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STEM Faculty Perceptions of Library Research Support and Bibliometric Services: A Qualitative Study

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Abstract

Academic librarians strive to provide quality support for faculty researchers. Existing content analysis of top-ranking university libraries' websites revealed the main types of research services provided by academic librarians. But what specific services do STEM faculty consider essential for their research needs? What are the most effective communication methods to convey research service information to STEM faculty? How do STEM faculty follow cutting-edge developments in their fields? Do STEM faculty value information provided by bibliometric tools? This study attempts to answer the above questions through interviews with 30 STEM faculty at a medium-sized R1 university. Patterns in each discipline and across all interviews were analyzed through reflexive thematic analysis to capture both semantic/surface and latent/implicit meanings of participants' comments. Findings demonstrate that their data management needs go beyond a plan template, and they do not prioritize open access publishing. Along with their communication preference, current awareness of tool preferences and perceptions of bibliometric tools, and research impact evaluation are shared.

Keywords: STEM faculty, Interviews, Library research support, Bibliometric services, Research impact evaluation, RDM (research data management) plan, Open Access (OA) publishing, Transformative agreements, Information seeking behaviors, Reflexive thematic analysis

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Introduction

Academic libraries demonstrate value through research support in addition to other endeavors. Librarians actively participate in research impact evaluation and institutional ranking when universities are competing for talent and limited funding opportunities. Library professionals have surveyed top universities' library websites to better understand the types of research services being provided (Si et al., 2019). These studies provide valuable overviews of research support and can help academic libraries enhance their own services. However, it would also be valuable to identify what types of research services faculty consider as essential or very important so that librarians can work more effectively on services faculty value most.

The culture of evaluation in higher education has prompted academic libraries to offer research impact measurement and bibliometric mapping/data visualization services. Tools used in research impact measurement typically include journal ranking, citation counts, the *h*-index and altmetrics. Software widely used in data visualization and knowledge mapping include VOSViewer, CiteSpace, HistCite, SciMAT, and Sci2 (Chen, 2017). Networks produced by the above tools consist of collaboration networks (author and institution), keyword co-occurrence, active research areas, document co-citation, author co-citation, and bibliometric coupling (Chen, 2017). Like research support, perceptions from faculty on bibliometric tools will inform library professionals about whether faculty are interested in these tools and if they are, what features are most desired.

To fill the above knowledge gap, through interviews with STEM faculty, the following research questions (RQs) will be answered:

RQ1: What research supports are considered essential or very important by STEM faculty?

RQ2: What are the most effective communication methods to convey research service information to STEM faculty?

RQ3: How do STEM faculty follow cutting-edge developments in their fields with library resources?

RQ4: Do STEM faculty consider bibliometric tools beneficial to their research?

RQ5: Are there cross-disciplinary common themes or disciplinary specific needs?

Answers to these questions through this qualitative research can help science and engineering librarians implement research support more effectively and select the most important services to focus on.

Literature Review

This literature review first outlines major types of research support revealed through website content analysis, updates in the two most common research support areas (open access and research data management), and recent developments in bibliometric services/research impact evaluation. This section concludes with studies librarians have carried out to explore researchers' uses of and needs for library collections and services.

Types of Research Support Services

Library research support is integrated into various stages of the research life cycle: planning, data management, publishing, archiving, and discovery (University of Central Florida Libraries, n.d.). A study surveyed library websites of the top ten universities from the ARWU (Academic Ranking of World Universities) of the University of Shanghai and the Times Higher Education World University Rankings (Fernández-Marcial et al., 2016). Their study identified open access (OA) and research data management (RDM) as the most developed support areas. Another survey of library websites of the top 100 universities on the QS World University Rankings also revealed OA (84%, 64 out of 76) and RDM (82%, 62 out of 76) as the services provided by the largest number of institutions (Si et al., 2019).

Open Access (OA)

Academic libraries are actively involved in educating researchers on types of OA, avoiding predatory OA journals, and fulfilling the public access policy requirements of funding agencies. Disciplines have adopted OA publishing models at different rates, with agriculture and biological science at the top (27% of journals in Scopus), followed by computer science (16%), mathematics (14%), physics and astronomy (14%), chemistry (14%), and engineering (13%) (Björk & Korkeamäki, 2020). Article processing charges (APCs) are charged for some gold and hybrid OA journals. A survey of authors revealed that 31% of them used grant money and 10% used their institutional funding in developed countries to pay for APCs (Solomon & Björk, 2012). To reduce APC expenses for their researchers, many universities or library consortia have reached transformative agreements with major publishers and case studies have been published on their success or failure in various institutions (Dodd, 2024; Rawlins, 2024). On the other hand, a survey of librarians identified top barriers to promoting OA publishing: lack of OA funding, lack of support from administration, and education of researchers on OA knowledge (Hadad & Aharony, 2024).

Research Data Management (RDM)

RDM has been defined as "the design and creation of data, storage, security, preservation, retrieval, sharing, and reuse" (Cox & Pinfield, 2014, p. 300). A study surveyed 185 university library's websites in the U.S and categorized data services into three types: active services through direct interactions with patrons, providing information in the form of web-based content, and educational services through trainings (Yoon & Schultz, 2017). This study also identified data deposit as the top service and data management planning as the second most offered data service. Another qualitative study used individual interviews and focus groups with academic librarians in 2012 and 2013 and identified five factors influencing what RDM services were offered: technology availability, librarian expertise, researchers' adoption of the program, leadership support, and collaboration with other campus units (Faniel &

Connaway, 2018). A survey of 240 librarians revealed that data science and outreach skills were their most desired trainings as they sought to develop their RDM expertise (Tang & Hu, 2019). Despite challenges in offering RDM services, academic libraries are playing a key role in data management programs due to their advocacy for open science and its integration with other library services.

Bibliometric Services/Research Impact Evaluation

As pointed out by Gumpenberger et al. (2012, p. 175), academic librarians are a "perfect fit" for bibliometric services since they are experts of bibliographic databases and have plenty of experience with data analysis. A website analysis of 62 Association of American University members revealed that 61 of them provided webpages or LibGuides on research impact and metrics. These metrics included journal ranking metrics (e.g., the Journal Citation Report and Impact Factors), author-level metrics (e.g., the *h*-index), altmetrics, and author identification tools (ORCID and ResearcherID) (Suiter & Moulaison, 2015). Another study surveyed librarians of major Canadian research universities on their new and emerging librarian roles. This study identified top areas in the bibliometric services: bibliometric training, citation reports, altmetrics, research impact, and the *h*-index (Ducas et al., 2020). A case study reported the experience of developing a research impact service at the University of Houston to increase the university's research output (Malone, 2023). Based on their experience, they concluded that without a research information management system, it is very time consuming to run research impact reports for each individual researcher, and the service was not sustainable. On the other hand, medical libraries are providing more bibliometric services beyond traditional citation reports and journal ranking, such as reports on the impact of a publication, a grant, a department or an organization, publication visualization, or research trend analysis of an area (Gutzman et al., 2018). The experience of providing research impact services by medical libraries also revealed that marketing and expertise with specialized databases and tools are required (Gutzman et al., 2018).

Exploration of Information-Seeking Behavior in Specific Institutions and Various Disciplines

Librarians have been performing quantitative and qualitative studies to explore researchers' information seeking behavior in general or in various disciplines. Nickels and Davis (2020) interviewed 22 researchers at different career stages of diverse disciplines in 2018 and 2019 at North Carolina State University. They investigated challenges these researchers faced, their library outreach preference, information sources they used, how they located this information, and library research support they used. They made recommendations on strengthening library research support and outreach strategies. Another recent study was carried out at Missouri State University through a survey, direct observation, and 24 semi-structured interviews with faculty (Miller et al., 2023a; 2023b). They studied library collections, space, and services faculty used and identified nine themes in library services with the top three being information search and full-text retrieval, citation management, and research support. At the discipline level, there have been recent studies on the information-seeking habits of mathematicians (Gordon et al., 2020), computer scientists (Athukorala et al., 2013; Tucci, 2011), engineering faculty (Engel et al., 2011; Tucci, 2011; Zhang, 2015), physicists (Gordon et al., 2022) and chemists (Gordon et al., 2018). Findings from the current study will be compared with discoveries in the above related disciplines in the "analysis and discussion" section. Through semi-structured interviews of STEM faculty and reflexive thematic analysis (TA), this current study will further librarians' understanding in the following areas:

- What research services are valued most by faculty and what are efficient outreach communication channels?
- How do STEM faculty keep track of cutting-edge developments in their areas?
- Are STEM faculty interested in bibliometric or research impact evaluation services?
- Are there common patterns revealed across disciplines or distinctive patterns for individual fields?

Methods

The study was approved as exempt from annual review (level I) by the Institutional Review Board (IRB) of Kent State University (No. 1173).

Data Collection

I used a sampling method known as snowballing and initially invited faculty with whom I regularly collaborate to participate in a semi-structured interview. "Snowballing" or chain sampling is one type of purposeful sampling approach (Patton, 2014, p. 451). This sampling method was selected because it helped "locate information-rich key informants" (Patton, 2014, p. 451). A semi-structured interview is the most common type used in qualitative research, during which participants can raise their own questions in addition to answering the researcher's questions (Braun & Clarke, 2013, p. 78). I initially began the interview invitations with faculty that I collaborated with more often, such as the departmental library representatives. Then I asked faculty and graduate students to recommend other faculty who might be willing to participate in the study and who are very active in doing research.

The guiding interview questions were as follows:

- What types of research support services are important to you?
- What are effective ways for the library to promote research support services?
- How do you identify research fronts and pivotal publications in your research field?
- If the library provides research impact services, such as identifying research fronts and active areas/research trend analysis, would you be interested in such a service?

For the final interview question, which focused on bibliometric/research impact evaluation, I summarized types of networks in bibliometric analysis: author/institution collaboration analysis, keyword co-occurrence analysis for research fronts, and co-citation analysis for topics and active research areas in a field, and demonstrated images from VosViewer (https://www.vosviewer.com/) and CiteSpace (https://citespace.podia.com/). Most of the interviews were conducted in person, but for the faculty that I interviewed through a Microsoft Teams audio call, websites of the two tools were sent out via email before the interview.

Demographics

I interviewed 30 STEM faculty from four departments and one college, all of which are my liaison departments. The interviews took place from January through September 2024. Out of the 30 interviews, one was conducted through a Microsoft Teams audio call, four were through Microsoft Teams video conferences, and 25 were in-person interviews. Interviews lasted from 45 minutes to three hours, with most interviews lasting approximately one hour. Detailed notes were taken during the interviews and field notes and a summary of the interview were written down immediately after each interview. The number of faculty from each department and their corresponding academic ranks are shown in Table 1.

Table 1. Number of faculty interviewed from each department and their academic ranks

Department/college	Total number of interviewees	Number of tenure-track faculty	Number of tenured faculty
Chemistry/biochemistry	10	4	6
Computer science	4	2	2
Engineering	7	5	2
Mathematics/statistics	4	0	4
Physics	5	0	5

Data Analysis

I used reflexive thematic analysis (TA) in data interpretation. Reflexive TA was proposed by Braun and Clarke (2006) and later updated (2019) with Big Q qualitative as its theoretical framework. Reflexive TA recognizes researcher subjectivity as a strength in qualitative research and that “a single coder is a normal and good practice in reflexive TA” (Braun & Clarke, 2022, p. 55). I chose reflexive TA because it is the most “fully qualitative” TA approach and thus is best suited to explore the deep and nuanced meaning of qualitative studies (Braun & Clarke, 2022, p. 247). Reflexive TA required the recognition that my experiences and assumptions influenced how I asked interview questions and my interpretation of the data.

Flexibility offered by reflexive TA also allowed me to do inductive analysis and produce both semantic and latent codes and to capture patterns across the dataset. Semantic codes capture the surface or descriptive meanings of data. Latent codes explore implicit or hidden meanings of the data, which involve a more active engagement with data. I further developed codes into subthemes and themes, as demonstrated in the thematic map in the “analysis and discussion” section. A theme has its “central organizing concept” (Braun & Clarke, 2022, p. 77), and themes and subthemes were developed based on research questions. However, themes are not research topic summaries in reflexive TA. In reflexive TA, simple counts of words or ideas discussed are discouraged, and themes and subthemes are developed based on how important they are to answer the research questions. Although common patterns can be important, less frequent themes can also be valuable for addressing research questions (Buetow, 2010).

"Data saturation" is the point where no new information or themes are generated from data. It is widely used as the "gold standard" to decide sample size in qualitative research. However, in reflexive TA, it is not recommended to be used as a standard to decide sample size due to data complexity (Braun & Clarke, 2022, p. 28). In general, a sample size of 6-10 is considered a "small" project, 11-20 as a "medium" project, and larger than 20 as a "large" project for data collection through interviews (Braun & Clarke, 2013, p. 48). Since 15-30 are typical sample sizes to identify patterns across data (Braun & Clarke, 2013, p. 55), I listed the possibility of including 20-30 individual interviews in my IRB application. Ultimately, I interviewed 30 STEM faculty.

Background on Transformative Agreements and OA Publishing Funding at the University

During the time frame of these interviews, Kent State University had transformative OA publishing agreements with five publishers through the library consortium OhioLINK: Cambridge University Press, Elsevier, Institute of Physics, Springer, and Wiley. In addition, Kent State has an OA publishing fund to cover $1,500 or half of the article APC, whichever is less. Each faculty can receive this fund up to twice each fiscal year for gold OA journals only. This fund is managed by the University Libraries, and receives contributions from the University Research Council, the Division of Research and Economic Development, and the University Libraries.

Analysis and Discussion

In this section, I first focus on themes and subthemes of each discipline, then make recommendations for academic librarians based on patterns produced across the entire dataset related to the research questions. Since I did not record the interviews, no quotation marks are used for participants' thoughts. The participant's code follows each interviewee's input. This study reports three themes: (1) library assets, which includes library collections and library services that faculty value; (2) faculty behaviors and practices, which characterizes faculty work processes and supports, such as tools used to improve productivity and stay current; and (3) challenges and concerns, which covers areas they think can be improved. Google Scholar and arXiv are considered as library collections because they are listed in the A to Z databases on the Kent State University Libraries' website.

Mathematics/Statistics

The thematic map for mathematics and statistics faculty interviews analysis is shown in Figure 1. Thematic maps for the analyses of other departments' faculty interviews are in a supplementary data file in OSF (https://osf.io/a7xkc/) as they share similar themes with some different subthemes.

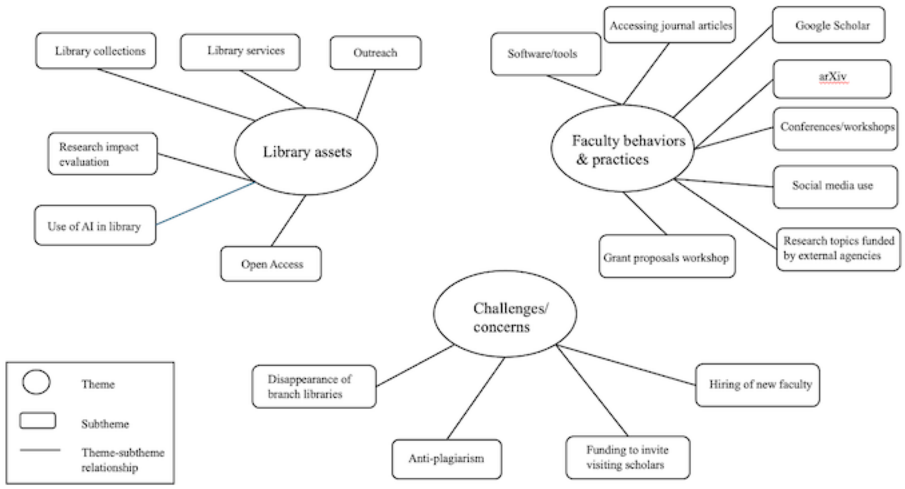

Figure 1. Thematic map for mathematics and statistics faculty interviews analysis

Four math/statistics faculty participated in this study. In general, they value the books, e-journals, and databases provided as part of the library collection. They use Google Scholar (GS), arXiv, MathSciNet, and Web of Science (WoS) in their research, with WoS for topics outside of mathematics (Theme 1: library assets – library collections). They also use OhioLINK (a library consortial catalog) to request books and interlibrary loan service (Theme 1: library assets – library services). Two out of four mentioned that non-library sponsored grant writing workshops were helpful when they were applying for funding for the first time as a junior faculty (Theme 2: faculty behaviors and practices – grant proposal workshop). None noted data management plan support as essential or important in their research. Math faculty clearly pointed out that they do not need DMPs in their research.

When considering channels to promote library resources and services, they recommended faculty meetings each semester, short emails through the departmental library representative, the library website, and in-person meetings with faculty. Math faculty pointed out that they would only pay attention to these library communications if the content was helpful to their research and teaching; for example, serving as an undergraduate student research symposium judge. One interviewee stated that not much from the library's research support was useful to them (Theme 1: library assets – outreach).

To keep track of developments in their fields, math and statistics faculty read journal articles, attend professional conferences for networking, use GS and X (formerly known as Twitter), and learn what topics have been funded by external sources. Two out of four attend workshops organized by the Banff International Research Station (https://www.birs.ca/), which offers one-week workshops in various mathematical areas in cities worldwide (Theme 2: faculty behaviors and practices). Math faculty pointed out that in mathematics it takes longer for an area to receive attention and to develop into a research front compared with other fields.

They also discussed concerns in their work, such as the high occurrence of plagiarism in students' assignments, the disappearance of a branch library where they can browse journals and network, lack of funding for visiting scholars, and hiring of new faculty to get new personnel for the department (Theme 3: challenges/concerns).

Their opinions on visualization/bibliometric tools varied. Two out of four were interested in these tools, whereas one was not, and one considered their usefulness as conditional.

Interviewees expressed reasons to be interested in these tools:

- I can use them in the literature review section when writing grant proposals. (Participant 4)
- I can use them to learn more about collaborations, how science was developed and to broaden my horizon. (Participant 7)

On the other hand, participants outlined reasons why they were not interested in these tools:

- These images look attractive. However, I know all of this information through GS and using them is not part of my research habit. (Participant 12)

Participants also explained why they considered these tools useful under some conditions, but not to them:

- These tools are not crucial to me, as I already have several research directions that I know about very well. They could be useful to junior faculty and graduate students, or a senior faculty looking for a new research area. (Participant 27)

The current study echoes findings and themes identified in other studies of information seeking behaviors of academic mathematicians with added nuance, while at the same time revealing new themes and trends. A 2019 survey of 112 Canadian mathematics students and faculty from four institutions identified GS, arXiv.org, MathSciNet, and WoS as the most often used databases (Gordon et al., 2020), which mirrored the results of the current study. In the current study, math faculty also mentioned interest in Scopus, which the Kent State University Library does not subscribe to. Furthermore, the current study adds more details on how mathematics and statistics faculty use GS and arXiv. They follow influential research groups in their fields closely in GS. Older papers from the 1980s and 1990s could not be found in arXiv, and thus it is not a tool for searching. The 2019 study (Gordon et al., 2020) also interviewed 11 mathematics faculty and revealed "the slower pace of math" (p. 268) as one of the four themes, which echoes the finding from the current study: math is less sensitive to hot areas. It may take ten years for a topic to be developed and expanded in math, especially in pure math with an average 1.5 years for a manuscript to be published. The Gordon et al. survey revealed that academic mathematicians did not normally use social media and forums to stay current. In the present study, math/statistics faculty expressed interest in both social media tools and AI. However, they showed no interest in DMPs, a distinction from faculty of other departments in the current study. Krantz (2017) commented on the difference between math and other hard sciences: "a mathematician deals with ideas … in the end, a solution to a mathematical problem comes from pure thought" (p. 2). This statement was reflected in the current study: math faculty stressed the importance of visiting scholars from all over the world and new faculty hiring for the exchange of new ideas.

Computer Science

Four computer science (CS) faculty were interviewed in this study. The participants valued online journals and conference proceedings, and databases such as IEEE Xplore and ACM (Association for Computing Machinery) Digital Library (Theme 1: library assets – online journals/conference proceedings). OA publishing is not a priority for them. Currently, the University's OA publishing fund only supports gold OA journals, and they hope the scope can expand to hybrid journals and conference proceedings. They were also worried about the quality of OA journals, even if they received invitations to publish in some journals with an APC waiver (Theme 3: challenges/concerns). They considered the DMP templates provided by the library useful (Theme 1: library assets – data management). Two out of four CS faculty hoped there could be a single place or newsletter to find funding opportunities based on disciplines and subfields. Currently, the University's Office of Sponsored Research sends out separate emails for each individual funding opportunity (Theme 3: challenges/concerns). Another concern was that there was not enough time left to apply for grants when they learned about a funding opportunity (Theme 3: challenges/concerns). They also expressed the need for software to improve productivity, such as the premium Overleaf subscription, writing tools such as Grammarly, graph-creating tools such as Prism, and video editing tools (Theme 3: challenges/concerns). At Kent State, the university IT manages software with university-wide site licenses. Some software is paid for by individual departments (such as ChemDraw by the Department of Chemistry and Biochemistry) or individual labs.

As far as effective ways to reach out, they recommended educational videos featuring faculty and students' research like those shown in museums, emails from the librarian related to research, and workshops on library services that offer rewards or are made mandatory by the University (Theme 1: library assets – outreach).

To keep up with developments, computer science faculty use recommendations and citation alerts from GS, attend conferences, learn from collaborators, and receive journal notifications. They also serve as conference organizers and reviewers, and volunteer as facilitators for the forums in ACM *XRDS: Crossroads*, *The ACM Magazine for Students* to learn ground-breaking research (Theme 2: faculty behaviors and practices). CS faculty stressed the importance of using arXiv to obtain a timestamp for their research and to get credit for their ideas due to the slow peer-reviewing process (Theme 3: challenges/concerns). Tenured faculty claimed they do research that they deem important for society even if it easily takes 50 years for a technology to develop applications, whereas junior faculty had to do research where they can obtain funding (Theme 2: faculty behaviors and practices).

Most CS faculty interviewed were not interested in the research impact evaluation/visualization tools. Three out of four were not interested in these tools, whereas one considered their usefulness as conditional.

Interviewees outlined reasons why they were not interested in these tools:

- These tools can create author collaboration networks. However, collaboration requires trust and keywords are too broad. These tools provide good information but things like collaboration may not work out in real life. (Participant 10)
- I may have used these tools when I was very early in my career. But I am way over that stage. I do not see any benefits I can get. I always know what is happening by reading journal articles. (Participant 18)
- I know what I am doing now. They might be helpful if I start a new research topic in my career in 30 years. (Participant 19)

They also explained why they considered these tools could be useful under some conditions:

- There is a deep learning curve for these tools, and they tend to provide a lot of information, which makes data interpretation time-consuming. They can provide useful information. However, I already have a global view of my field, and these tools are not necessary to me. I may use them if I am writing a survey paper on the recent developments, challenges and future directions of a topic, or start a new research area. (Participant 15)

CS faculty mentioned using the Erdős number at dblp (computer science bibliography, https://dblp.org/) to measure "collaborative distance" from Paul Erdős, a Hungarian mathematician, and claimed most computer scientists were within 5 or 6 collaborators away from him (Theme 2: faculty behaviors and practices).

Computer scientists are considered early adopters of novel search technologies. A focus group study of computer science and engineering faculty at the College of New Jersey gathered their information seeking habits (Tucci, 2011). Although four computer science faculty and 14 engineering faculty participated in the study, their information seeking patterns were reported as a group. However, one theme was that faculty requested access to subject-specific databases (IEEE Xplore and the ACM Digital Library (DL)), claiming that they were only interested in journals where their peers published. IEEE Xplore and ACM DL are probably the top subject databases for computer science. In the current study, faculty also complained about the lack of access to some IEEE journals, which were not included in the library's subscription package.

Another study used mixed methods (interviews, diary logs, and direct observations) to study the information seeking behavior of six computer scientists at different career stages at the University of Helsinki (Athukorala et al., 2013). In that study, computer scientists thought it was difficult to find a good collaboration tool. Similarly, in the present study, computer scientists requested a site subscription to Overleaf for collaboration and to image/video editing tools to increase productivity. In the study at the University of Helsinki, computer scientists also considered the most difficult task "exploration of unfamiliar research areas" and the authors suggested that databases could include "interactive visualizations" to support this type of search (Athukorala et al., 2013, p. 9). Bibliometric and data visualization tools can be useful for these types of exploratory searches, which require expertise to use and interpret the data generated.

Physics

Five physics faculty participated in this study. The physics faculty interviewed use online journals and databases such as WoS, arXiv, Inspire HEP, and GS (Theme 1: library assets – library collections). They also use OhioLINK and interlibrary loan to request books (Theme 1: library assets – library services). Physics faculty hoped the University could develop OA publishing agreements with more publishers, claiming that in 60% of the cases, the University's OA publishing transformative agreements did not include their preferred journals (Theme 3: challenges/concerns). One faculty pointed out that they would not pay to publish OA, with the exception of *Nature Communications*, which is a gold OA journal (Theme 1: library assets – Open Access). Physics faculty also considered SciHub as an essential tool in their research (Theme 2: faculty behaviors and practices). Faculty also expressed a need for a data management plan service beyond a DMP template with the relatively recent new requirement from funding agencies, such as the NSF which requires researchers to "deposit practically all research data into some depositories and get DOIs for them" (participant 23). Physics faculty pointed out that "help with these depositories (where they are, how to access them, how to submit the data there, how to get DOIs, etc.) would be very useful to the faculty" (participant 23) (Theme 1: library assets – data management). Important software/tools they use included high performance computing such as the Ohio Supercomputer Center, cloud storage, online collaborating platforms like Overleaf and Microsoft's SharePoint, molecular simulation and data visualization tools like OVITO, graphic design tools like Photoshop, and PDF and video editing tools (Theme 2: faculty behaviors and practices – software/tools).

Physics faculty also expressed concerns and challenges in areas such as lack of services from the University to tell the story of their important publications to the public for press releases, graphic design for public outreach so people outside their field can better understand their research, and time lost using SciENcv (the biosketch tool used by funding agencies such as NSF, NIH, and DOE). Like computer science faculty, they also would like to receive targeted funding opportunity information related their research interests, and access to tools such as the premium versions of Overleaf and Grammarly. They also hope their personal webpages can be updated automatically with recent publications so prospective students can see the most up-to-date information about their research (Theme 3: challenges/concerns).

Physics faculty recommended library open houses and workshops as effective ways to reach out and promote library resources and services. They think of the library as the place to learn reliable information and novel tools (Theme 1: library assets – outreach). Other outreach methods they recommended included webpages or emails forwarded by the departmental secretary or Chair, and the University's faculty/staff newsletter. However, some physics faculty did not think they needed anything from the library, had not been to the library building for decades, and hence it was hard to catch their attention.

Physics faculty consider it is crucial to capture new research areas ahead of trends. They use the following methods to keep current in their fields (Theme 2: faculty behaviors and practices):

- Reading journal articles
- Attending conferences/workshops
- GS alerts, citations, and recommendations
- Through funding agencies (U.S., European, South Korea, and Japan)
- Talking with colleagues during research leaves/sabbaticals
- Reviewing manuscripts and grant proposals
- Citations from the introduction section of important publications

Physics faculty praised GS recommendations as "the best" and also mentioned they cared about their Erdős numbers.

Out of the five physics faculty interviewed, four considered the visualization/bibliometrics tools as useful under some situations, although they may not be useful to them. One expressed no interest in such tools. They summarized the reasons that these tools could be beneficial under some conditions:

- I do not need it since I have a fixed research interest. You need a platform to find collaborators, such as face-to-face meetings at conferences. These tools can be useful for junior faculty and graduate students, and mid-career faculty who need to branch out to diversify their research interests. (Participant 6)
- I receive my own research impact information through GS and major conferences. The audience's comments and individual stories on how impactful my talks were are more important to me than citations. I will use these tools if I am writing a roadmap or national level policy document, or if I worked at a funding agency to decide what fields to fund. (Participant 21)
- They can be useful when I am writing a team-based proposal for multi-disciplinary research and need to find a specialist in an area. However, this need does not arise very often. (Participant 23)
- I do not need the information on authorship and the timeline of keywords. I am interested in the information from the cited references, since this feature is not available in Inspire HEP. (Participant 26)

Physics faculty also explained why they were not interested in these tools:

- Although these images look fancy, I do not think these tools can advance my science. I take online notes when I read online articles. I may overlook a few important publications and authors. However, I just do not think I can outsource this type of work, and nobody can make decisions for me. Even my own graduate students could not always judge whether some articles provided relevant information to our research, not to mention software trying to do this work. I am not sure what to do with the keywords provided. (Participant 16)

Like faculty in other fields, physicists rely on a combination of databases. A survey of 182 academic physicists in seven Canadian institutions in 2019 revealed that the most popular databases used were arXiv (71%), GS (71%) and WoS (23%) (Gordon et al., 2022), which mirrors the findings from the current study. In the second phase of the Gordon et al. study, they also interviewed 11 participants and summarized four main themes, one of which was that arXiv was important to physics and its subfields. In the current study, arXiv appeared to be important to physicists, computer scientists, mathematicians, engineering faculty, and chemists with a physics background. A computer science faculty member pointed out that they deposited their preprints in arXiv to obtain a time stamp for their ideas due to slow peer reviewing. Physics faculty seem to deposit both pre-prints and post-prints of their publications in arXiv. Another study of the reading and citing behaviors of high energy physics (HEP) scientists revealed that they were four to eight times more likely to download preprints of an article from arXiv than from the journal's website (Gentil-Beccot et al., 2010). However, HEP faculty interviewed in the current study also pointed out that this was a small field, and every project involved many researchers from many countries. Therefore, the collaboration network provided by the bibliometric tools were not helpful, but the citation networks could be useful since Inspire does not have such a function.

Engineering

A total of seven engineering faculty were interviewed in this study. Engineering faculty considered online journals/conference proceedings and databases such as GS and arXiv as essential for their research (Theme 1: library assets – collections). They also valued library services such as OhioLINK (a library consortial catalog) and interlibrary loan for requesting books (Theme 1: library assets – services). Software they used included Microsoft Visual Studio for coding, MATLAB, SolidWorks for engineering design, Ansys Fluent for simulation and Overleaf (Theme 1: faculty behaviors and practices – software/tools). Engineering faculty also considered subject librarians as essential since they can look at the entire department or college's research needs with a broad view for library collection needs (Theme 1: library assets – library services).

As far as OA publishing is concerned, they appeared to care more about what they can read, not whether they could publish their own manuscripts OA. However, engineering faculty pointed out ASME's (American Society of Mechanical Engineers) OA APC charge was too high ($3,000) to be paid with their own grant funds (Theme 1: library assets – Open Access; Theme 3: challenges/concerns – Open Access). They hope that the library can review DMPs for new faculty to make sure no components are missing. However, faculty also pointed out that they needed more help when they were close to finishing a grant-supported project and were required to share their data, which is beyond the scope of a DMP template (Theme 1: library assets – data management). Faculty also expressed the need to obtain help from the library on grant proposal development and wondered whether generative AI could assist on this issue. They also stressed the need for conducting literature searches to figure out whether their ideas were novel and if there had been publications or patents on their ideas. They hope librarians can respond in a timely manner, have background in their fields, understand their jargon, and make intellectual contributions to their research and publications (Theme 1: library assets – grant proposal development; Theme 1: library assets – library services).

Engineering faculty described challenges in areas such as a heavy teaching load and work volume, lack of motivated graduate students, and lack of financial support for graduate students from the department and university (especially first- and second-year students). They were also concerned about their access to the Ohio Supercomputer.

Although each faculty member receives a $1,000 credit, they are not sure how long this credit will last. They also hope the University can do a better job of promoting faculty research to the U.S. government and private foundations. The lack of a university-wide site license to MATLAB and Overleaf was another concern. The library does not subscribe to any major standards, such as ASTM (American Society for Testing and Materials), IEEE, and ISO (International Organization for Standardization). No faculty interviewed in the current study complained about lacking access to standards, although it was mentioned that the college purchased the Radio Technical Commission for Aeronautics (RTCA) standards (Theme 3: challenges/concerns).

Engineering faculty recommended faculty meetings, in-person meetings between librarians and faculty, a physical card or flyer listing library services, word of mouth, direct emails or Microsoft Teams messages from the librarian, emails forwarded by the associate dean of research of the college, or annual workshops for new faculty as their communication preferences (Theme 1: library assets – outreach).

Engineering faculty keep current with the latest developments in their fields through the following channels:

- Reading journal articles, especially review articles
- Attending conferences
- GS recommendations
- Number of articles appearing on a topic
- Government energy policies
- Funding agencies' announcements
- ResearchGate
- WeChat subscriptions
- Following news in magazines, such as *Aerospace America*
- Discussion with collaborators

Engineering faculty considered feeds from WeChat as up to date and unbiased. If they are interested in a topic feed in the subscriptions, they will go search the topic in top conference proceedings. They also consider top conferences more important than top journals for finding out what the research fronts are and exchanging ideas (Theme 2: faculty behaviors and practices).

Out of the seven engineering faculty interviewed, four considered the research impact evaluation service as useful, and outlined their rationales:

- I will use this service. Once my current field is saturated, it can help me branch out to new areas to see where the excitement is and who the main players are. (Participant 5)
- This service is useful since it is a big data source of citations. (Participant 9)
- This service is useful since it can help me expand my ideas and write in grant proposals what my research's impact in other related areas could be. (Participant 11)
- These tools are very useful. I hope to get a personalized report to learn who has cited my work and who is doing similar work. (Participant 29)

On the other hand, three faculty considered that these research impact and data visualization tools could be beneficial but with some limitations:

- I will use it if it is easy to use but will not rely on these tools. What I can learn from keywords is very limited. If I just chase hot spots, it will be very hard to get funding. (Participant 14)
- It is useful when entering a new field. It is also very useful for funding agencies. I hope there is a similar tool to track research topics that were funded by agencies in various fields. (Participant 28)
- I am willing to give these tools a try if there is not a steep learning curve, and I need time to do it. The keywords timeline is not useful to me. However, I am willing to test the collaboration network and cited references features. I know people through conferences and GS. But I may not know the whole picture. (Participant 30)

Engineers and scientists demonstrate distinct information seeking behaviors, although STEM librarians often discuss "science and technology/engineering" as a group. An earlier study surveyed 903 engineering faculty from 20 public research universities in the United States about their information seeking behaviors and identified access to electronic journals as the most crucial need (Engel et al., 2011). A more recent study surveyed 38 engineering faculty from Mississippi State University and revealed GS was the most popular database and faculty valued the library's website for finding library collections and services (Zhang, 2015). Findings from the current study corroborate some discoveries from the 2015 survey. However, at the time of that study, data management services were relatively new and thus had a lower awareness level (32%). Currently, they appear to be a well-recognized service, probably due to mandatory requirements from funding agencies. A 2017 survey of 58 engineers in the workplace in the UK revealed that 95% of them used search engines, while only 9% used social media as their information resources (Wellings & Casselden, 2017). Although engineers were using databases or search engines much more often than social media for in-depth information seeking, in the current study they are using more social media tools to stay current in their fields, such as ResearchGate and WeChat official channels. A recent study disclosed that 56% of 117 Chinese medical libraries analyzed used WeChat to promote their collections and services, with reading promotion as the most important theme (Zhang et al., 2024). The trend of social media use by STEM faculty may be an area of future research.

Chemistry/Biochemistry

A total of ten chemistry and biochemistry faculty were interviewed in this study. Similar to researchers in other fields, chemistry faculty consider online journals and databases such as SciFinder, Reaxys, Web of Science, PubMed, Cambridge Structural Database, and GS as necessary in their research (Theme 1: library assets – collections). They use interlibrary loan and OhioLink to request books and course reserves (Theme 1: library assets – library services). Software they used include ChemDraw, EndNote, BioRender for image and illustration, TopSpin for NMR (Nuclear Magnetic Resonance) spectra, and Blender for 3D images (Theme 1: library assets – software/tools).

They indicated the importance of data management is increasing from being "good to have" to "essential." In addition to a generic template mandated by the funding agencies, they also hoped to be able to self-archive their data and store their data in the cloud to prevent data loss when their research produced a large amount of data such as videos (Theme 1: library assets – data management).

They welcome the University's financial support for OA publishing due to reasons such as giving them more options to select which journals to submit manuscripts to or avoiding paying the APCs from their own funding. Chemistry faculty participants pointed out that they would choose the *Journal of the American Chemical Society* (JACS) to publish with instead of *Nature Communications*, since JACS provides a green OA option, whereas the latter charges an APC of about $7,000. Chemistry faculty sometimes did not choose to publish OA because of inertial behavior to publish with certain, known journals, and because of the extra step required to apply for OA funding from the university library. Some chemistry faculty interviewees claimed that people who could understand their research would be affiliated with a library and thus OA publishing was not a concern to them (Theme 1: library assets – Open Access). Junior faculty also appreciated the assistance provided by the university for budget management and the paid proposal reviewing service provided by external reviewers. They also attached great importance to database trainings, such as SciFinder, Reaxys, EndNote, and chemical patents searching. Two faculty considered the one-credit chemical information course taught by the STEM librarian as essential. However, it was also pointed out that patents do not count for tenure and promotion and are not considered in NSF grant proposals (Theme 1: library assets – chemical information course).

Chemistry faculty participants were concerned about their teaching load and students' quality. They are not happy with students' writing skills and have been asking both their domestic and international graduate students to use the free version of ChatGPT to revise their manuscripts, so the faculty do not need to correct their grammar. Chemistry faculty are also using the free version of ChatGPT to revise their own manuscripts and grant proposals and claimed a lot of time was saved (Theme 3: challenges/concerns: students' writing skills). However, data privacy was also a concern to them when using generative AI tools. Some chemistry faculty did not think ChatGPT knew the real challenges in their field and did not advise their graduate students to use it. They are also concerned with the quality of information resources students are using, such as YouTube instead of library resources (Theme 3: challenges/concerns: quality of information sources). They pointed out students' lack of understanding of traditional chemistry research handbooks, such as the *Encyclopedia of Reagents for Organic Synthesis* and the Science of Synthesis (*Houben-Weyl Methods in Organic Chemistry*), which would lead to usage decline and possible cancelation (Theme 3: challenges/concerns: lack of understanding of chemistry databases). Although a one-credit chemical information course is taught by the chemistry librarian, faculty would like a stronger visibility of the library and hope the course can be mandatory and included in the departmental curriculum mapping and graduate student handbook. They also hope there can be a site license for software such as BioRender and a full version of ChemDraw (currently the Chemistry and Biochemistry Department only provides a site license for the basic version) (Theme 3: challenges/concerns: software/tools). They are also concerned with the preservation of journals, such as

Heterocycles, which ceased publishing in December 2023 (Chawla, 2024) (Theme 3: challenges/concerns: preservation of ceased journals).

Chemistry faculty recommended the following outreach methods:

- Face-to-face meetings with faculty
- Departmental faculty meeting
- Faculty research and innovation forums organized by the Division of Research and Economic Development
- Direct emails from the librarian
- Providing database trainings
- Faculty and graduate student listservs
- Meetings with graduate students through the graduate student coordinator
- Annual newsletters

Chemistry and biochemistry faculty stay current in their areas through the following ways:

- Reading publications from top journals, including literature review articles
- Attending conferences, such as those of the American Chemical Society, the American Physical Society, and the Gordon Research Conferences
- Funding agencies' white papers/roundtable reports
- Wikipedia
- GS, by following major players
- Chemical and Engineering (C&EN) News
- As a reviewer of manuscripts and grant proposals
- Private newsletters that you only receive if you contribute
- Updates on LinkedIn
- European public radio programs about science

Chemistry faculty value professional conferences as venues for networking and idea-exchange. However, they also pointed out that the sessions they could attend in one conference were limited, and they may not be able to attend the one-week-long conferences organized by APS or ACS due to teaching responsibilities. On the other hand, the Gordon Research Conferences (https://www.grc.org/) seem to be an important venue for chemistry, physics, and material sciences faculty to learn exciting ideas in their fields since each conference is topic-focused and held in the summer with about 100-150 attendees, which provides excellent networking and interdisciplinary experiences.

Chemistry/biochemistry faculty demonstrated interest in bibliometrics/data visualization tools but also expressed reservations. Participants expressed reasons why they thought these tools could be beneficial:

- I am interested in these tools, and I also use altmetrics to identify popular topics. (Participant 2)

- It is useful to me because the number of publications I can read is limited. These tools can broaden the pool of articles and bring to my attention some specific articles. They can also suggest new areas that I can move to. (Participant 8)
- I am interested in this tool since it can help me find potential collaborators and reviews of manuscripts and grants, or writers of support letters. I would like to see the research trends too. (Participant 25)

Some interviewees deemed the use of these tools limited and listed the following reasons:

- It is useful as a lazy people's way of finding information. However, it is too late when you see the research fronts. What is most important is your vision/idea and you need to capture hot topics before it becomes hot, which can only be realized by reading publications in my opinion. (Participant 1)
- These tools look very fancy. However, I know my areas very well. I know all the major players and what they are doing through GS. I do not need any of this information from a software. I do not think it is useful to faculty, even to graduate students. To graduate students, what is most important is reading publications and communication with their advisors. I may use it if I am writing a very important review article and need to discuss the impact of my area in other fields. (Participant 17)
- The collaboration network is more an outreach/educational/public relation/marketing tool. I am interested in the cited-reference network since there can be researchers in different areas such as engineering. They can describe the same topic in different ways that I am not aware of. (Participant 20)
- I know all of this information with my experience. This tool is useful to graduate students and postdocs to learn peers and additional players outside their own areas, and the evolution of the fields. (Participant 24)

Some chemistry faculty expressed no interest in these tools with the following rationales:

- I am not going to use this service since these visualizations are based on research that already happened. It is faster to catch research trends through reading literature, such as what some major research groups are doing, where their research interest shifted to, and what they published. What I can do is also decided by instruments and the funding I have access to. It takes time to accumulate knowledge in a field. (Participant 3)
- These tools are just useful to information professions, not to researchers. It is not useful for me to know what other people have done. I just need to focus on my own research and make sure what I am doing is innovative/unique and nobody has published on it through literature searches. (Participant 13)
- These tools look interesting, but they are not useful to me. I already learned hot topics from conferences and more citations do not indicate more important work. Hot topics come and go, and what is shown here is the past, not the future. I need to lead a research trend, not to follow it. Faculty's work is thinking in a different way. (Participant 22)

Chemistry is an experimental and highly collaborative science, typically with a principal investigator leading a research group with undergraduate and graduate students and postdoctoral researchers. In the current study, faculty were not asked to rate themselves on their information searching skills. However, they emphasized the importance of chemical information training for graduate students, stressing that graduate students' knowledge was incomplete. A recent study surveyed 231 academic chemists from four Canadian research universities (Gordon et al., 2018). Although GS was the most popular searching tool (61%) in the survey, SciFinder (55%), WoS/Scopus (55%), Reaxys (24%), and PubMed (17%) were also frequently used tools. Findings from the current study echo the takeaways of the study in 2018, indicating chemists and biochemists heavily rely on the chemical structure and reaction databases SciFinder and Reaxys. The 2018 study also interviewed 14 chemists using focus groups and revealed that academic chemists in general dismissed the importance of patents, either because they thought scholarly literature was higher quality or they were not trained to use patents. In the present study, chemistry faculty also pointed out that patents do not count in tenure and promotion, cannot be cited in funding proposals, and the University's tech transfer service is not sufficient to connect faculty with corporations. A lot of research data is produced in chemical research, and in the current study faculty pointed out that their data is stored in various places. A recent survey of 119 chemists on their data management and sharing behavior in the Chinese Academy of Sciences reported that a majority used their personal computers (82%) and paper lab notebooks (75%) to preserve data, while only 2% used subject data repositories. This finding indicated the lack of knowledge of chemical data repositories among academic chemists (Chen & Wu, 2017). In their study, 71% respondents also "extremely need" or "needed" data management service (Chen & Wu, 2017, p. 351), which mirrored the theme of the current study: chemists are generating large datasets, data storage is fragmented, and they hope to receive more guidance on research data management.

Recommendations for Librarians

Several dominant themes were generated in this study, ranging from what research services faculty consider as library assets, to their attitudes towards bibliometric and visualization tools. Access to databases and online journals are still the core of library services. Table 2 lists major databases and software/tools used by faculty in each discipline. Recommendations for academic librarians are made accordingly.

Table 2. Databases, software, and tools used by faculty by discipline

Discipline	Databases	Software and Tools
Chemistry and Biochemistry	SciFinder, Reaxys, Web of Science, PubMed, Cambridge Structural Database, Google Scholar	ChemDraw, EndNote, BioRender (for image and illustration), TopSpin (for NMR spectra), Blender (for 3D images)
Computer Science	Google Scholar, arXiv, IEEE Xplore, ACM Digital Library	Overleaf, Grammarly, Prism (for image editing), video-editing tools
Engineering	Google Scholar, arXiv, IEEE Xplore, ACM Digital Library	Microsoft Visual Studio (for coding), MATLAB, SolidWorks (for engineering

		design), Ansys Fluent (for simulation), Overleaf
Mathematics and Statistics	Google Scholar, arXiv, MathSciNet, Web of Science, Scopus	R
Physics	Google Scholar, arXiv, Inspire HEP, Web of Science	Overleaf, Grammarly, graphic design tools, OVITO (for molecular simulation and data visualization), Microsoft SharePoint, Photoshop, Adobe, video-editing tools, Ohio Supercomputer Center

Library Services as Library Assets

STEM faculty participants in this study tended to consider the following library research services as library assets: library instruction of specialized databases and DMP support. Their attitude towards OA publishing was lukewarm.

GS can be a tool in librarians' instruction toolbox, since it is a very popular search tool that faculty use across disciplines, although they still use their field-specific databases. They especially like the "recommendation" function from GS and use it to follow the key contributors in their fields. They praised GS as "comprehensive" and "easy to use" ("no learning curve"). This finding suggests that librarians can integrate GS into subject-specific database instruction and trainings. Meanwhile, faculty were concerned about the quality of information sources students have been using like YouTube. Librarians can emphasize the difference between GS and library databases, and the distinctions of various types of information resources (books, handbooks, journal articles and patents).

Data storage and management seem to be gaining more attention to fulfill the requirements of funding agencies. Faculty used to need a DMP template for their grant proposals. Now they hope to get education on how to deposit all their raw data, codes, and calculations related to their publications in a findable repository, ideally with a link to the underlying publication(s). These widespread requirements from the funding agencies could be a library outreach opportunity.

Science and engineering faculty appear not to prioritize OA publishing, although they appreciate the financial support from the University, which gave them more options when considering potential journals to submit their manuscripts to or helped them avoid paying for APCs from their startup or grant funds. However, they care more about what journals' articles they have online access to; they do not care that much about whether their own publications are behind a paywall. They mentioned manuscripts submitted to gold OA journals were accepted more easily. On the other hand, they were also concerned about the quality and reputation of these journals. A common belief among faculty is that OA articles receive more citations. Yet research on the effect of OA on citation rates is mixed: some gold OA journals received fewer citations, and ultimately the number of citations received depends on the research quality (Young & Brandes, 2020; Zhang & Watson, 2017). The University's OA publishing agreements and funding only covers a few major publishers and gold OA journals. If faculty would like to publish in hybrid journals, the APCs are typically around $3,000 per article, which was considered too expensive to be covered with their grants. Education for faculty on Green OA and the influence of OA on citation accumulation could be more cost-effective than funneling funding to pay for expensive APCs. On the other hand, physics faculty seem to embrace the OA culture and deposit both pre-prints and post-prints of their publications in arXiv. To encourage faculty to deposit in the IR, user experience testing could be done to make the platform more intuitive to use. Collaboration between the science and engineering librarian and the scholar communication librarian will be key to promote green OA on campus.

Faculty Attitude Towards Bibliometrics and Research Impact Evaluation

Faculty opinions on bibliometric and data visualization tools for use in research impact evaluation are mixed. Out of the three types of networks (collaboration, keywords, and cited references), they seem to be most interested in the citation network. One common concern is that these tools typically generate a lot of data, and as a result, data interpretation would be time-consuming and would require a steep learning curve. Senior faculty typically think they already know all the information based on their experiences. However, they think these tools can be beneficial to junior faculty or graduate students. Some junior faculty claimed that they also knew their areas and the major contributors very well through GS. Yet the tools can be useful to these faculty if they step into a new area or write an important review/roadmap article. Another common theme is that these tools can be used by funding agencies or when they write about the broader impact of their research in grant proposals. Based on interviews in the current study, a customized report of an individual's research impact for faculty tenure and promotion could be part of the library's research service. Tenure-track faculty seem to be more interested in a customized research impact report of their publications. However, such a service will require librarians to have expertise with these bibliometric tools as well as sufficient library staffing. Health science librarians' research evaluation experience can be emulated by other academic librarians (Gutzman et al., 2018).

Conclusion and Future Work

In this study 30 STEM faculty in mathematics/statistics, computer science, physics, engineering and chemistry/biochemistry were interviewed to explore their research support needs from the library, their outreach and communication preferences, their use of current awareness tools, and opinions on the value of bibliometrics/research impact evaluation services. Findings from this study suggest that academic libraries can strengthen instruction on subject-specific databases along with GS. Librarians can provide more guidance on data storage and sharing in addition to support with writing DMPs. Education for faculty on Green OA/self-archiving seems to be the most cost-effective way to advocate for OA publishing. A customized research impact report appears to be attractive to tenure-track faculty. A research trend analysis report will benefit faculty who are entering a new research area. Results from this study will help science and engineering librarians focus their resources more efficiently and identify new outreach and collaboration opportunities.

One possible future work is to do a reflexive TA analysis focusing on faculty comments about the value of bibliometrics tools. Reflexive TA can be used to develop analyses on the entire or part of a dataset, due to its flexibility (Braun & Clarke, 2022, p. 101). A reflexive TA analysis on this part of the dataset will give a more concise picture on the reasons why they would or would not embrace these tools. A similar study could be conducted at other types of universities to find out whether findings from this current study are transferable.

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