

Research Practices of Civil and Environmental Engineering Scholars at the University of Waterloo

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Background

Ithaka S+R Research Study

This report is an investigation of research practices of Civil and Environmental Engineering (CEE) scholars at the University of Waterloo. The study was conducted by the Library, and was part of a larger suite of parallel studies of Civil and Environmental Engineering scholars at institutions of higher education in the U.S. and Canada. The study was coordinated by [Ithaka S+R](#) whose goal is to “provide research and strategic guidance to help the academic and cultural communities serve the public good and navigate economic, technological, and demographic change”¹. Under the sponsorship of the American Society of Civil Engineers (ASCE), participating institutions, including the University of Toronto, Carnegie Mellon University, Georgia Tech, Virginia Tech, University of Colorado Boulder, the University of Illinois Urbana-Champaign and the University of Waterloo, engaged in local studies of CEE faculty member research practices and compiled independent research results and recommendations for creating or enhancing local services and supports. In addition, participating institutions contributed their findings to a final capstone report by Ithaka S+R. The Ithaka capstone report provides a cumulative view of the evolving needs of Civil and Environmental Engineering scholars and includes recommendations that libraries, universities and engineering societies can use to support the changing research practices of engineering scholars. For information on the methodology of this study, refer to Appendix A.

Civil and Environmental Engineering at the University of Waterloo

The Department of Civil and Environmental Engineering at the University of Waterloo is one of the largest combined departments of architectural, civil,

¹ <http://www.sr.ithaka.org/>

environmental and geological engineering in Canada.² With an enrollment of 830 undergraduate and 180 graduate students³ that will continue to grow, the Department offers four fully accredited undergraduate degrees, and three graduate programs.⁴ All of the engineering undergraduate programs at Waterloo are based on a co-operative education system where academic terms alternate with work terms, allowing students to gain up to two years of relevant work experience. At the graduate level, the thesis-based Master of Applied Science (MASc) and Doctorate (PhD) programs provide students with industry- or government-funded research opportunities, while the course-based Master of Engineering (MEng) program offers working engineers the opportunity to upgrade their technical background. Among the 42 distinguished CEE faculty, the four research areas of focus are⁵:

- Environmental & Water Resources Engineering (E&WR)
- Geotechnical Engineering (GEO)
- Structures, Mechanics & Construction Engineering (SM&C)
- Transportation Engineering (TRANS)

Limitations

We attempted to recruit faculty from all ranks; however we did not have the opportunity to interview any assistant professors for this study. All of the participants had been awarded tenure and served in an associate or full professor capacity. This may have influenced our findings in that the participants we spoke with had established their research areas, their labs, and all currently had graduate students under their supervision.

Findings

Research Focus and Methods

At the 2018 Canadian Society for Civil Engineering (CESC) Annual Conference, a panel “addressed serious, urgent and growing issues for the profession, and for society: a) Sustainability and Innovation; b) Inclusivity and Social Justice; and c) Accessibility & Universal Design of the Built Environment.”⁶

² <https://uwaterloo.ca/civil-environmental-engineering/>

³ <https://uwaterloo.ca/civil-environmental-engineering/about-civil-and-environmental-engineering>

⁴ <https://uwaterloo.ca/civil-environmental-engineering/programs>

⁵ <https://uwaterloo.ca/civil-environmental-engineering/research>

⁶ What lies ahead? (2018). *Canadian Civil Engineer*, 35(3), 14.

The panel asked “if CSCE, a community of active and impactful professionals, who could have disproportionate impact on directions and models in the realm of infrastructure, can rise to the occasion in new ways with new collaborations?”⁷

During the interviews for this study, consistent themes and research priorities emerged between these conversations at the national level and the current and future research activities and priorities for the University of Waterloo Civil Engineering scholars. As the participants articulated their research priorities, and as themes for future research were discussed, an emphasis on sustainability, lessening environmental impact, improving safety and continuously improving and innovating practices related to the built environment were clearly articulated. One participant commented that in his field,

The whole paradigm of waste management is evolving with more of an emphasis on sustainability and resource recovery, looking at waste not as just something that you invest all kinds of energy and resources into cleanup, but rather to look at utilization of the wastes for gathering and recovering resources.

With broader collaborations and technical advances enabling, for example, the advent of Internet of Things and big data streaming from embedded sensors, the participants saw challenges and opportunities ahead in managing and advancing their research.

The specific research areas of the participants in this study included construction automation, productivity improvement using robotics, three-dimensional machine vision, artificial intelligence, infrastructure management, smart infrastructure, pavement engineering and management, public water supply, wastewater treatment processes and their environmental impacts, mechanics of soils, rock mechanics, and foundation design.

Participants engaged in a combination of research methods, such as “experimental, theoretical, simulation, field studies, laboratory studies”, as one participant noted. With the emphasis on doing applied research, specific methodologies included controlled experiments, scan-to-model analysis, field instrumentation using sensors, statistical analysis, life-cycle cost analysis, and computer modeling and simulation. The researchers in wastewater treatment particularly remarked on the scale-up process modeling of bench-scale investigations to pilot-scale studies. While using well-established software such as MATLAB for data analysis was the most common practice among all participants, they also developed new code or algorithms when no pre-existing software was available.

⁷ What lies ahead? (2018). *Canadian Civil Engineer*, 35(3), 14.

Working with others

While the majority of academic collaborations were concentrated in North America, others spread across the world in Europe, Chile, Hong Kong, South Korea, Australia and New Zealand (Figure 1).



Figure 1: Where Academic Collaborators Were Located

Listed under the categories of within CEE, within engineering and outside engineering, Figure 2 shows the range of disciplinary backgrounds of academic collaborators with whom the participants had worked.

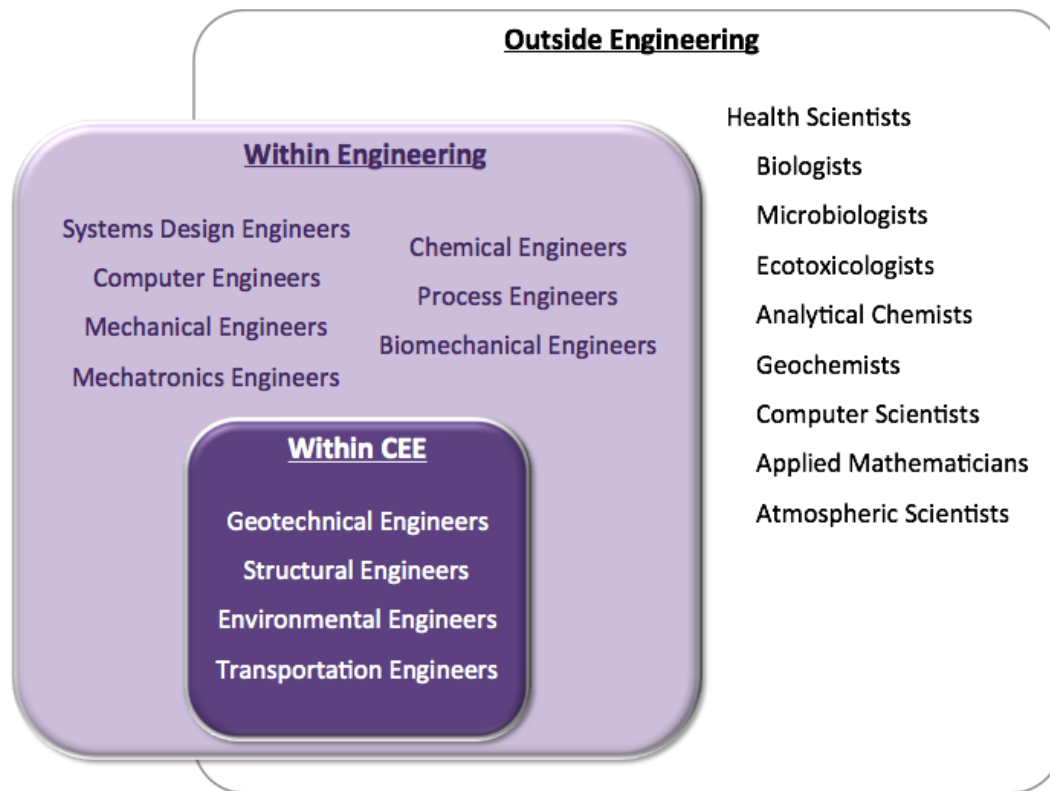


Figure 2: Disciplinary focus of collaborators

In addition to academic colleagues, the participants noted they worked closely with municipal and provincial governments, industry associations, and the private sector. Collaboration challenges in these relationships tended to revolve around the gathering and sharing of data. One of the biggest concerns was the proprietary nature of industry data:

We have had partners who have wanted [to work with us] but were not able to resolve the desire to have us analyze their data with the fear of giving us access to their data [...] where they suddenly panic because the data they feel is their customers' data and not their own.

Another complication stemmed from balancing the need to share data with the need to protect research subjects' privacy. As one participant noted:

There is a real challenge in the academic community now around how do you make the data available without jeopardizing the anonymity of the subject, which might have been an industrial partner [...] just like we don't want to jeopardize the privacy of an individual.

Furthermore, with research projects that involved human subjects, participants wondered when ethics approval would be required from the Office of Research

Ethics.⁸ “We have done the training and we know where the boundaries are but it is still fuzzy”, contended one participant.

When it came to data sharing, one participant said that in their experience larger organizations were more reluctant to share their data, while others would like to see a more efficient way to gather data from multiple facilities across the province.

Funding and Its Impact on The Research Process

The process of securing and allocating scarce funding to support a research program, bring value to research partners and meet funder requirements was identified as competitive, time consuming, and a high priority for the researchers.

Unique to the Canadian context is federal government research funding provided by the Natural Sciences and Engineering Research Council (NSERC)⁹ of Canada which “supports university students in their advanced studies, promotes and supports discovery research, and fosters innovation by encouraging Canadian companies to participate and invest in postsecondary research projects”.¹⁰ Beyond NSERC, CEE scholars reported securing research funding from provincial and municipal levels of government, industry, and industry associations, sometimes in combination.

Maintaining research programs involved allocating funding to support graduate students and postdocs; covering the costs associated with administrative and overhead expenses, including maintaining a lab, software licenses and equipment; and in some cases, the hiring of research scientists or engineers. To meet requirements and expectations for open access sharing of research results, data management planning and the sharing of research data, researchers anticipated that budgets will increasingly be stretched to cover the direct costs and staff time associated with these activities (Figure 3).

⁸ The institutional review board at the University of Waterloo

⁹ Canadian Institutes of Health Research (CIHR), Natural Sciences and Engineering Research Council of Canada (NSERC) and Social Sciences and Humanities Research Council (SSHRC) make up the Tri-Agency federal granting councils

¹⁰ http://www.nserc-crsng.gc.ca/NSERC-CRSNG/Index_eng.asp

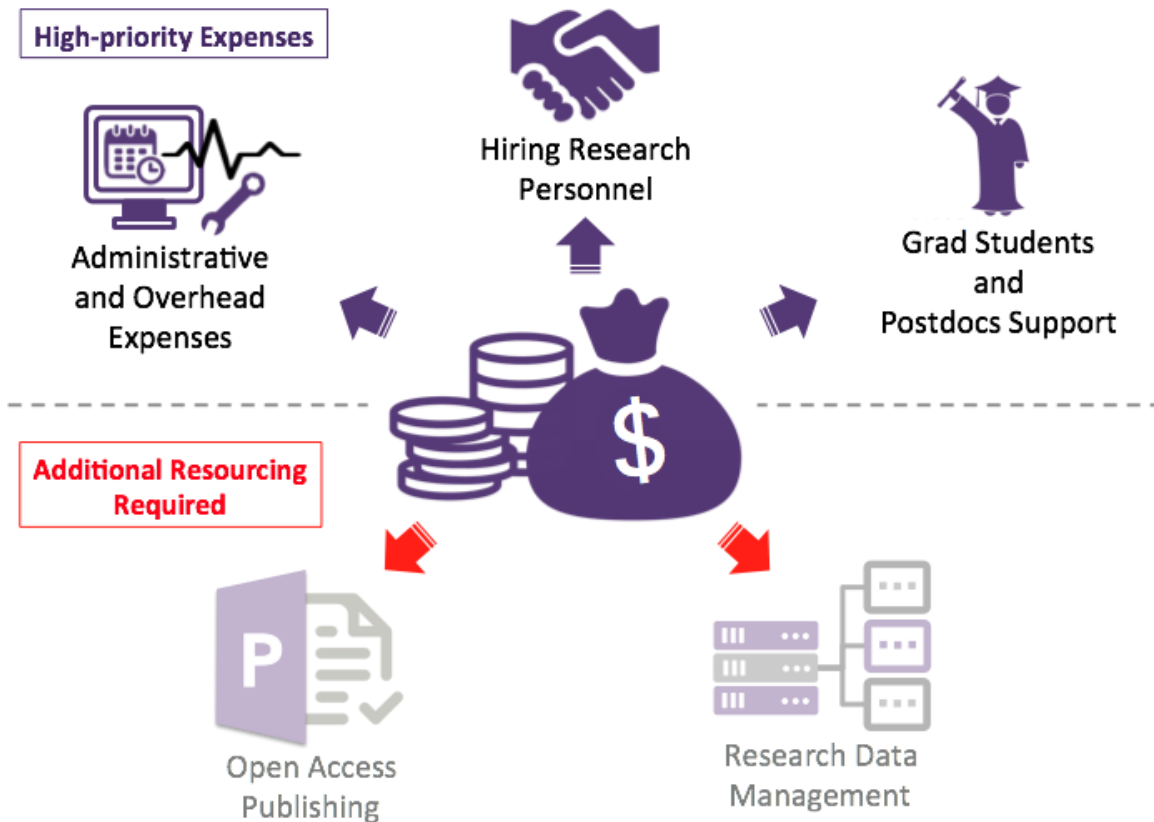


Figure 3: Costs of doing research¹¹

Allocating research funds to cover the cost of open access publishing was specifically mentioned as a concern by the participants. As one participant stated, “We have limited research resources and often it costs more to publish in open access journals, so I am hesitant to spend our limited research resources on having our papers published [in them]”. Author paid open access models can cost several thousand dollars: some researchers noted that this money would be better spent on hiring graduate students.

Role of Graduate Students

A prominent theme that emerged from the interviews was the role of graduate students in keeping a research program going. From literature searching and data management to the publication of research results, researchers aimed to guide graduate students in taking charge of their academic responsibilities (Figure 4).

¹¹ The Graduate icon used in this image was created by Gan Khoo Lay from the Noun Project under the Creative Commons Attribution (CC BY) license.

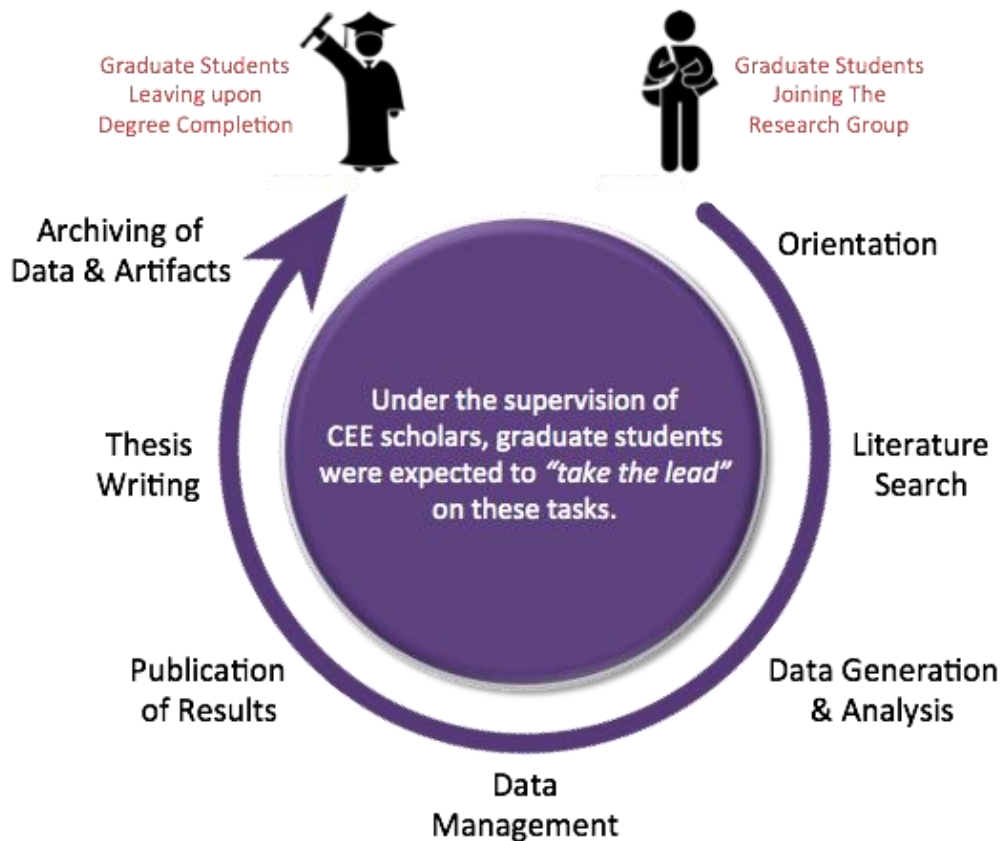


Figure 4: Graduate Students and Their Expected Tasks throughout Their Academic Career¹²

Figure 4 represents the general stages of the graduate student academic research process. Starting with the literature search, faculty members noted that they provide some initial guidance for their students in terms of key authors or papers in the research area. However, the expectation is that graduate students will continue this research on their own:

I do expect the grad students themselves [to keep] abreast of the relevant literature, because they need to be actively engaged in that in terms of defining their projects and using information to help interpret their results and so on.

According to faculty members, graduate students face challenges in finding published information. Specifically, faculty noted difficulties with keyword or subject searching in unfamiliar subject areas, and missing key content. The impact of this challenge was articulated by one faculty member as follows: “I wasted years working on a subject that I thought no articles had been done and had done tons of

¹² The College Student and Graduate icons used in this image were created by Gan Khoon Lay from the Noun Project under the Creative Commons Attribution (CC BY) license.

searches and my students had done tons of searches but we didn't know the word goniometer. If we had known the word goniometer, we would have known that somebody had done this."

With data generation and analysis being one of the key research tasks, graduate students typically "each have responsibility for their own data management." While data were entered into spreadsheets, and incorporated into tables or figures by graduate students for current use, one of the faculty members also had a shared lab server for students to backup their data. The faculty member would advise students to follow a certain naming scheme, and typically:

There should be a README text file which explains the data, when it was collected, what it is about, and [the README file] also goes right into the same [backup] folder. So, if somebody is picking the data from the folder, they click on the README file and they have some running text that describes the data, what the naming convention is, when it was taken, why it was taken.

Other participants did not have such a detailed data managing protocol, and would encourage their graduate students to attend future data management workshops if they were offered by the Library.

Following the general progression illustrated in Figure 4, publication of research results was identified as a key activity. In most cases, graduate students were expected to take the lead on finding appropriate publications for their research. When it came to where to publish, several participants would make recommendations to their students, but would usually support a student's preference. One faculty member noted that balance should be considered between publishing in high-impact academic journals and knowledge dissemination for engineering practitioners, depending on the graduate student's ultimate career goal.

In addition to the publication of research results, "the end product of every student's work is a thesis" which plays an important part in the sharing of new knowledge and making research outputs and data publicly available. The thesis contains data, code, and other information providing context for the thesis topic. However, the electronic format used to store theses is not conducive to the reuse or mining of data contained in an appendix, which faculty members pointed out as problematic. An opportunity exists for the CEE scholars and the Library to explore the practice of including research data in the appendix of a thesis and consider options for making the data more accessible, such as depositing a dataset in the OCUL Dataverse repository and obtaining a permanent DOI link to those data.

Upon degree completion, graduate students were expected to transfer and archive their research data and files. There was no universal strategy among the CEE scholars for archiving research data and files, and individual solutions existed within different groups. For examples, one participant used an internally shared lab

server while another used a cloud storage solution that was external to the University. In another case, “the research associate would get the data and electronic files from the students [...] on a memory stick”, or via their university hard drive.

The turnover of graduate students upon degree completion was noted to have an impact on research. One participant had given up on publishing a paper because “it [was] too overwhelming a task” to manipulate data collected and included in a former student’s thesis. Depending on the stage of research project, a new graduate student or postdoctoral fellow might be assigned to continue with data collection if the research is ongoing.

Managing research data

Participants commented that the diverse nature of their work resulted in project data that varied in size from datasets that were “modest in size” to “data that is massive like gigabytes or terabytes where we have image data or video data”. With some projects, researchers have “enormous quantities of data coming in from “continuously operating probes” or sensors and then it is a matter of “taking that data and reducing it to a form where you can start to extract information out of the data”.

Working with unique data structures and diverse projects impacted thinking about the longer term management and archiving of research data. Many faculty members admitted to having “no standard approach to gathering data”. Workload, the evolving and fragmented landscape of platforms to store and share research data, and storage capacity issues for large datasets impacted researchers’ decisions to fully implement data management practices beyond current personal practices. One participant summed up the situation: “it is almost impossible to have a cohesive research data management strategy and maintain it over time”.

Participants all saw an opportunity for moving towards stable, centralized repositories to consistently archive and provide access to research data and for centralized data gathering systems that would enable data collection from research partners on a broad scale. Solutions could include a campus-wide repository, or broader, depending on researchers needs. Interest was also expressed in a repository for working data, as opposed to only archiving finalized data sets.

Keeping up to date

Peer reviewed journal articles were identified as the main source of information about research advances. Other sources for keeping current included government reports, technical reports and standards and codes. Popular magazines and media outlets provided a means for identifying new research areas, fostering innovation

and ensuring research is topical. While conference proceedings were mentioned by several participants as a source for keeping current, others commented that publishing important findings in conference proceedings is declining as scholarly publishing practices preference higher impact journals.

Attending conferences continues to be seen as a good way to keep up-to-date and gain additional insights into a topic. Several faculty members indicated that “hallway conversations are almost as important as what you hear in a session”.

Keeping up with the volume of relevant literature published each year posed a challenge for faculty's research and grant writing activities. One participant described the issue in relation to emerging technologies:

You might see a new technology evolving but there might be hundreds of papers a year where people are looking at different aspects or understanding it. Parsing through all that and trying to sift through all that and trying to sift out what is really useful information, and what is perhaps not, can be a challenge.

Several CEE scholars shared that they stay current by peer-reviewing journal articles or participating on editorial boards for journals in their field. The downside of this method is being “bombarded with requests from journals to review papers”.

Discovery

Google and Google Scholar were mentioned repeatedly as the preferred means of searching for relevant information and described as “easier to search”, and that it [Google] “does the job most of the time”. Participants noted varying levels of success discovering relevant information when searching databases made available via the Library website. One participant commented that in the process of proposal writing, they might use Scopus to “go and dig out new literature”. While these databases were recognized as being more rigorous, several participants tended not to use them because they were “too much work” or required a “skill set to rigorously do research in it”. Several participants noted that they use alerts to keep up with the published literature in their areas or to monitor topics considered to be on the “boundary with other disciplines”.

The value of sharing information across personal networks was also raised during the interviews. The comment was made that “it is better to have a personal network or trusted colleagues who share stuff that is relevant but also interesting”. Scholarly sharing networks/sites, such as ResearchGate, were mentioned as a way to discover information or share with others. However, one participant noted concerns about the lack of clarity around copyright and the complicated terms of use for these sites.

Having found relevant information, through whatever means, participants identified a number of practices for how they managed this information. PDF versions of articles might be printed and stored or saved in an electronic format on a local computer using a system of subject or topical folders. One participant commented that information retrieved in an electronic format was not necessarily saved or stored: “because we have access, I may not always save it. I’ll download it and use what I need and then that’s it”.

The discovery and use of data produced by others was identified as a specific challenge. This included finding data published in the literature, typically in the appendix of a publication or thesis, locating provincial and municipal government data and sourcing data from industry partners. When working with the data, the researchers were careful to point out that it was important to understand the context in which the data were created, and depending on the source, there was often an additional step to clean the data and check for quality.

Publishing practice

In discussing how CEE researchers shared their research results, participants identified their priorities based on the weight they attached to publishing for the academic community and for having impact by disseminating results to industry research partners and practitioners. Figure 5 demonstrates the convergence and divide between knowledge dissemination vehicles and their intended audiences.

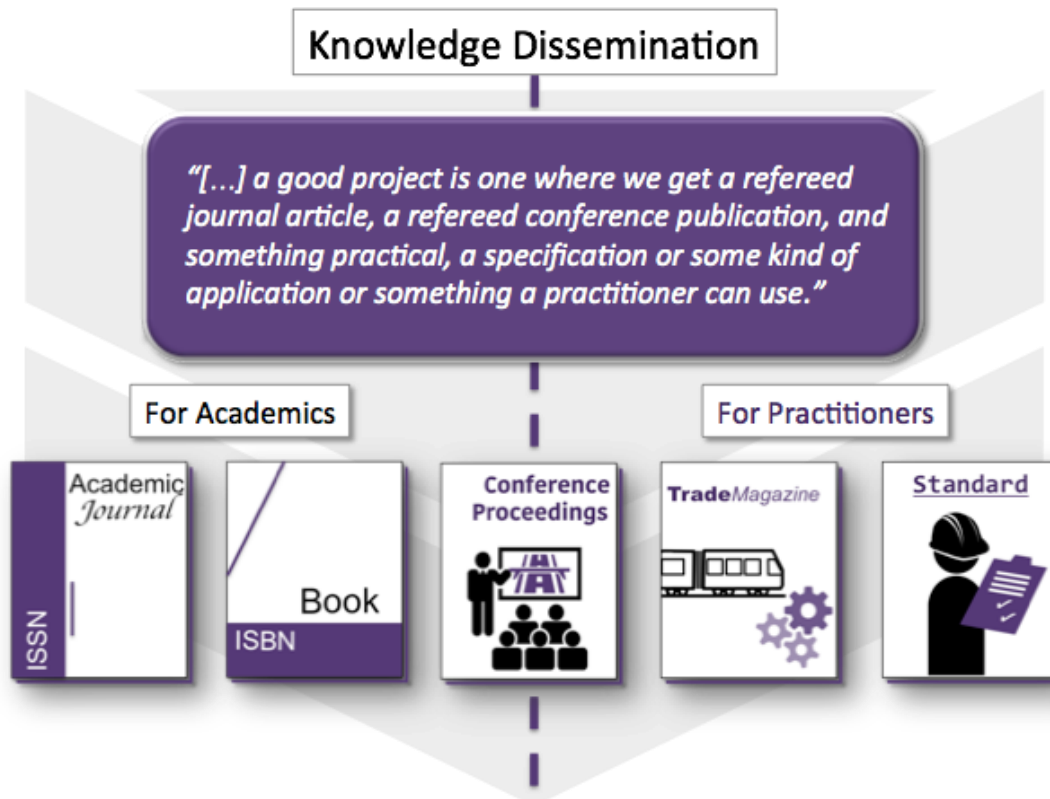


Figure 5: Knowledge Dissemination Vehicles

For academic sharing, peer reviewed journals were mentioned most often and the goal was “to publish in the best journal that we can”. When selecting journals for article submission, the researchers considered impact factor, reputation of the journal, turnaround time for peer review, the best fit based on the type or nature of work and prioritizing journals where “other papers that are closely aligned with our work are published”. The comment was also made that “a journal that invites me through a mass mailing is one I am obviously not going to publish in”.

Conference papers were discussed and there were several factors related to decision making about authoring conference papers. When thinking about the scholarly sharing of research findings, researchers worried about compromising potential journal publications if they published in conference proceedings. However, attending conferences was still seen as a valuable practice, in part because they attract industry partners as well as researchers. This might also mean that a journal that is more applied in nature is identified as a place for publication because “practitioners read it and [authors] know that the information will be used”. Other venues for reaching practitioners included trade journals, specifications, association meetings, annual information days for partners, and government or agency reports. These other venues are not usually represented in traditional bibliometric research impact measures that are based on journal citation counts, so knowledge dissemination in these venues may not be reflected in a researcher’s bibliometrics rating.

Participants were asked about open access dissemination of their research and if/how it fits in with their publishing practice. While many researchers support open access in theory, there was general agreement that author paid models are a barrier to open access publication in practice. One researcher summarized: “everything else being equal, then sure it is certainly to your benefit to have your work more readily available to people around the world. Especially to people who don’t have access to the library systems we have”. Largely, participants expressed concern over publisher costs associated with making peer reviewed articles open access and would not consider this a viable or sustainable practice. Participants were aware of Tri-Agency open access publishing requirements for peer reviewed articles “arising from Agency-supported research”,¹³ however, they generally found the open access landscape confusing and, unless mandated to do so as a requirement of funding, they typically were not publishing open access with intent. The fact that engineers often received funding from diverse sources beyond the Tri-Agency resulted in limited participation in open access publishing.

If researchers did not opt to pay to publish open access in a known, reputable journal, they had concerns over the quality and impact of alternate open access publications. Issues related to copyright, maintaining awareness of which versions of published articles could be contributed to an open access repository, and the workload associated with the process of contributing articles to a repository were all identified as barriers to participating in open access via institutional or disciplinary repositories. Several participants knew that the Library had a repository that could be used to meet open access requirements. One researcher was currently participating in a Library initiative to add versions of previously published papers permitted for open access posting to the repository¹⁴, however the workload associated with locating the permitted versions of papers for posting may impact continued involvement in this initiative.

Social Media

Participants were asked about using social media as a way to communicate about their research. One participant commented that they might use their website to publish stories about their lab, and several mentioned ResearchGate or LinkedIn as a way to make their papers available for private sharing or to “individual requestors”. However, participants expressed concerns about various aspects of the social media landscape. Workload associated with creating and maintaining an online presence was mentioned several times as a reason for not fully embracing social media, along with considerations about impact:

¹³ TriAgency Open Access Policy on Publications

http://www.science.gc.ca/eic/site/063.nsf/eng/h_F6765465.html?OpenDocument

¹⁴ <https://uwaterloo.ca/library/uwspace/uwspace-copyright-review-and-deposit-service>

We are not sure whether our partners would value or whether they would have time to follow social media on the job and this is something we probably need to discuss with them and if they felt that it was valuable to them then I could see us developing more of a presence on social media.

Interviews indicated a general level of skepticism around using social media. Comments included “social media is actually a distraction”, “I am queasy about the copyright issues”, and “I still believe that you do your work, you publish, and then whoever needs to find out will find you out”. While some participants expressed a desire to participate more fully in social media in the future, most participants indicated this is not a top priority.

Conclusions

It was evident from these interviews that the Library can play a strategic role in supporting the work of CEE faculty members. Faculty members consistently expressed concern over their workloads, specifically the pressures of keeping up-to-date in current research areas; identifying new research topics; grant writing and securing research funding; sustaining a research program; supporting the academic and research success of students; disseminating scholarly research results to peers; and translating knowledge to meet the needs of practitioners. In essence, CEE scholars face considerable demands on their time, leaving little time to take on additional scholarly responsibilities related to their work. The following are some key areas where the Library could collaborate and provide value to the CEE department.

Data management is top of mind for many researchers, and the Library could provide support in implementing consistent data management plans, and providing continued guidance in identifying platforms for the curating, sharing and archiving of data. One desirable research support service mentioned repeatedly was a campus-wide cloud storage/data repository system. Not only could a campus platform provide automatic data backup and data access to partners without relying on third-party systems, standard protocols of its usage could also be developed according to the needs of the local researchers. Last but not least, research support in data mining both within and beyond Waterloo would be an asset in advancing research and discovery.

Mentoring graduate students who are preparing to be future researchers was a consistent theme throughout the interviews. There are opportunities for the Library to develop programming that will support the research lifecycle of a graduate student, from building information seeking and inquiry skills, to adopting best practices for data management, to navigating the publishing landscape. However, the risk of overloading students with just-in-case information was also noted. To

that end, several participants were open to the idea of more targeted, just-in-time library workshops during research group meetings.

Collections were noted as a specific area for improvement. Several faculty members commented on not having access to the most up-to-date, state-of-the-art literature in their areas, and on the recent cancellation of journal or research database subscriptions. One participant pointed out the difficulty of researching in a small discipline, like Geotechnical Engineering, within Civil Engineering, “because there are more faculty in other areas, they get the preference of getting all the journals in their area”.

The Library currently provides many of the needed services and supports identified during the interviews, however it was evident that faculty members and graduate students are unaware of this support (Appendix I). One participant specified that “the Library in general should do a better job of customer service and telling people what [services are available]” in order to have a more visible presence on campus. In the future, it will be a key priority to better promote existing Library services, and move more quickly to adapt to users’ changing needs.

Recommendations

By interviewing CEE faculty about their research practices, the Library was able to identify key areas where we can work with CEE scholars to create or enhance services and support. At the same time, there are areas where it may be best for the Library to collaborate or refer to other campus departments to meet researcher’s needs. For instance, while many interviewees expressed a need for localized cloud storage for their data, this is out of scope for the Library’s current services. The following recommendations reflect service and support opportunities in areas of interest or concern to faculty members:

Target Graduate Students

Graduate students were a consistent theme through the interviews. While faculty help to train graduate students in effective research processes, they also rely on them to uncover emerging topics/best practices. Graduate students are also in the early stages of developing their research workflows, so they are a key target audience for communications on data storage and file naming conventions.

Share Data Management Expertise

Waterloo’s librarians have expertise in data management, and it is becoming increasingly important to connect these librarians with CEE faculty and graduate students to help with training and implementing data management plans, identifying appropriate data management platforms, and understanding the emerging national infrastructure for depositing and sharing data. One difficulty the Library faces is determining the appropriate time to share this knowledge throughout the research process. Identifying innovative “just-in-time” opportunities

with faculty members, graduate students and lab or research groups will be a key service aspect moving forward.

Improve Communication Between the Library and the CEE Department

This study highlights the importance of improving communication between the Library and the CEE department to better enhance Library outreach to these researchers. In many ways, the Library already offers the services that researchers require, however many researchers remain unaware of this support. Opportunities exist to effectively communicate about existing services and create effective two-way communication channels that will support service evolution so that researchers can take advantage of Library help in the future. Based on the participant interviews, more frequent in-person presentations from librarians at department meetings to raise awareness of services and support in areas including bibliometrics, research data management, open access publishing or copyright would be helpful. Contacting faculty members and offering to meet with their research teams and/or engaging in conversations about more effective email communication are also actions identified that would strengthen communication.

Support Faculty When They Are Publishing Open Access to Meet Grant Requirements

While Waterloo's institutional repository provides a mechanism for meeting open access grant requirements, it is evident that faculty still face difficulties with the process of depositing their articles. A key theme from this research was faculty's intense workloads, so the Library has an opportunity to investigate ways to streamline processes to help make CEE researchers' "work more readily available to researchers around the world".

Explore ways to help Faculty Articulate Research Impact beyond Bibliometrics Analysis

This study shed light on the value industry partnerships have on research application, and the effect they have on research dissemination. In particular, faculty members might make a decision to present research findings at technical sessions of conferences or regional meetings, such as the Ontario Good Roads Association conference, or contribute to an association publication or trade journal in order to reach practitioners in their field. Traditional bibliometric measures may not capture the impact of research being heavily used by engineers and practitioners in government and industry sectors.

Understand the Perspectives of Early Career or Assistant Faculty

The interviews did not include any new or assistant faculty; all participants were tenured, full-time faculty members, who may have different perspectives on the research and publishing process. Therefore, it is an important next step to undertake further research to determine how the perspectives of these other groups align or diverge from the perspectives already gathered through this study.

Support for the project was provided by the Office of the Provost and the Library at the University of Waterloo.

Appendix A: Methodology

Upon receiving ethics clearance from the Office of Research Ethics in late October 2017 (Figure A1), the project investigating research practices of CEE scholars was launched on November 16 with a recruitment announcement by the CEE Librarian (see Appendices B - E for the recruitment documents). The faculty members contacted included assistant, associate and full professors. In mid-January 2018, a project update was given at a CEE department meeting followed by a final individualized recruitment reminder email (Appendix F).

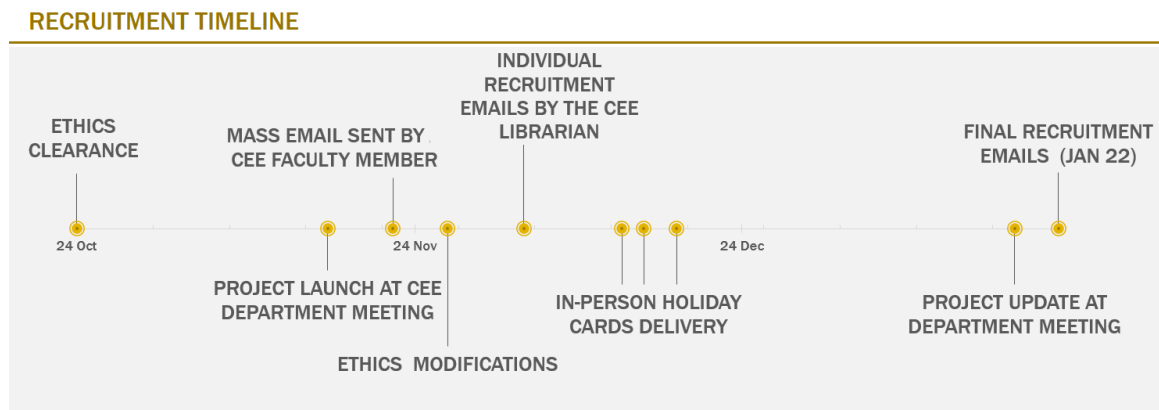


Figure A1: Recruitment Timeline

Of the 42 faculty invited to participate, a faculty member on sabbatical declined, three initially expressed interest but did not proceed with scheduling an interview, and 32 did not respond. Six faculty members (14% of the department) were interviewed with the distribution of research areas summarized in Table A1.

Table A1: CEE Research Area Distribution of The Interviewed Participants

CEE Research Area	Number of Faculty	Number of Participants	%*
Environmental & Water Resources	18	2	11
Geotechnical	3	1	33
Structures, Mechanics & Construction	15	2	13
Transportation	6	1	17
Total:	42	6	14

* % = Number of Participants / Number of Faculty · 100

Interviews were conducted in the office of the participant by the CEE Librarian between November 2017 and February 2018. Written consent was obtained from the participants (see Appendix D and Appendix G). The interviews were audio-recorded using two digital voice recorders, and lasted from 23 to 74 minutes. The semi-structured interview guide (Appendix H) was developed by Ithaka S+R, and explored six areas: 1) research focus and methods, 2) working with others, 3) working with data, 4) working with published information, 5) publishing practices, and 6) state of civil and environmental engineering. The interviews were transcribed, anonymized and checked for accuracy by the authors.

Coding and qualitative analysis

Initial open coding was done by one of the authors on two interview transcripts. The codes were reviewed, discussed and a list of themes and codes was created. The remaining interviews were divided between two authors and coded separately in Excel. The results of the coding were discussed to ensure consistency in application and interpretation. Codes and key quotes were tracked in Excel and examined by the authors in order to determine key themes and trends.

Appendix B: Civil and Environmental Engineering department meeting recruitment slide, meeting handout, and postcard accompanying a holiday greeting card

Call for Participants

Purpose: To examine the research support needs and challenges of scholars in Civil & Environmental Engineering

Other Participating Institutions: University of Toronto, Carnegie Mellon University, Georgia Tech, Virginia Tech + 7 others

Benefits: Service improvement to help you with your research, data management, publishing and other scholarly activities

Contact: Siu Yu, Engineering & Entrepreneurship Librarian, ext. 32648, shyu@uwaterloo.ca

Sponsors & Collaborators:



University of Waterloo Library Study of Civil & Environmental Engineering Researchers. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #22525)



Appendix C: Mass email recruitment text sent by a CEE faculty member

Subject: Invitation to participate in the University of Waterloo Library study on Civil and Environmental Engineering Research

Dear Colleagues:

The University of Waterloo Library is conducting a study to examine the research support needs of scholars in Civil and Environmental Engineering. Your perspective will be incredibly helpful and the Library will use the results to improve their services to researchers in areas such as discovering and accessing information, managing information, including research data, and providing support for meeting open access requirements for publication.

The local University of Waterloo study is part of a larger suite of parallel studies of Civil and Environmental Engineering scholars at other institutions of higher education in the U.S. and Canada, coordinated by [Ithaka S+R](#), a not-for-profit research and consulting service. Under the sponsorship of ASCE, participating institutions including the University of Toronto, Carnegie Mellon University, Georgia Tech, Virginia Tech, University of Colorado Boulder, and University of Illinois Urbana-Champaign will contribute to a landmark final report by Ithaka S+R. This publically available report will summarize the evolving needs of Civil and Environmental Engineering scholars and will include recommendations that libraries, universities and engineering societies can use to support the changing research practices of engineering scholars. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee.

Attached is an information letter with additional information about the study and list of questions that study participants will be asked. The Library researchers for this project are Siu Yu, our Civil and Environmental Engineering liaison librarian and Jennifer Haas, Head, Information Services & Resources at the Davis Centre Library. Siu will be responsible for recruiting participants and will be conducting interviews and de-identifying the research data. To avoid conflict of interest, neither Carl Haas, the current interim Chair, nor Jennifer will know who has and has not participated in the study and discussions around data collection will not occur with the Chair.

If you are interested in participating, please contact Siu Yu, Engineering & Entrepreneurship Librarian, University of Waterloo Library, extension 32648, shyu@uwaterloo.ca.

Thank you for your consideration and I encourage you to participate in this important study.

Sincerely,
[CEE Faculty, signature]

Appendix D: Research support services for the field of Civil and Environmental Engineering, Information Letter

Title of the research study: Research Support Services Study for the Field of Civil and Environmental Engineering

Researchers: Siu Hong Yu, Civil & Environmental Engineering Liaison Librarian and Jennifer Haas, Head of Information Services & Resources, Davis Centre Library

Reasons for the study: This research study seeks to examine the research practices of scholars in Civil and Environmental Engineering in order to improve Library services that support research.

What you will be asked to do: Your participation in the study involves a 60 minute audio-recorded interview about your research practices and support needs as a Civil and Environmental Engineering scholar. The interview will be audio recorded to ensure an accurate recording of your responses. With your permission, we also may take photographs to document your work space, however, you will not appear in the photographs. Your participation is completely voluntary. You are free to decline to answer questions you prefer not to answer. You are free to withdraw consent and discontinue participation in the interview at any time for any reason. De-identified interview data will be used to compile a report of local University of Waterloo responses.

The local University of Waterloo study is part of a larger suite of parallel studies of Civil and Environmental Engineering scholars at other institutions of higher education in the U.S. and Canada, coordinated by [Ithaka S+R](#), a not-for-profit research and consulting service. Under the sponsorship of ASCE, participating institutions including the University of Toronto, Carnegie Mellon University, Georgia Tech, Virginia Tech, University of Colorado Boulder, and University of Illinois Urbana-Champaign will share their de-identified data with Ithaka S+R and it will be synthesized into a final capstone report. The publically available final report will summarize the evolving needs of Civil and Environmental Engineering scholars and will include recommendations that libraries, universities and engineering societies can use to support the changing research practices of engineering scholars. Once all the data are collected and analyzed for this project, we plan on sharing this information with the research community through publications, seminars, conferences and presentations.

Benefits and Risks: There are no known risks associated with participating in this study. Benefits include improved or new Library research support services for Civil and Environmental Engineering in areas that may include information discovery and access, data management and support for meeting open access requirements for publication.

How your confidentiality will be maintained: If you choose to participate, your name will not be linked to your interview responses or work space photographs at any time. We do not include your name on any of the interview data and there is no link between the Consent Form and your responses.

Data Retention and Storage: Paper records, audio recordings and electronic data will be kept by Waterloo for at least 1 year after the completion of the report of local findings. Data

stored at Waterloo will be stored in locked cabinets and non-networked drives of computers in the Davis Centre Library. De-identified data will be shared with Ithaka S+R and will be retained for at least 1 year following the report of Waterloo's local findings. Participants will not be able to withdraw their data from the study after it has been de-identified.

Conflict of Interest: To avoid conflict of interest, neither Carl Haas, the current interim Chair of the Civil and Environmental Engineering Department, nor Jennifer Haas, Head of Information Services & Resources, Davis Centre Library, will know who has and has not participated in the study and discussions around data collection will not occur with the Chair.

About Ithaka S+R: [Ithaka S+R](#) "provides research... to help the academic communities... navigate economic, technological, and demographic change". The [Civil and Environmental Engineering study](#) is part of their Libraries & Scholarly Communication program. Disciplines studied as part of this program include Chemistry, History, Agriculture and Public Health (report in progress). The [Agriculture](#) report has just been released and includes recommendations for training students in information discovery as a way to support agricultural scholars and for supporting the dissemination of agricultural research to the broader public. The Civil and Environmental Engineering study marks the first time Canadian universities have participated in the Ithaka studies.

Questions?

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #22525). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions or if you would like additional information to assist you in reaching a decision about participation, please contact: Siu Yu, Engineering & Entrepreneurship Librarian, University of Waterloo Library, extension 32648, shyu@uwaterloo.ca or Jennifer Haas, Head, Davis Information Services & Resources, University of Waterloo Library, extension 37469, j2haas@uwaterloo.ca.

Appendix E: Individual email recruitment text sent by the CEE Librarian

Subject: Invitation to participate in the University of Waterloo Library study on Civil and Environmental Engineering Research

Dear [Dr. *Lastname*]:

The University of Waterloo Library is conducting a study to examine the research support needs of scholars in Civil and Environmental Engineering here at the University of Waterloo.

Your perspective as a researcher in the areas of [insert Civil & Environmental Engineering research interests included in their profile] will be incredibly helpful toward identifying and developing Library research support services for scholars in all areas of Civil and Environmental Engineering. *X* [number of volunteers already agreed to participate] faculty members in the Civil and Environmental Engineering Department have provided valuable insights to the study. To ensure that the data is reliable and representative, however, your participation is strongly encouraged.

The local University of Waterloo study is part of a larger suite of parallel studies of Civil and Environmental Engineering scholars at other institutions of higher education in the U.S. and Canada, coordinated by Ithaka S+R, a not-for-profit research and consulting service. De-identified data will be shared with Ithaka S+R. Under the sponsorship of ASCE, participating institutions including the University of Toronto, Carnegie Mellon University, Georgia Tech, Virginia Tech, University of Colorado Boulder, and University of Illinois Urbana-Champaign will contribute to a landmark final report by Ithaka S+R. This publically available report will summarize the evolving needs of Civil and Environmental Engineering scholars and will include recommendations that libraries, universities and engineering societies can use to support the changing research practices of engineering scholars. Once all the data are collected and analyzed for this project, we plan on sharing this information with the research community through publications, seminars, conferences and presentations. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee.

Participation in the study is voluntary. If you are interested in participating, please contact me directly by replying to this email. Thank you so much for your consideration. Your time and insights are greatly appreciated and will shape how we move forward supporting your research.

Sincerely,
Siu Yu, MSc, MLIS
Engineering & Entrepreneurship Librarian
University of Waterloo Library
519-888-4567, ext 32648
shyu@uwaterloo.ca



Appendix F: Individualized recruitment reminder email sent by the CEE Librarian

Subject: Invitation reminder to participate in the University of Waterloo Library study on Civil and Environmental Engineering Research

Dear [Dr. *Lastname*]:

This is a friendly call-to-participate reminder for a study that the University of Waterloo Library is conducting on your research support needs as a scholar in Civil and Environmental Engineering. Your perspective as a researcher in the areas of [insert Civil & Environmental Engineering research interests included in their profile] will be incredibly helpful toward identifying and developing Library research support services for scholars in all areas of Civil and Environmental Engineering.

This study is sponsored by ASCE. The information gathered at the University of Waterloo will be included in a landmark international report by Ithaka S+R, a not-for-profit research and consulting service, and will be essential for the University of Waterloo Library to better support your research needs. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee.

X [number of volunteers already agreed to participate] faculty members in the Civil and Environmental Engineering Department have provided valuable insights to the study. To ensure that the data is reliable and representative, however, your participation is strongly encouraged. To participate, please contact me directly by replying to this email.

Thank you so much for your consideration. Your time and insights are greatly appreciated and will shape how we move forward supporting your research.

Sincerely,
Siu Yu, MSc, MLIS
Engineering & Entrepreneurship Librarian
University of Waterloo Library
519-888-4567, ext 32648
shyu@uwaterloo.ca



Appendix G: Written Consent Form

CONSENT FORM

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about a study being conducted by Siu Yu and Jennifer Haas at the University of Waterloo Library. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that my interview will be audio recorded to ensure an accurate recording of my responses.

I am also aware that excerpts from the interview may be included in publications that come from this research, with the understanding that the quotations will be anonymous.

I was informed that I may withdraw my consent at any time without penalty by advising the researcher.

I am aware that once my data has been de-identified it cannot be withdrawn.

I am aware that the de-identified data is shared with Ithaka S+R.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#22525). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions contact Siu Yu, Engineering & Entrepreneurship Librarian, University of Waterloo Library, extension 32648, shyu@uwaterloo.ca or Jennifer Haas, Head, Davis Information Services & Resources, University of Waterloo Library, extension 37469, j2haas@uwaterloo.ca.

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

YES NO

I am aware that my interview will be audio recorded.

YES NO

I agree to the use of anonymous quotations in any publications that come of this research.

YES NO

I agree to have my work-space documented through photographs.

YES NO

I am aware that my interview data will be shared with Ithaka S+R once any and all identifying information has been removed from the interview responses.

YES NO

Participant Name: _____ (Please print)

Participant Signature: _____

Witness Name: _____ (Please print)

Witness Signature: _____

Date: _____

Appendix H: Semi-structured interview guide

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?

Appendix I: Library Research Support Services

Existing Library research support services include:

- Collection development and curation
- One-on-one research consultations with liaison librarians and specialists, covering:
 - Clarifying research questions
 - Developing information seeking strategies within and across disciplines
 - Literature searching advice for grant applications
 - Literature searching advice/support for meta analysis research
- Research Data Management support, including:
 - Developing data management plans
 - Advising on research data repositories
- Calculate your Academic Footprint (bibliometric measures)
- UWSpace (Institutional Repository), including the UWSpace copyright review and deposit service
- Open Access publishing support
- Copyright
- Workshops developed by the Library and in collaboration with campus partners on topics such as:
 - Copyright and your thesis
 - The Tri-Agency Open Access Policy - from author rights to depositing in UWSpace,
 - Predatory publishing
 - Commercializing your research
- Graduate orientation presentations