contributions to the field, even though these were not always considered important for tenure and promotion. Reports could be relatively short or could number hundreds of pages. For example, one research group produced a large guidance manual for practitioners in the field. Reports might be shared with the funder, client, or industry partner, with the research center, or might even be posted publicly online. Other means of disseminating research results included book chapters and textbooks. Some researchers also considered data sharing as a means of disseminating their research results, particularly to their funders. They might upload the data directly through a web interface or give the funder access to the data storage location or archive.

Several researchers mentioned interest in promoting their research through more mobile-friendly means than traditional journal articles, and providing easier links between research products such as papers and corresponding datasets and presentations. A few researchers shared their research in ways that were not public, such as through ASHRAE reports, which are available to ASHRAE members only. One researcher described challenges presented by nondisclosure agreements with industry partners, which restricted the ability to meaningfully share project results at all.

The scholars were very deliberate in their publishing practices, reflecting the importance of publishing for establishing a reputation, earning promotion and tenure, and obtaining funding for future research. In general, scholars viewed journals as higher quality outlets for publication than conference proceedings or textbooks. Depending on the subfield, having a paper accepted to a sufficiently selective conference could still be a strong positive. Scholars also reported being less likely to write textbooks for financial reasons: while textbooks could lead to royalties, publishing articles was more likely to attract research funding and lead to gaining tenure. One researcher noted that it would benefit the field if faculty could get credit in the tenure process from publishing frequently downloaded datasets, but that this is not the current practice.

The subject and scope of a journal were crucial characteristics when deciding where to publish, as these played a role in determining the most likely audience for an article. In some cases this meant finding a subject-focused journal in just the right subfield, while in others it meant choosing a journal with a broader scope and thus a wider audience. While academics are expected to publish peer-reviewed journal articles, those articles are often not available or useful to practicing engineers outside academia, who make up a significant audience for scholars in this field. Conversely, practical reports that might be highly valued by practicing engineers are not highly rewarded by the promotion and review structure of academia. Scholars also considered the preferences of their funding organizations when publishing. One interviewee noted that NSF panels want to see high impact journals while other funders may want to see very practical and applied research. In some cases, publications were chosen to influence future funding decisions, while in others, this choice could be constrained by the conditions of the current grant or contract.

Nearly all the interviewees mentioned journal quality, and impact factor as a proxy for quality, as key factors in deciding where to publish. Since Web of Science is used to measure impact factor, many researchers considered it crucial for a journal to be included in this database. However, one interviewee
mentioned that research-only positions do not require evidence of high impact factors to the extent that faculty assessments do. Older, well established journals with a solid reputation in the field might also be chosen despite a lower impact factor. One researcher chose journals partly to create international impact for research projects, while another mentioned that papers reporting on findings that seemed unique and important would be more likely to be submitted to the highest-profile journal possible.

Reliance on impact factor might simplify the question of measuring journal quality, but it also created its own problems for researchers. One interviewee shared that it could be a challenge to match high impact factor with a good fit in terms of publication scope or target audience. The best fitting journal might not be the one with the highest impact factor, so a researcher would need to weigh fit against concerns for future promotion and review. Two researchers described their concerns about the possibility of researchers and journals gaming the impact factor system to boost their own profiles, particularly regarding self-citations. Another interviewee mentioned discussions among editorial boards about increasing the impact factor of the journal; one possibility would be to provide easier or more affordable open access options, while another would be to change which commercial publisher a professional society used.

Several interviewees noted that the career stage of a researcher was also a factor in deciding where to publish. Pre-tenure faculty were encouraged to publish in high-impact journals and to use diverse venues for publication and might feel significant pressure to publish as much as possible, as quickly as possible. Graduate students also were advised to publish in journals with a high impact factor; as one interviewee said, “we've got a fairly short list of journals we like to get our kids into, and they're all excited about impact factor.” One tenured researcher commented that high impact factor was no longer a personal factor in where to publish, but that this was a bigger consideration for students.

Scholars felt it was also important to have a sense of how likely it was that a given journal or refereed conference would accept a paper. Experienced researchers were likely to have developed strategies for determining where to submit their work as they gained an understanding of which publications reach which audiences and cases where some journals have higher standards than others even from the same publisher.

Several interviewees also commented on the importance of how a journal’s editors and reviewers treat authors. They described a preference for journals that streamline the review and publication process. No journal can make the review process instantaneous, but the time required for a paper to go from submission to review to acceptance and eventual publication depends heavily on a journal’s policies and editorial staff. Shorter turnaround times were obviously preferred, especially when graduate students or pre-tenure faculty were among the group of authors for a paper, but scholars reported that some journals are still very slow. One scholar pointed out that this can be exacerbated when journals request multiple rounds of revisions before publishing a paper, though another described improvements in journals’ turnaround time to publication.

A journal could also be considered less author-friendly based on how likely its reviewers were to give serious, knowledgeable, and useful feedback on submitted papers. As the number of researchers
increases worldwide, with growing pressure on many to demonstrate their value to their organizations by publishing, there is an increase in the number of papers submitted to journals and a corresponding need for more reviewers. To be effective, reviewers must be knowledgeable about their fields and about key research directions. One researcher commented from the perspective of an editorial board member about how difficult it can be to find enough reviewers for a journal, and how important it is that reviews be fair; negative reviews that are not clear on how a paper can be improved are frustrating to both authors and editors. Another participant noted sometimes getting papers back with comments from only two reviewers instead of three, and perceiving a decline over time in the quality of reviews. A third interviewee said,

“When you submit a paper, it's largely a random process who gets assigned to review that paper. ... I end up being late a lot of times in my paper review, but I always give a thorough review. And then I'll get comments back on mine. A few sentences maybe, and particularly if it's not a favorable review that's really frustrating because you don't know what you can do. I think that gets back to the quantity issue because everybody is being encouraged to publish more and somebody's got to review those.”

Publishing practices continue to develop in this field. More than one scholar commented positively on some of the advantages online publishing has brought to journals, such as the ability to post accepted articles online before print publication or adding more visual and even video content to supplement articles. One interviewee pointed out that researchers increasingly must self-promote to get their work noticed. Some interviewees saw a potential role for the library when sharing their research results with the academic community and beyond. Expanding on this, one researcher suggested that the library might be able to help make publications more visible to other researchers.

Most interviewees did not use open access outlets for sharing their work, but the researchers who did reported using a variety of options. These included releases to campus and other media outlets, DOT publications, the ISU Digital Repository, patents, dissertations, project websites, and YouTube videos. Researchers perceived several advantages to open access publishing, most important that some state and federal funding sources require it. Also, having easily accessible papers offered the potential for more frequent citation of their work, enhancing the researchers’ reputations. As one interviewee noted, “nobody pays” thirty dollars for access to a single article from a publisher’s website. In other words, articles that could not be obtained for free were less likely to be used and cited. Responses to our questions about finding information suggested that researchers and students were also unlikely to use library systems for finding articles. Publishing articles through open access, and ensuring their discoverability through search engines like Google and Google Scholar, could go a long way toward increasing visibility and building a researcher’s reputation.

Interviewees were most familiar with open access publishing in the form of article processing charges (APCs) for commercial journals. Most scholars indicated that they did not choose, or only rarely chose, this publication option. This was largely due to a lack of funds to cover APCs. Even where funds were available to pay APCs, the researcher might object to “paying twice” -- once to research and prepare the article, and again to make it open access. One researcher mentioned that the library could help authors
cover APCs, but did not offer suggestions for where funding for this might come from or how money might be distributed. Many of the scholars agreed that they would be more willing to choose this option if it were free or of minimal cost. At the same time, several scholars saw the high APCs of traditional journals as necessary to support the editorial review process when articles are made open access. The ISU Library is in the very early stages of investigating “read and publish” agreements with publishers that could address this issue.

Interviewees were also aware of engineering journals which were open access for all articles, but they voiced concerns about this publishing model. Predatory and low-quality journals that lack a good review process are well-known problems. To authors, publishing in an open access journal was only a good idea if the journal had a good reputation, and it was important not to waste good research output in a bad or mediocre journal. One researcher noted judging journal quality as an area where assistance from the library could be a useful timesaver.

Institutional repositories are a growing option for researchers wanting to make publications open access. Iowa State University has its own digital repository, functioning as a unit of the ISU Library, where faculty can submit their publications and presentations. Most of the researchers interviewed were at least somewhat aware of the ISU Digital Repository, or expressed interest in learning how to participate more fully. One had used the institutional repository at a previous institution. Some had publications in the Digital Repository due to ISU-based co-authors submitting their co-authored papers, even if they were not active participants themselves. At least one other reported sending an updated list of publications to the DR, but only when prompted to do so; taking the time to do this regularly was a low priority on the list of a PI’s duties. The bepress platform currently used for the DR provides monthly emailed summaries of download activity to authors, which one researcher appreciated.

When asked about their use of social media, most interviewees reported that they did not use social media to disseminate their research. Several were aware of at least some other researchers using Twitter, but did not use the platform themselves. Several interviewees mentioned using ResearchGate in the social media context, most commonly to post a list of publications without uploading the full papers. One interviewee described using YouTube to create quick visualizations to show students or for display during a talk. While a few interviewees did see some potential for promoting their work through social media, they did not feel they had enough time to participate effectively.

The CCEE department and the InTrans research center have some social media presence, which the researchers seemed to appreciate as a means for getting the word out about their work. In general, however, the interviewees did not perceive social media as a useful way to seek information.

**RECOMMENDATIONS**

**COLLABORATION**

- The College of Engineering or the Engineering Research Institute could develop guidance and/or provide facilitation for a reflection and assessment process on the conclusion of collaborative research projects, aiming to improve procedures and organization for future collaborations.
• The College of Engineering or Office of the Vice President for Research could promote the use of funds not tied to specific projects for defraying expenses of travel to events with a high likelihood of productive networking.
• Librarians could provide training in best practices for managing information and documents collaboratively.

INFORMATION MANAGEMENT

• The ISU Library should actively ensure that PIs and their students know who their liaison librarian is and are aware of library services that could help with the literature review process.
• Librarians should develop and promote training on information management and citation management to researchers and students in this department. The Library already offers workshops on citation management and one-on-one research consultations, but training targeted to specific research groups or institutes may be better received.
• As Google Scholar is a favorite literature review tool for many of these researchers, librarians should be sure to engage with the department to make sure everyone has Google Scholar set up to integrate with library resources.
• Training on how to do complementary searching with other databases, whether open access choices like TRID or library-sponsored resources such as Web of Science or Compendex, would be most useful if targeted by subfield.

DATA MANAGEMENT

• ISU should provide training for faculty and students on best practices for data management and organization. The Library is already offering occasional brief workshops in this area, which can be assessed and improved, and customized for specific disciplinary needs. Discipline-specific brief sessions or online modules could be developed for use by research groups or classes.
• University IT services, or a task force of IT staff that work with departments which conduct field research, could investigate better support for wireless collection of data from remote sensors, such as through app development or cellular network access.
• The Chief Information Officer and appropriate IT strategy groups should continue to improve campus support for data analysis, including more access to high-performance computing clusters, more powerful computers for research groups, software and analysis training, and storage technology.
• The Office of the Vice President for Research and the Office of Intellectual Property and Technology Transfer should explore ways to expedite the implementation of data sharing and sponsored research agreements.
• The College of Engineering should consider further technical training for students in areas like computer coding or using statistical software. These could be added to for-credit courses or offered as workshops or mini-course series.
SCHOLARLY COMMUNICATION

- Librarians should assist scholars in identifying predatory and low-quality journals, and take steps to ensure that they know this service exists.
- Librarians should provide targeted assistance to help researchers better understand the meaning of impact factor and other publication metrics.
- The library and other academic support units on campus should pursue ways to make funding for APCs and open access publishing easily available, for example through “read and publish” agreements with publishers.
- The ISU Library should continue to invest in products and services that support metadata schemas designed for use beyond the library context, such as schema.org, to increase discoverability of library resources, including faculty publications, through search engines.

CONCLUSIONS

The Iowa State University portion of the study is a single segment of the Ithaka S+R study, which will investigate the needs of civil and environmental engineering scholars at a total of eleven institutions around the US and Canada. The perspectives and experiences of ISU’s CCEE scholars will help inform the results of the nationwide Ithaka report, due in early 2019.

Civil, Construction, and Environmental Engineering is a broad field, with far-reaching impacts and diverse faculty needs. Understanding the research process, information needs, and publishing practices of these researchers is necessary for Iowa State University and for the ISU Library to fully support their research. Opportunities for improved support span the research process, from the development of a research question, through the process of collecting and using data, through publication and dissemination of research results. Through the interviews detailed here, we have developed recommendations in each area for potential support, which will lay a foundation for better meeting the needs of researchers and students in this department.

APPENDIX 1: PARTICIPATING INSTITUTIONS

- Carnegie Mellon University
- Georgia Institute of Technology
- Iowa State University
- North Carolina State University
- University of Colorado Boulder
- University of Delaware
- University of Illinois Urbana-Champaign
- University of Toronto
- University of Waterloo
- University of Wisconsin-Madison
- Virginia Polytechnic Institute and State University
APPENDIX 2: QUESTIONNAIRE

Research focus and methods

- Describe your current research focus and projects.
- How is your research situated within the field of Civil and/or Environmental Engineering?
  - Does your work engage with any other fields or disciplines?
- What research methods do you typically use to conduct your research?
  - How do your methods relate to work done by others in Civil and/or Environmental Engineering [and, if, relevant in the other fields you engage with]?

Working with others

- Do you regularly work with, consult or collaborate with any others as part of your research process?
  - If so, who have you worked with and how?
    - Lab or on-campus research group
    - Other scholars or researchers [e.g. faculty at the university or other universities, student assistants, independent researchers]
    - Research support professionals: e.g. librarians, technologists
    - Other individuals or communities beyond the academy
    - Others not captured here?
- Have you encountered any challenges in the process of working with others? [focus on information-related challenges, e.g. finding information, data management, process of writing up results]
- Are there any resources, services or other supports that would help you more effectively develop and maintain these relationships?

Working with Data

- Does your research typically produce data? If so,
  - What kinds of data does your research typically produce? [prompt: describe the processes in which the data is produced over the course of the research]
  - How do you analyze the data? [e.g. using a pre-existing software package, designing own software, create models]
  - How do you manage and store data for your current use?
  - Do you use any other tools to record your research data? [E.g. electronic lab notebooks]. If so, describe.
  - What are your plans for managing the data and associated information beyond your current use? [e.g. protocols for sharing, destruction schedule, plans for depositing in a closed or open repository]
  - Have you encountered any challenges in the process of working with the data your research produces? If so, describe.
  - Are there any resources, services or other supports that would help you more effectively work with the data your research produces?
Does your research involve working with data produced by others? If so,
• What kinds of data produced by others do you typically work with?
• How do you find that data?
• How do you incorporate the data into your final research outputs? [e.g. included in the appendices, visually expressed as a table or figure]
• How do you manage and store data for your current use?
• What are your plans for managing the data beyond your current use?
• Have you encountered any challenges working with this kind of information?
• Are there any resources, services or other supports that would help you more effectively work with the data produced by others?

Working with Published Information
• What kinds of published information do you rely on to do your research? [e.g. pre-prints, peer-reviewed articles, textbooks]
  • How do you locate this information? [Prompt for where and how they search for information and whether they receive any help from others in the process]
  • How do you manage and store this information for your ongoing use?
  • What are your plans for managing this information in the long-term?
  • Have you experienced any challenges working with this kind of information?
  • Are there any resources, services or other supports that would help you more effectively work with this kind of information?

Publishing Practices
• Where do you typically publish your scholarly research?
  • What are your key considerations in determining where to publish?
  • Have you ever made your scholarly publications available through open access? [e.g. pre-print archive; institutional repository, open access journal or journal option]. If yes, describe which venues.
    • Describe your considerations when determining whether or not to do so.
• Do you disseminate your research beyond scholarly publications? [If so, probe for where they publish and why they publish in these venues]
• Do you use social networking or other digital media platforms to communicate about your work [e.g. ResearchGate, Twitter, YouTube]?
  • If yes, describe which venues and your experiences using them.
  • If no, explain your level of familiarity and reasons for not choosing to engage with these kinds of platforms.
• How do your publishing practices relate to those typical in your discipline?
• Have you encountered any challenges in the process of publishing your work?
• Are there any resources, services or other supports that would help you in the process of publishing?
State of the Field and Wrapping Up

- How do you connect with your colleagues and/or keep up with trends in your field more broadly? [e.g. conferences, social networking]
- What future challenges and opportunities do you see for the broader field?
- Is there anything else about your experiences or needs as a scholar that you think it is important for me to know that was not covered in the previous questions?