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Ithaka S&R Study: Examining the Research Support Needs of Civil and Environmental Engineering Faculty
University of Delaware Local Report

August 2018

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Introduction

Beginning in the Fall 2017, the University of Delaware joined 10 other institutions (see Appendix A) to participate in a study conducted by Ithaka S+R, a not-for-profit research and consulting service. The goal of the study was to provide an in-depth qualitative analysis of the research practices of academics in the field of Civil and Environmental Engineering. Each participating institution will complete a report on the research practices in their local environment and Ithaka will produce a final report that would detail the state of research in the discipline as a whole.

The information gathered is to be used to identify improvements to pre-existing research support services at the University of Delaware as well as to identify opportunities to develop new research support services for Civil and Environmental Engineering more widely.

This report outlines research methods, collaboration activities, data management practices, publishing and dissemination activities, and future challenges and opportunities. The information presented here relates solely to the data collected at the University of Delaware.

The Civil & Environmental Engineering Department

The College of Engineering at the University of Delaware (UD) maintains an excellent reputation, being ranked among the top 50 college of engineering departments in the nation by US News and World Report. The Department of Civil and Environmental Engineering (CEE) is consistently listed in the top 15 of the "100 best values in public education" by *Kiplinger's Personal Finance* magazine. The Department offers bachelor's degrees and minors in Civil and Environmental Engineering, Construction Engineering and Management, and a Master of Civil Engineering, Master of Applied Sciences, and Ph.D. degrees.

Civil and environmental engineering focuses on the built and natural environment, including the design and maintenance of infrastructure and buildings, and stewardship of natural resources. From the numerous sub-disciplines for research, the UD CEE department covers the following: Civil Infrastructure Systems, Coastal & Ocean, Environmental & Water, Geotechnical, Railroad & Transit, Structural, Construction, and Transportation. CEE scholars do research with practical applications in mind, looking to contribute solutions to sustainability goals related to climate change and adaptation, disaster resiliency, sustainable materials, bridge construction and maintenance, sustainable transportation and infrastructure systems, among others.

There are currently 32 faculty in the department. In 2017 there were 395 undergraduate students and 102 graduate students. All classes are taught by the core faculty or by qualified adjunct faculty who are active in the profession. The department generates over $7 million in general and research expenditures every year. Many of the faculty have won University, College of Engineering, or national teaching awards.

Methodology

The University of Delaware research team was comprised of three librarians: Erin Daix, Librarian and Director of Assessment; Sabine Lanteri, Senior Assistant Librarian and Science Liaison Librarian; and Tom Melvin, Librarian and liaison to the Department of Civil & Environmental Engineering.

The methodology and interview questions for this qualitative study were developed by Ithaka S&R and employ semi-structured interviews as the method of data collection. Training on interview methods and report writing was provided by Ithaka S&R during a two-day workshop for all the project leaders from each participating institution. Additionally, the study was reviewed by the University of Delaware Institutional Review Board and given Exempt status (Appendix B).

In October 2017, the Research Team met with the Department Chair to discuss the study. With support from the department chair, the Research Team also attended a department meeting to explain the study to the faculty and encourage their participation.

In December 2017, all 32 full-time faculty members from the Department of Civil and Environmental Engineering were invited by email (Appendix C) to participate in a 60-minute interview. During the interviews, a standard list of questions (Appendix D), was asked with an opportunity for additional or follow-up questions. Interviews were conducted in the offices of the participating faculty.

The interviews were recorded and then transcribed by a third party company, Transcript Divas. The research team coded the transcripts and identified the key responses and major themes, and the anonymized and redacted transcripts were supplied to Ithaka S&R for the national report.

Research Focus and Methods

Civil and environmental engineering is a broad and diverse discipline with a wide range of research interests including but not limited to structural, construction, transportation, and environmental engineering as well as coastal/shoreline research, water and wastewater issues and natural hazards. The faculty interviews touched on all aspects of the department's research activities except for geotechnical engineering.

> "THE WAY THAT I INTERPRET CIVIL AND ENVIRONMENTAL ENGINEERING, PARTICULARLY CIVIL, IS THAT IT'S PUBLIC WORK."

Civil infrastructure research involves the planning, design, construction, maintenance and operations of infrastructure supporting human activities. This research utilizes projections in population growth and creates computer models to predict the needs of the population, from pedestrians to air travel, as they relate to the civil infrastructure of a particular area from pedestrians to air travel.

This research also assists in the creation of computer models using real-time traffic and GIS data that can help police and emergency first responders by providing them with information on traffic patterns in the area of an emergency. These programs will help with the delivery of medical supplies during emergencies or road closures after accidents or natural hazard events.

Structural engineering deals with analyzing how a structure (e.g., bridges or buildings) operates by monitoring the structural health, structural mechanics, structural dynamics, computational structural analysis and structural engineering materials of these objects.

One aspect of bridge engineering involves investigating the condition of existing bridges by utilizing various monitoring methods. The data that is collected will be used to create computer models to predict the lifetime of the structure and determine when maintenance will be needed. The research also results in new construction techniques and material applications.

Research in building engineering and structural health monitoring operates in much the same way. Faculty and their research assistants monitor existing structures and the data gathered is used to create computer models that can predict future degradation of the structure. Another goal of the research is to identify new and better methods of design that also incorporate innovative and sustainable construction materials.

Transportation engineering employs data analysis techniques toward the improvement of infrastructure systems by utilizing advanced statistics, probabilistic metrics and machine learning techniques. The goals are greater efficiency and cost savings in the transportation process.

Construction engineering engages with many other disciplines such as computer science (artificial intelligence), operations research (mathematical tools), materials science (3D

printing), and mechanical engineering (for machines, robots) in an effort to improve construction techniques. Technologies such as building information modeling, virtual reality, and visualization are revolutionizing the industry by providing construction engineers with unprecedented insights into the building process. Projected research includes real time observation of construction sites with the goal of increasing the efficiency of the workforce.

Coastal and ocean engineering looks into the ongoing shoreline processes as well as construction within the coastal zone. Research focuses on sediment transport processes and turbulence mixing in the near shore and estuary environment as well as investigating the role of sand dunes in protecting beach communities. This work primarily develops and utilizes numerical models to assist in shoreline conservation efforts. Other researchers are investigating ocean-related hydrodynamics and the creation of propagation models for tsunamis crossing the ocean. Remote sensing methods are employed for gathering data and applying numerical modelling of these processes to obtain the final results. The ultimate goal of this research is to arrest or slow shoreline retreat by the creation of predictive models of the erosion process.

Hazard analysis is another aspect of coastal engineering being researched at the University. This can involve assessment of the initial hazard as well as using numerical models and tools such as computer programs for predicting the effects of a particular hazardous event on the environment and civil infrastructure.

The field of environmental engineering deals with environmental issues from the nanoscale to the global scale. Contamination caused by the activities and waste products of a modern society affect the water, air, soil, and ecosystems in complex ways that must be clearly understood in order to successfully address these problems.

Much of the research deals with models for toxicity of metals, pesticides, and other elements in bodies of water. The goal is to better protect bodies of water by monitoring the elements in the water.

Microbiologists are increasingly involved in civil and environmental research with work on waste water treatment or mitigating oil spills through biodegradation with microbes. The diversity of research topics for microbiologists has increased and is not necessarily limited to a water environment. Learning more about microbes present in the built environment, for example, can lead to development of an early warning system for damage due to such microbes. This type of research involves a great deal of work identifying DNA structures of microbes and working on methods to use this knowledge to reduce the damage caused by the microbes.

The majority of the CEE scholars interviewed build or work with models, computer programs or simulations to predict or describe the process under study. The type of research being performed often involves large data sets due to the scale of the phenomena being studied, the level of detail available, or both. Data analysis techniques can involve image analysis, statistical

interpretations or post-processing video recordings. Some CEE scholars generate their own data-sets, while others search for data sets from elsewhere. In some cases, additional information can be gleaned from such data sets.

Collaboration

Every faculty member that the team interviewed stressed the importance and necessity of collaborating with other people in order to perform their research. These collaborations take place with other researchers at the University of Delaware and with people at other institutions, the government and the private sector. The nature of the collaborations depends on the type of research that they are conducting.

> "LIFE IS MORE THAN MATH. THAT'S WHY WE NEED ALL THESE DIFFERENT PARTNERS, PARTNERS FROM THE UNIVERSITY, PARTNERS FROM THE GOVERNMENT, PRIVATE SECTOR, LIBRARY-HUGE, I MEAN A HUGE PART OF OUR WORK."

The collaborative relationship can be between partners working jointly on a research project, work that is outsourced to someone with the necessary subject expertise, to a supplier of information, services, or data, or clients or recipients of the research output.

For example, government agencies were often cited as supplying data sets as well as being funding or grant sources. Collaboration can also have both supplier and client components, such as when a state agency contracts to conduct a study and supplies the data as well. Another example is a private company that might agree to have its construction site be used as a research platform, and can then benefit from the recommendations in workflow efficiency and process improvements.

Collaboration within the University of Delaware

A common theme from all of the faculty was the importance of student assistance while conducting their research. These students include undergraduate, graduate, and PhD candidates. Quite often these are the people who perform the majority of the lab and field work that constitutes the bulk of the research operation. It is not an overstatement to say that most research would not be possible without the assistance provided by these students.

Within the University of Delaware itself, collaboration often involves faculty from other departments and research units. Estimating the future traffic needs of communities involves consulting with social science researchers in order to obtain demographic and behavioral information. Economists and social policy researchers can also assist civil engineers by supplying data on future costs and policy changes that can affect transportation issues. Colleagues in the math department assist in the creation of statistical models used to predict future traffic flows and IT Services is frequently used in the creation of computer modelling. Electrical engineers can help with the development and deployment of sensors used to track various actions such as traffic flow and pedestrian activity.

Mechanical Engineering and Materials Science are two departments that were frequently noted as important collaborators with structural and construction engineering researchers. Intersecting interests for these departments include the use of robotics and composite materials in the construction process.

The College of Marine Science and Policy was often mentioned as an important partner in research dealing with water quality as well as shoreline and coastal engineering. Oceanographers in particular were referenced as important collaborators in this area. Chemical engineering plays an important role in assisting with research in water quality and pollution matters. This work can also include biochemists and biologists working in the Center for Bioinformatics and Computational Biology as well as the Delaware Biotechnology Institute. The Disaster Research Center was mentioned in the context of research on the effects of earthquakes and tsunamis on beach erosion and population movement after a disaster.

Collaboration outside the University of Delaware

Collaboration outside of the University takes on myriad forms. Transportation researchers do a great deal of work with state agencies such as the Delaware Department of Transportation (DELDOT), the Delaware River Port Authority (DRPA) and the Delaware River and Bay Authority (DRBA). UD researchers often receive data from these agencies, as well as from other states such as New Jersey and New York to assist them in their research on traffic patterns and related issues.

Collaboration with federal agencies such as the Federal Highway Administration and the Army Corps of Engineers is also very common. The T^2/LTAP Program, located within the Delaware Center for Transportation, is a collaboration among state universities, state departments of transportation, and the Federal Highway Administration. It is one of 58 centers throughout the United States that promotes training, technology transfer, and research project implementation at state and local transportation agencies.

The Environmental Protection Agency, Army Corps of Engineers, National Weather Service, and the National Tsunami Hazard Mitigation Program were all mentioned as important collaborators on the national level when performing research in environmental areas. These agencies might provide data necessary for the research or supply information on research that they have already completed that will assist a particular new research effort.

Collaboration through professional organizations such as the American Society of Civil Engineers (ASCE) was another topic that was discussed by many. Attendance at professional conferences is a common method for networking and keeping up with the work of other researchers. Other organizations that came up include the American Association of State Highway and Transportation Officials (AASHTO) and the Transportation Research Board Asset Management Committee.

Construction engineering researchers collaborate with private companies in the industry in order to find better methods for building construction. By observing the day-to-day operations that occur at an actual construction site, the researchers work to find ways to improve the efficiency of the construction operation and cut both time and costs.

Collaboration Issues

Collaboration is not without its problems. Writing up the final results was a common theme with problems often arising due to the difficulties of sharing drafts and agreeing on which platform to utilize.

> "THE MORE PEOPLE YOU WORK WITH, THE MORE CHALLENGES THERE ARE."

File sharing and data storage are also major issues that were frequently cited when collaborating with others. Agreeing on formats and platforms can be time consuming as well as frustrating. Collaborators, especially ones at other institutions, often will not have access to the same data and might be collecting data on a particular topic from different sources, having a negative effect on project management. Purchasing data from an outside vendor sometimes raises questions about the quality of the data used, how it is collected, and discrepancies in sample size.

Experience was mentioned as the greatest asset in the area of collaboration. Maneuvering through academic politics, dealing with government agencies and private consulting firms, submitting grant proposals and other aspects of the collaborative process all became easier as one gained experience in the field.

Uses of Data

Research in civil and environmental engineering utilizes many types and formats of data. The data, arising from original research or obtained from outside sources, are often used to create final research outputs such as numerical models and computer code which are used to predict the future behavior of the object of the research, be it transportation infrastructure, structures, or environmental issues.

Data Types

Transportation engineering researchers utilize traffic pattern data (often obtained from an outside source such as the state government or private industry) to create computer models to assist with analyzing current and future infrastructure needs. The raw data is typically gathered using a number of remote sensing techniques such as GPS signals, cell phone tower tracking devices, and Bluetooth® signal monitors that have been placed throughout the state.

Monitoring the movements of vehicles via these various systems allows the researchers to map the flow of traffic over time and helps identify problem areas both geographically as well as by time of day. Video data are also incorporated by placing cameras at key locations and monitoring traffic activity throughout the day. Students working with the researchers may also take on-site observations at selected locations as part of the research process.

Other research investigates railways and their operations, obtaining rail track data from AMTRAK and other sources, to create computer models to help improve railway operations as well as monitoring system infrastructure.

Structural engineering utilizes data gathered on various types of structures to assess both the current condition of the structure as well as future maintenance requirements. Research in this area is also concerned with finding new and better ways of designing and building these structures.

Bridge engineering data is gathered using remote sensing devices that monitor the bridge for stress and other indicators that can contribute to fatigue and wear. This data is recorded on computers and then processed using programs like MATLAB to develop models that can be run using a variety of input factors in order to understand how the bridge will operate under various loads or how it will react to extreme events such as earthquakes.

Buildings are monitored using similar methods. Sensing devices are used to obtain data on how the structure is performing and this data can then be used to construct models that will help in the design of stronger buildings and the components (girders, etc.) used in their construction.

Numerical and computer models are often the final product in coastal and shoreline research as well. Data are gathered from a combination of sources including laboratory experiments, field

work, and outside vendors. Some of this research focuses on studying sediment transport processes and turbulence mixing in the near shore environment. The final output of this research takes the form of computer models that can be used by people working on the state or county level to solve local environmental issues (shoreline erosion, water pollution) as well as disaster planning and hazard mitigation.

Microbiologists involved in civil and environmental engineering have unique data needs and requirements, often working with genetic sequencing and using this data to investigate how particular organisms are affecting construction materials. Much of the data used for this type of research is obtained from outside resources and national repositories such as the National Gene Vector Biorepository (NGVB) or the National Center for Biotechnology Information (NCBI). They also perform original research in order to obtain DNA data on specific organisms that are present in particular materials used in engineering. Collecting this data can be a time-consuming, long-term process that involves a great deal of analysis. The end products of this research are bioinformatics in the form of DNA sequences that are then made available to other researchers through national repositories.

Data Management

The lack of formalized data management strategies was a common theme among almost all of the researchers that we interviewed. Most researchers have developed their own practices over time and these vary depending on the type of data being stored and the need to make it available to other people.

Short term storage needs were dealt with in a number of ways. If there was a large amount of data involved, many of the researchers made use of the UD servers available through the University Information Technology (IT) unit. This was a popular option for the faculty due to the convenience and the availability of automatic backup capabilities but does make it difficult to share the data with others outside the University of Delaware environment. Less important data and data that didn't require as much storage space were often kept on hard drives maintained by the faculty or their staff. This popular option offers many advantages including ease of use as well as the ability to easily share the data with colleagues at other institutions. However, drawbacks include keeping track of the hard drives and ensuring that someone is responsible for making sure that the data is backed up on a regular basis. Reliability issues and breakage were also brought up as areas of concern with these devices.

Cloud services are also used as storage options, Google Drive being used most often, but others such as Dropbox were also mentioned. These services provide the ability to easily share the data with other researchers but also come with concerns about security and cost.

Long term storage follows many of the same conventions, although quite a few of the researchers admitted that they did not put a great deal of thought into this area. Subject specific repositories were discussed for some of the areas being studied, environmental data

being an area that appeared to have a lot of options provided by both the federal government and other research institutions. GitHub was cited by many interviewees as a good repository for maintaining numerical models and computer code. But other researchers were not aware of any repositories that are available for the specific research that they are conducting and many expressed the desire for this option in the future.

A few researchers are still using outdated techniques for their long term storage. CD-ROMs, paper files, floppy discs and flash drives were all mentioned at one point as storage devices that are still being used to hold data.

Data Challenges

The sheer amount of data that has to be managed is one of the biggest challenges faced by researchers. Modern data gathering techniques have become so sophisticated that the size of the data sets themselves can be problematic. Additionally, most raw data must be processed in order to be applied to a specific research problem. More data also means more "cleaning up" of that data. Another problem is inadequate, inconsistent or nonexistent metadata for their particular area of study.

Storage, both long and short term, becomes an issue when so much data is being produced. Having to share data with colleagues at other institutions can be a challenge when terabytes of data are involved, especially if a researcher needs to run that data through an off-site computer model. Additionally, many researchers talked about the lack of available storage space for older data that they would like to retain but often lack the capability to do so. It is not uncommon to waste a good deal of time and money recreating data that was probably already produced but never saved and no longer available.

Both the government and the private sector are often hesitant to share data that a researcher needs. This can be due to a fear that the data might be manipulated in ways that would put the government in a bad light (accident data was specifically mentioned in this regard), or a private company might have concerns of revealing too much about its corporate methods and practices. A specific concern in this area was the collection (or lack thereof) of data by federal agencies as well as the problem of data disappearing over time.

It was obvious from these interviews that the lack of any formalized data management practice is an issue that will have to be addressed at some point in the future. This was especially evident when discussing long term data storage, where it was frequently mentioned that researchers were not aware of available options or precisely what their responsibility was in this area. As data management becomes more entwined with research funding it will be important to have the educational resources in place to disseminate this information to researchers on campus.

Information Research and Publishing Practices

Researchers in civil and environmental engineering share many practices when obtaining materials for their projects as well as in their personal publishing practices. Most of the differences in both research methods and publishing habits are due to the specific area of research of the faculty member. However, even when accounting for these differences, many similarities emerged in this area.

Information Research and Management

Searching for relevant publications is an important part of the research process, especially at the beginning of a project. Peer-reviewed journal articles were mentioned most frequently as the primary source for this research, but many other resources are also consulted at this stage. Conference proceedings and presentations, research reports, society publications, news articles and government documents are all important sources of information. Which of these publications has the most relevance is dependent on the area of research involved. Textbooks are the one resource that most interviewees said are not helpful due to the time lag involved in publication.

Google Scholar was mentioned by almost every participant as a main resource for locating prior research in their area of study. Its ease of use as well as having the ability to retrieve the full text of the article via the UD Get It! feature makes Google Scholar an easy choice for most researchers. The fact that it is not subject specific is not a concern for most faculty as they are usually searching for articles on specialized topics and Google Scholar's search algorithms are sophisticated enough to filter in exactly what they need.

Other resources given as useful for retrieving peer-reviewed literature were the Web of Science, Scopus, PubMed and GeoRef. The list also includes specific association databases such as IEEE/Xplore, the ASCE Library, and the Transportation Research Information Services (TRIS). Many faculty simply browse the table of contents of journals in their field, specifically those which they have come to rely on over the course of their careers.

Conferences and meetings are often sources of information regarding new research from colleagues at other institutions. Attendees will often share information about their current research as well as offering a heads-up on upcoming publications.

> "I've always lived and died by my Xerox collection."

Keeping track of the information retrieved through these methods presents a major challenge to researchers. Many still rely on tried and true methods of storage that they have employed for many years. Photocopies of articles are still filed away in cabinets, arranged by author, title or subject matter. Additionally, many

faculty still prefer to read from a paper copy so that even if an online version of an article is available they will print it out for convenience.

Some faculty do use an online bibliographic management system such as EndNote or Mendeley to store their articles, although this option was not being used as much as might be expected.

Other formats for storage include CD-ROMs, DVDs, and hard drives. Many researchers rely on their student assistants to manage both the retrieval and storage of this material. However, the inevitable problems associated with retaining older research materials usually demand that at some point these items will be discarded in order to make room for newer material.

Publishing Practices

Peer-reviewed journals are by far the most preferred method of publication. Academics still want their research published in highly cited journals with a good reputation within their discipline. A few researchers mentioned that their work was more appropriate for publication in conference proceedings due to the practical nature of the research, but this was the exception to the norm.

A common theme from almost all of the participants is a concern regarding the number of journals that are now available for peer-reviewed publishing. A contributing factor to this phenomenon may be the increasing number of early-career faculty who must find outlets in which to publish the results of their research. These non-tenured faculty are frequently competing for space in highly regarded journals with more experienced tenured faculty, forcing the less experienced researchers to publish in one of the newer titles that does not have the prestige associated with the older, more established journals.

The peer review process itself was considered by many of the researchers to be problematic and outdated. The time involved in going through the process is often a cause for frustration and can delay the timely release of research results. Concern was also expressed about having the right people reviewing the submissions, especially when the research topic involved a combination of subjects from various fields. This can result in the researcher selecting a more subject-focused society journal for their publication. As one researcher put it, *"I really feel like society journals make more of an effort to get the right people to review it."*

Very few of the researchers interviewed had published under an open access (OA) model. Late career faculty often do not see the need to publish this way, and early career faculty are eager to publish in prestigious journals that might not offer an OA option. The high cost of OA publishing was also cited as a barrier as well as concerns about the quality of the OA publications and how much exposure the work would get when published in an OA title. A few interviewees have placed some of their work on UDSpace (the institutional repository at University of Delaware), but this OA option is not being used on a regular basis.

The problems that most researchers brought up in relation to the publishing process centered on editing and formatting submissions. The advent of online submissions has only increased the time associated with this process as each journal requires adherence to its own unique format. And as mentioned above, the peer review process itself is seen by many researchers as a hurdle to overcome when publishing the results of their work.

Very few researchers interviewed used social media to promote awareness of their work. One person mentioned using Twitter to announce when their papers were published but made a point of saying that their use of the platform was minimal. YouTube was cited by a few people as a platform that presented possibilities for showing the results of their computer models, but none had actually used it yet for that purpose. Only one interviewee talked about using multiple social media platforms (Facebook, Twitter, and Instagram) and was surprised at the positive response they received.

Recommendations

The Morris Library is valued by faculty as an important resource that is constantly used for its reference services, access to up-to-date academic publications and specialized services such as the GIS digital mapping system. In order to continue to serve and improve our ability to meet the needs of the UD research community we offer the following recommendations.

Data management practices

As revealed through these interviews, "big data" is prevalent especially with the rise of more sophisticated tools and techniques for measurements and computations. The data management practices described by the researchers did vary and usually reflected the needs of the specific sub-discipline involved. Although each researcher developed techniques to keep track of their archived data, there are no consistent practices among the researchers. Many researchers use funding sources that do not require a detailed data management plan (DMP), but it is not unreasonable to assume that may change in the future.

Data sets generated today may be analyzed tomorrow in unforeseen ways. Creating a DMP, therefore, especially at the start of a research, can save time, money and frustration for future researchers. One of the stated goals of the recently launched Data Science Institute at UD is to foster interdisciplinary research collaboration across the campus. Such collaborations would be facilitated by having a robust DMP covering metadata, storage and archiving.

The Library could take the following actions: continue to offer workshops to educate on best practices in data management; partner with the Data Science Institute to contribute to their inventory of available data resources and computational tools; create a research data service for consultation on data management practices.

Raise awareness of open access services

Open access (OA) publishing is another area that is not being utilized by many researchers at this time. Most researchers appear to be aware of open access as a concept but have not taken the extra step of actually using the OA model to disseminate their research. The cost associated with OA publishing was the most frequently mentioned reason for not using this option, but there are also concerns about the quality of the publications themselves and the ability to expose their work to the intended audience. The Library should continue its efforts to increase awareness of open access options to the faculty. Additionally, the University may need to examine the possibility of assisting faculty with the publishing costs with these models.

Research impact through social media

These interviews clearly revealed that social media platforms are hardly being used at all. Although a few faculty occasionally use social media to promote their research, most do not seem to be aware of the potential benefits.

As research gets published more frequently in electronic format, tracking online articles is not limited to only the number of views, shares or downloads. Additionally, other media types produced for or during the research process, such as data, tools, software, websites, videos, etc., may be just as important as the articles that accompany them.

Thus, traditional citation-based metrics become inadequate to measure the true impact of a scholar's work and alternative indicators (altmetrics) are necessary. For an online item, altmetrics can answer questions such as:

- How many times was it downloaded or shared (on Facebook, Twitter, etc.)?
- Are other researchers commenting on it?
- Which countries are looking at my research?
- Was it covered by news agencies?

The Library could offer workshops on altmetrics and other measures of social media use in order to increase awareness of these tools and their importance in measuring the influence of a researcher's output.

Citation management tools for organizing published information

Just about all the faculty have a combination of paper and electronic copies of the articles they read and save as part of their research. What is surprising is just how few are utilizing any of the available citation management tools as a way to organize their files. RefWorks, the tool currently supported by the Library, did not come up in the interviews at all, and while EndNote and Mendeley were both mentioned, neither is widely used. The Library could expand its workshops beyond RefWorks to cover other citation management tools and explore ways to assist researchers on how to use these tools with their preferred platforms, e.g., Google Scholar.

Current awareness strategies

Another recurrent theme was the scattered nature of the process by which researchers gather publications relevant to their interests. Compounding this issue is the exploding number of peer-reviewed journals appearing in each discipline every year. Most researchers have developed a system that fits their individual needs, but these methods appear to be narrow in focus and risk overlooking literature that might be relevant to their research interests. The Library can promote different strategies for keeping current with the literature, from setting up saved search alerts, to using apps such as Browzine for custom creating a list of journals to

browse through on a single interface. Employing a variety of techniques would allow researchers to cover a broad range of subject areas to reflect the interdisciplinary nature of the field.

Increased engagement with graduate students

An important finding from the interviews is the prominent role played by graduate and post-doctorate students in faculty research. These students often conduct the majority of early research for a project: performing literature searches, managing the data collected and used throughout the project, conducting experiments, entering data into spreadsheets, and other tasks vital to the success of the project. The Library could explore ways to reach out to these students that would supplement the graduate student orientation they receive as part of their onboarding experience. Although challenging, identifying graduate students that are actively assisting with research projects could be accomplished by contacting the faculty about their research projects before a new semester begins.

More collaboration among UD colleagues

Many researchers collaborate with faculty at other institutions without realizing that someone on their own campus might be involved in similar research. Often, these outside collaborations come about through informal contacts at conferences or through suggestions provided by colleagues in their discipline, thus circumventing the need to investigate possible collaborations on their own campus. The Library can explore additional partnerships aimed at increasing awareness of ongoing research at the University and assist in the effort to promote collaborations between colleagues on campus.

Final Thoughts

The participants interviewed for this study provided invaluable insights into the research processes and associated challenges they face when conducting their research. The portrait of both the department faculty as well as their research practices was detailed, informative and substantial. It is the hope of the library team to use the information gathered through this study to improve the support services that the Library provides to the Civil and Environmental Engineering Department. By coordinating the conclusions of this report with data accumulated in the UD Faculty and Graduate Student Survey (conducted by UD Library, Museums & Press alongside Ithaka S&R), we will obtain the knowledge required to best serve the research needs of our faculty. We would like to express our sincere appreciation and gratitude to all of the faculty members who participated in this study and especially to the Chair of the Department of Civil and Environmental Engineering for the support offered for this project.

Appendix A. List of 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 B. IRB Exempt Letter

UNIVERSITY OF DELAWARE
RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE: October 9, 2017

TO: Erin Daix
FROM: University of Delaware IRB

STUDY TITLE: [1133934-1] Research Support Services for the Field of Civil and Environmental Engineering

SUBMISSION TYPE: New Project

ACTION: DETERMINATION OF EXEMPT STATUS
DECISION DATE: October 9, 2017

REVIEW CATEGORY: Exemption category # *(2)*

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.

Appendix C. Correspondence.

Subject: Ithaka letter

To the Faculty of the Department of Civil and Environmental Engineering

The Morris Library is participating in a survey being conducted by Ithaka S&R, an organization that produces reports on the research needs of academic disciplines. Their current project is concentrated on Civil and Environmental Engineering and we are one of eleven participating institutions. We are contacting you in the hope that you will agree to assist us in this effort.

We are hoping to interview fifteen faculty members in your department that are currently in the process of conducting research. The interviews will be recorded and then transcribed, after which the recordings will be deleted. No personal information will be included in the interviews and all of the librarians involved have passed IRB training. After the interviews are completed we will produce a report on our local findings which will be submitted to Ithaka S&R and used to produce their final report on the research needs of the discipline. This final report will be made publicly available by Ithaka S&R.

We will be attending the December 8th faculty meeting to answer any questions that you might have about the project. Further information about Ithaka S&R and the project can be found on a research guide that we have created located at:

http://guides.lib.udel.edu/Ithaka

Please do not hesitate to contact me if you have any questions. If you know that you would like to participate we encourage you to schedule a time for an interview as soon as possible.

Tom Melvin Sanine Lanteri Erin Daix

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Appendix D. Characteristics of Study Participants

Of the 32 full-time faculty in the department, ten agreed to participate, representing almost one-third of the population. When divided by position this represented a little more than a third of the professors, and roughly one-fifth each of the associate and assistant professors represented (figure 1). Of these ten participants, six come from the civil engineering side of the department, and four from environmental engineering. Figure 2 shows the research interests of the participants, but does not reflect all the areas of research within the department.

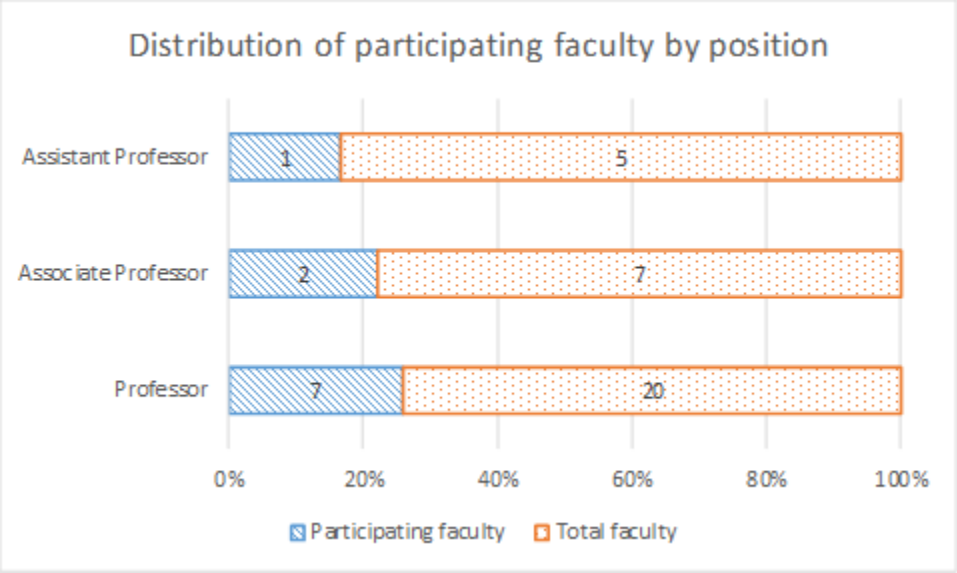

Figure 1 - Number of participating faculty by position

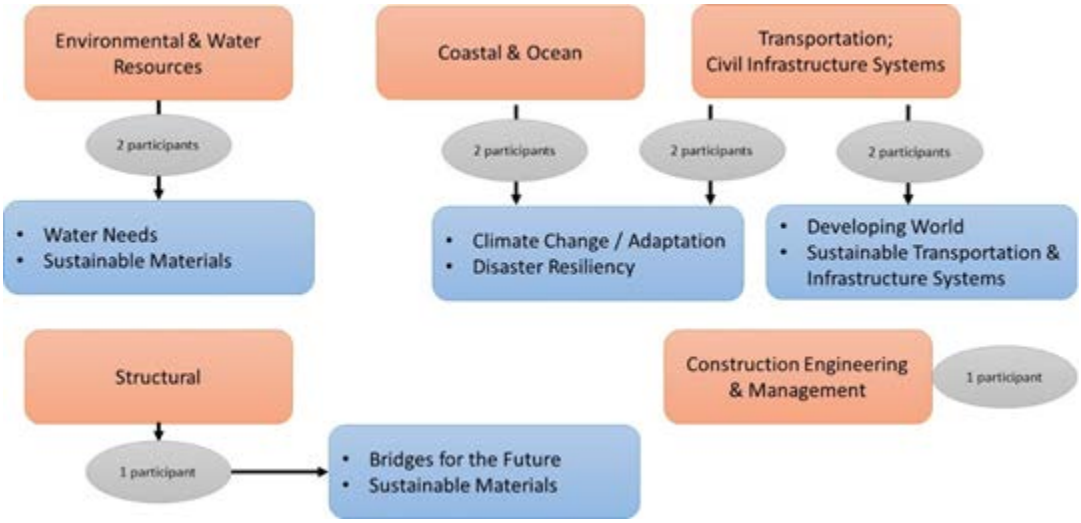

Figure 2 - Civil & Environmental Engineering - Research areas of participants

(Does not represent all research areas in the department)

Appendix E. Semi-Structured Interview Guide

Research Focus and Methods.

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

Working with Others (Collaboration)

1. Do you regularly work with, consult or collaborate with any others as part of your research process?
2. If yes, with whom have you worked and how?
3. Lab or on-campus research group
4. Other people: faculty here at UD or other universities; student assistants; independent researchers/engineers
5. Research support professionals: librarians, technologists, [programmers]
6. Other individuals or communities beyond the university [professional society, government department]
7. Other not captured here
8. Have you encountered any challenges in the process of working with others? [focus on the information-related challenges, e.g., finding information, data management, process of writing up results]
9. Are there any resources, services or other supports that would help you more effectively develop and maintain these relationships?

Working with Data

1. Does your research typically produce data? If so,
2. 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.]
3. How do you analyze the data? [e.g., using a pre-existing software package, designing own software, create models]
4. How do you manage and store data for your current use?
5. Do you use any other tools to record your research data [e.g., electronic lab notebooks]? If so, describe.
6. 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]
7. Have you encountered any challenges in the process of working with the data your research produces? If so, describe.
8. Are there any resources, services or other supports that would help you more effectively work with the data your research produces?
9. Does your research involve working with data produced by others? If so,
10. What kinds of data produced by others do you typically work with?
11. How do you find the data?

12. How do you incorporate the data into your final research outputs? [e.g., included in the appendices, visually expressed as a table or figure]
13. How do you manage and store this data for your current use?
14. What are your plans for managing the data beyond your current use?
15. Have you encountered any challenges working with this kind of information?
16. 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

1. What kinds of published information do you rely on to do your research? [e.g., pre-prints, peer-reviewed articles, textbooks]
2. 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.]
3. How do you manage and store this information for your ongoing use?
4. What are your plans for managing this information in the long-term?
5. Have you experienced any challenges working with this kind of information?
6. Are there any resources, services or other supports that would help you more effectively work with this kind of information?

Publishing Practices

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

State of the Field and Wrapping Up.

1. How do you connect with your colleagues and/or keep up with trends in your field more broadly? [e.g., conferences, social networking]
2. What future challenges and opportunities do you see for the broader field?
3. 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?