Issues in Science and Technology Librarianship

Adding Libraries to the Equation: Mathematical Sciences' Underutilization of Academic Librarians

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Abstract

Academic librarians do not engage with all disciplinary departments equally. Despite equal or even greater efforts, some departments are less responsive to librarian outreach. One such department is mathematics. To understand mathematics

departments' relationships with their academic librarians, three mathematics librarians created a 20-question survey that was disseminated to mathematics faculty, instructors, and instructional staff in the United States and Canada. Of the 188 survey participants, more than a third reported that they never engage with their librarians, approximately half only do so occasionally, and a mere eight percent of participants collaborated with librarians to provide information literacy instruction (IL) to their students. Participant responses revealed that mathematics faculty and instructors find librarian support unnecessary, often do not understand what librarians do or what services they offer and have limited time to include IL in course curricula. Participants also provided information about the resources they use for instruction, the university services and centers they use for their research, and the resources they would like to have in their library.

Keywords: Mathematics faculty, Academic librarians, Math librarians, Information literacy instruction, Faculty-librarian relationships

Recommended Citation:

Burke, J. L. C., Novosel, E. C., Kipnis, D. G., & Jayesekere, R. R. (2025). Adding libraries to the equation: Mathematical sciences' underutilization of academic librarians. *Issues in Science and Technology Librarianship, 110*. https://doi.org/10.29173/istl2857

Introduction

Library and information science (LIS) literature has long examined the evolving role of academic librarians in higher education. In recent decades, this body of scholarship has investigated the role and responsibilities of subject specialist/liaison librarians who provide support for specific disciplines by developing and maintaining collections, providing reference and research assistance, advocating for departmental resource needs, and providing library services such as IL instruction. To perform these duties well, subject specialists often cultivate relationships with their departments, which allows them to stay current with the knowledge and skills needed to meet changing needs and expectations (Appleton, 2018; LaRue, 2010; Monroe-Gulick et al., 2017).

Although outreach and relationship-building efforts are often welcomed by academic departments, librarians may occasionally encounter some that are less receptive. Through personal experiences and observations, the authors have found that mathematics is one such department. In such instances, it can be challenging for librarians to engage with and support students and researchers. As described by Gordon et al. (2020), mathematicians often focus on a narrow scope of research and curriculum that is often centered on the development of specific problem-solving skills, paying less attention to new research and developments across the broader spectrum of the discipline. Because mathematics courses rarely include academic research papers or other library resources, mathematics students and faculty are less inclined to engage with their librarians.

Limited research has explored the interactions between academic libraries and the faculty, researchers, and graduate students in mathematics and related fields (Gross et

al., 2016). To explore these relationships and learn more about mathematics faculty, the authors of this study developed a survey to investigate how often mathematics faculty and instructors contact, collaborate with, and refer students to their academic librarians, and to investigate the materials and services they use in their instruction and research. The survey was disseminated via listservs and individual emails to math faculty and instructors across the United States and Canada in November 2023. The aim of this study is to provide liaison librarians with information to inform and guide their outreach, service, and support efforts for math departments.

Research Questions:

1. How often do mathematics faculty interact with academic librarians?
2. For what purposes do mathematics faculty, instructors, and instructional staff interact with academic librarians?
3. What resources and services do mathematics faculty use for their research and instruction?

Literature Review

Liaison Relationships With Mathematics Departments

Little scholarly research has focused holistically on the relationships between mathematics faculty and their academic librarians (Albro et al., 2018; Barringer, 1989). However, considerable LIS scholarship has interrogated the value of liaison-faculty relationships and has argued that regular, intentional outreach to and communication with departments can facilitate relationship-building with faculty, staff, and students. Such relationships and the regular contact that can result from them allow liaison librarians to develop the disciplinary expertise necessary to provide targeted library services, reference support, and collection development (Church-Duran, 2017; Hamilton, 2021; Kranich et al., 2020; Palumbo et al., 2021).

Research also shows that departmental faculty, staff, researchers, and students often have a limited understanding of librarians' knowledge, value, and skills (Albro, 2018; Becksford, 2022; Yevelson-Shorsher & Bronstein, 2018). Relationship building has been shown to develop departmental constituents' awareness of their librarians' abilities and importance in the academic environment, which may encourage increased interest in collaboration (Bussmann et al., 2021; Hoodless & Pinfield, 2018; Monroe-Gulick et al., 2017; Palumbo et al., 2021; Zanin-Yost, 2018).

Yevelson-Shorsher and Bronstein (2018) interviewed liaison librarians and found that they value close relationships with their departments and that these connections are essential to their ability to fulfill their job duties. However, many felt that developing and maintaining such relationships takes considerable time and effort, and that some departmental colleagues did not view or treat librarians as equals, which they attributed to a lack of knowledge about librarianship.

Information Literacy (IL) Instruction

IL skills support student success in academic work and prepare them to be efficient, ethical, and critical producers and consumers of information in their future professions and daily life (Julien et al., 2018; Wang et al., 2023). In the past decade, the exponential growth of information sources available online, misinformation, data, and, most recently, content generated by artificial intelligence (AI), has made IL arguably more important in higher education settings (Cuevas-Cerveró et al., 2023; De Paor & Heravi, 2020; James & Filgo, 2023; Mullins & Boyd-Byrnes, 2024). Due to their specialized knowledge of information systems, librarians often provide IL instruction in courses, orientations, and workshops across campus. Librarians also provide elements of IL instruction in individual research consultations and reference work (Mohr et al., 2022).

Math Students and IL

LIS scholarship has observed that mathematics courses often concentrate on problem-solving skills, seldom incorporate academic resources beyond textbooks, and typically exclude the use of library resources and IL instruction (Barringer, 1989; Betne & Castonguay, 2008). Although a few math scholars discuss including IL skills in their courses to teach students how to gather information for real-world applications of math concepts and to teach research skills (Erickson, 2017; Erickson, 2019; Johnson et al., 2024), librarians have noted mathematicians' lack of interest in librarian-led IL instruction (Albro et al., 2018; Betne & Castonguay, 2008; Bussmann & Bond, 2015).

Despite these attitudes, librarians have found ways to incorporate IL instruction into mathematics curricula. Barringer (1989) developed IL activities that could be integrated directly into math courses to facilitate student exploration of the discipline while simultaneously equipping them with IL skills essential for graduate school and professional environments. Loesch (2011) collaborated with a mathematics/computer science professor to create an online, asynchronous course that covered the technical side of information retrieval as well as an exploration of information-seeking behavior, user experience considerations, and related IL topics. Gross et al. (2016) developed a pilot program to teach IL to math students in a writing course required for degree completion. Holden (2019) designed and implemented an eight-week, one-credit IL course for mathematics students based on the ACRL Framework. Thomson (2023) conducted surveys and interviews of mathematics librarians and found that they had considerable success providing IL instruction for graduate students and suggested that IL might be better received when viewed as important for graduate education.

Although the above examples demonstrate successful IL instruction for mathematics students, it is important to note that most were developed on an ad hoc basis due to the interest of specific faculty members, rather than as a broader, discipline-wide effort to incorporate such skills into mathematics curricula.

Mathematics Faculty Information-Seeking Behavior

Understanding disciplinary information-seeking habits helps librarians understand how to best provide faculty and students with access to appropriate resources and

services (Engel et al., 2011; Niu et al., 2010). Research shows that mathematicians tend to be independent researchers who rarely ask librarians for help. Newby (2005) observed that mathematics faculty not only adjusted easily to the migration from physical to electronic format, but also strongly preferred digital access in order to avoid going to the library. Sapa et al. (2014) and Gordon et al. (2020) found that mathematicians rely on personal relationships with colleagues to stay current in their highly specialized sub-fields and eschew following broader disciplinary developments. This limited method of information seeking works in mathematics because it is more siloed, less interdisciplinary, and moves at a slower pace than other STEM disciplines.

Gordon et al. (2020) argued that "mathematicians' work is usually understandable only to a small group of specialists" (p. 257). Steven Krantz, an American mathematician and scholar comments in his book Essentials of Mathematical Thinking (2017) that "mathematics is not like biology or physics or chemistry…A mathematician deals with ideas…in the end, a solution to a mathematical problem comes from pure thought" (p. 2). Such attitudes could lead mathematicians to assume that librarians lack the disciplinary expertise to be helpful. However, mathematicians with less experience in the field, such as new faculty and graduate students, have not yet formed their personal information-seeking habits and may be more open to learning IL skills from librarians (Rutter, 2002).

Methods

The research team used Qualtrics XM software to design a 20-question survey (Appendix A), which included a mix of quantitative and qualitative questions. Institutional Review Board (IRB) approvals were procured in the summer of 2023 from Butler University, the University of Colorado Boulder, and Rowan University.

The survey was disseminated to mathematics faculty and instructors in the United States and Canada during the first week of October 2023. To ensure broad outreach, recruitment invitations were posted to disciplinary listservs (Appendix B) and emailed to selected mathematics department heads and librarians with whom the researchers had established affiliations or previous contact. The researchers requested that these individuals further disseminate the survey to faculty members within their respective institutions. The survey was closed on November 14, 2023.

The research team reviewed all responses. 188 surveys were complete and were included in the study. Thirty-five participants indicated that they would be willing to be contacted for follow-up interviews and provided contact information, which was separated from the dataset and saved for future research efforts. Due to the limited size of the collected dataset (see Limitations), the data collected from participants' responses is presented using descriptive statistics.

Multiple questions on the survey gave participants the opportunity to answer in their own words by presenting them with a free-text box. For the questions regarding their teaching and research areas, participants provided a wide range of answers. Under the guidance of one of the research team members, who is a tenured mathematics professor, the research team grouped these areas and consolidated them into mathematical

subdisciplines for analysis purposes. Definitions of research areas are provided in Appendix C.

The open response options were included in many of the survey questions ('Course Materials,' 'Websites Used for Teaching,' 'Resources Wished from the Library,' 'Services Requested from the Library,' 'Reasons for not Working with the Librarian,' 'University Services or Centers Used,' and 'Conferences Attended'). These data were individually coded by all four authors, who then collaboratively agreed upon the themes within these answers. They then created a codebook for analysis. For example, in the variable 'Conferences Attended,' the responses "JMM," "Joint Math Meeting," and "Joint Mathematics Meeting" were regarded as identical.

Although most of the questions required participants to fill out or select one answer, four survey questions prompted participants to select all applicable options.

Results and Discussion

Results

Participant Demographics

The 188 survey participants were from institutions in 41 regions, including 34 states in the United States (89.4%, n = 168) and 7 provinces in Canada (10.6%, n = 20).

The largest age group of participants was between 30–39 years (28.2%, n = 53), followed by 60+ years (22.9%, n = 43), then 40–49 (20.2%, n = 38) and 50-59 (17.6%, n = 33), with the fewest number of participants identified as being from the 18–29 years group (11.2%, n = 21).

The majority (59.6%, n = 112) of the participants worked at public colleges or universities, whereas 38.3% (n = 72) were from private institutions. The remaining 2.1% (n = 4) were from community colleges and two-year colleges.

Institution Size

The largest group of participants (37.8%, n = 71) were from small institutions with an FTE student population under 9,999 (Figure 1). In contrast, the smallest number of participants were from large institutions, with 5.9% (n = 11) coming from institutions with 50,000 full-time equivalent (FTE) and 6.9% (n = 13) from those with 40,000–49,999 FTE. Figure 1 below shows the survey participants from each type of institution based on the student population of the institution.

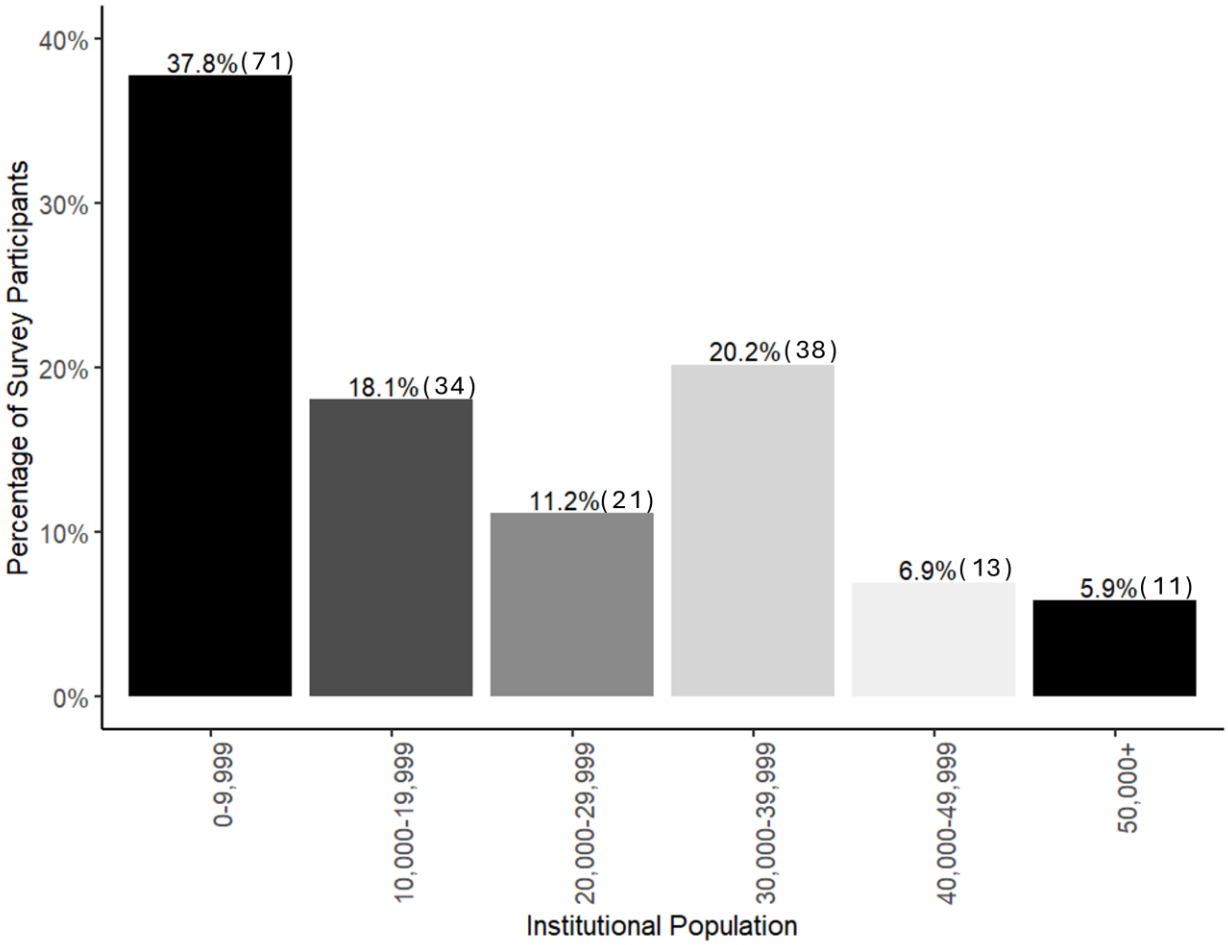

Figure 1. Institutional population of participants' institutions

Role or Rank of Participants

The majority (58.5%, n = 110) of participants identified their rank as "tenure-track professor" (Figure 2). The next highest categories were "full-time instructor" and "graduate, teaching or research assistant," both of which were selected by 20 participants each (10.6%).

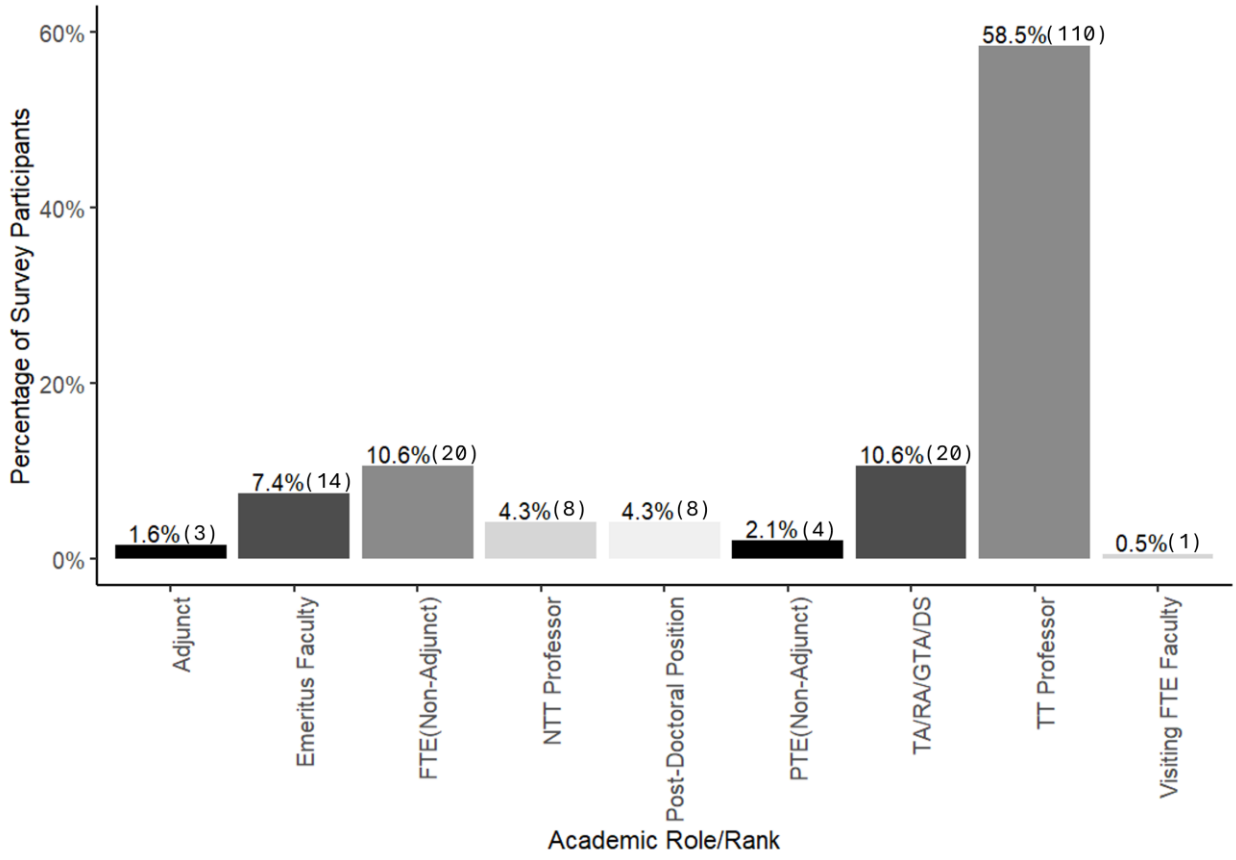

Figure 2. Academic role/rank of participants

Teaching Area of Participants

Participants were asked, "What is the primary area of Mathematics you teach?" The authors grouped the responses into the below-listed categories. For a complete list of answers, see Appendix C. It is important to note that the survey did not define these categories for participants. Each participant may have interpreted the listed options differently; therefore, this is a limitation of this study.

The largest group by teaching area included 35.3% (n = 65) of participants who reported teaching upper-level mathematics courses, followed by 21.2% (n = 35) of participants who teach lower-level mathematics courses, 16.8% (n = 31) who teach statistics, and 13% (n = 24) who teach applied mathematics courses (Figure 3). All remaining teaching areas, each of which were selected by 4% (n = 7) of participants or fewer, were combined into a single category called "All other teaching areas." This group had 13.6% (n = 25) participants and included the following teaching areas: mathematics education, physics, economics, graduate courses, participants teaching all areas of mathematical sciences, and four participants who do not teach.

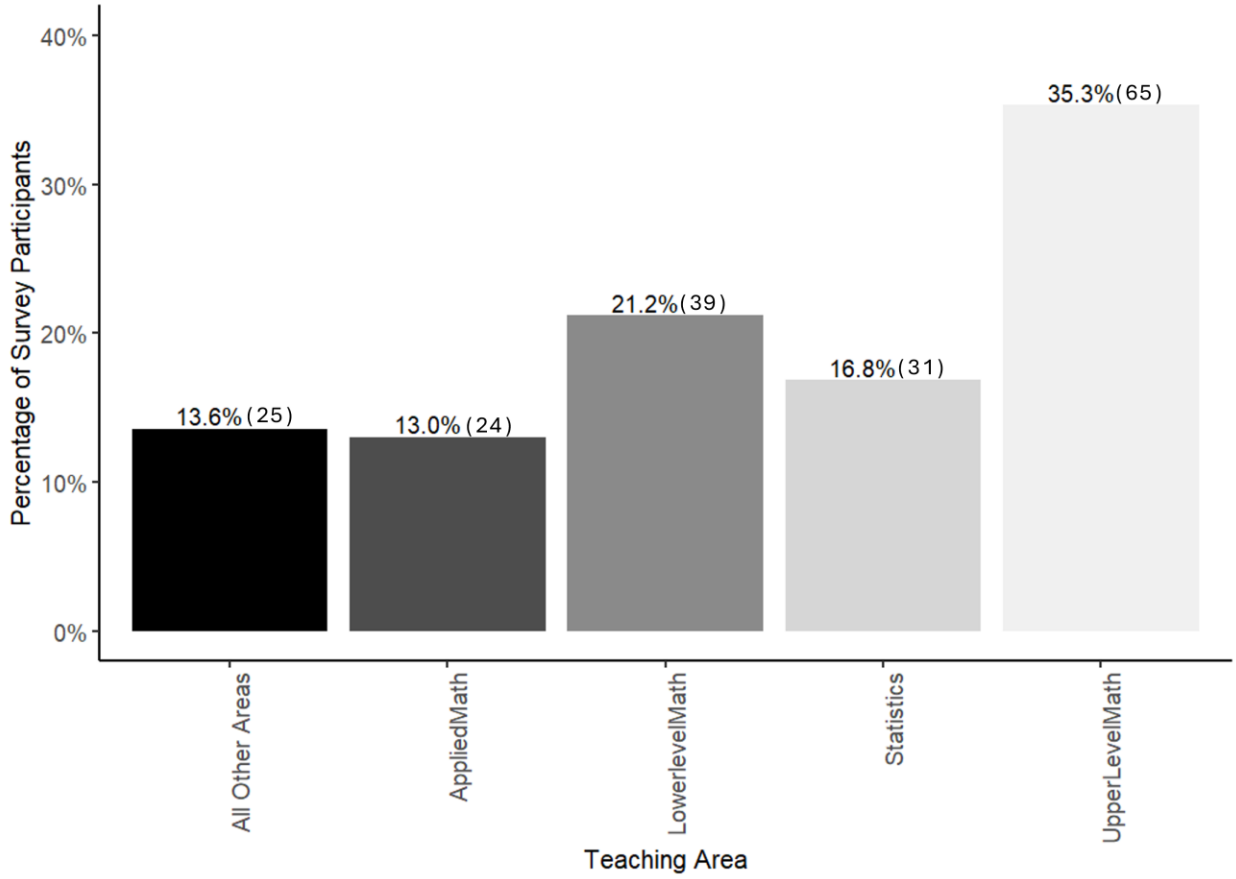

Figure 3. Teaching area of participants

Research Area of Participants

Participants were asked, "What is the primary area of Mathematics you research?" Similarly to the "Teaching Area" variable, answers included a wide variety of research topics. The authors grouped participant responses into the categories listed in Figure 4. For a complete list of answers, refer to Appendix C.

As with the Teaching Area variable, participants were not given these categories to choose from, as they were created by the researchers while coding the data to simplify the categories of research areas for analysis. This constitutes another limitation of this study.

The largest research category selected by participants was "pure mathematics," with 81 participants (44.1%). The next largest group was "applied mathematics" (22.9%, n = 40), followed by "statistics & data science" (17%, n = 31). 8.5% (n = 16) selected research in "education" and 7.4% (n = 14) indicated that they do not research (Figure 4).

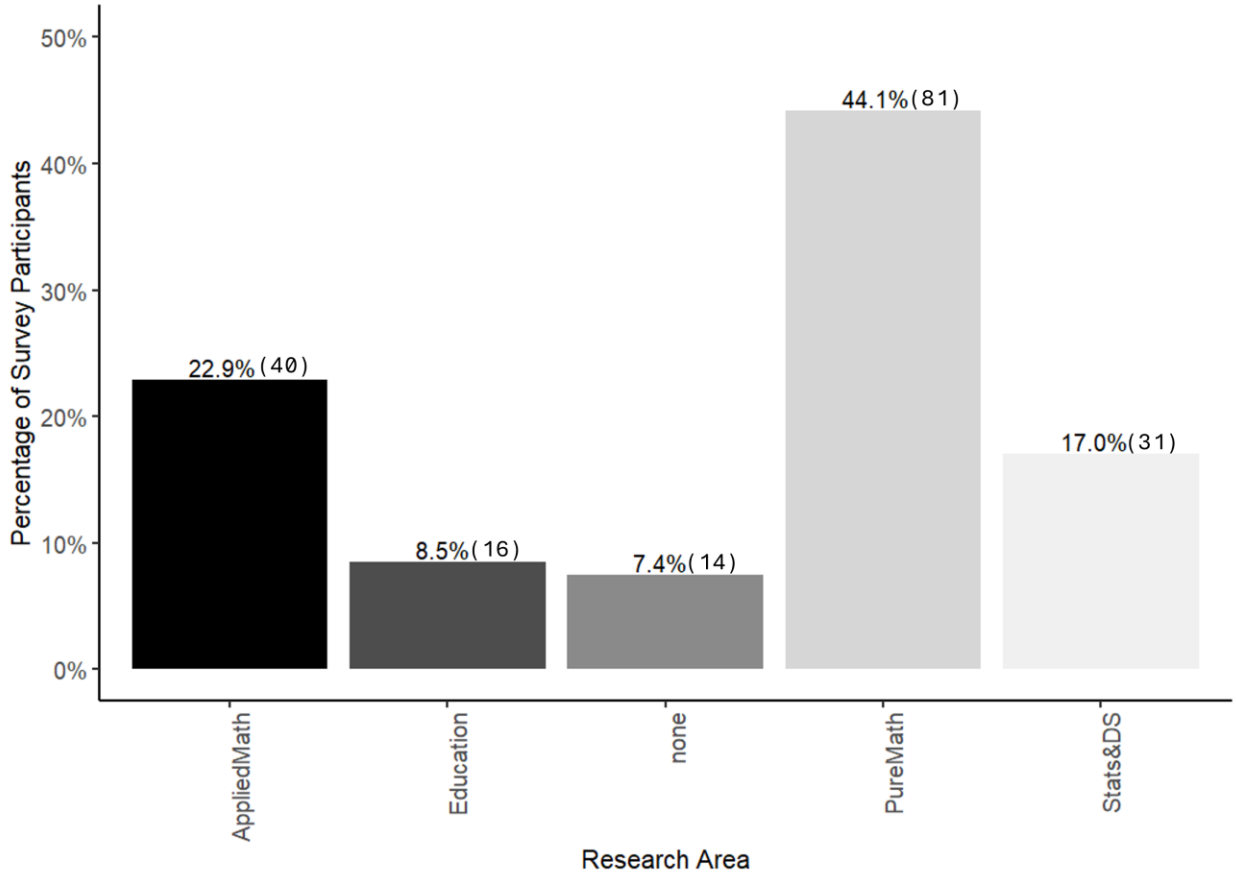

Figure 4. Research area of participants

Responses to Survey Questions

Q8. How Often Do You Interact With Your Librarian? Participants were asked to estimate the frequency of their contact with the librarian associated with their department. Almost half (47.9%, n = 90) of participants indicated that they contacted their librarian occasionally, which was defined as 1–2 times per academic year (Figure 5). 38.8% (n = 73) selected that they never contact their librarian, and only 13.3% (n = 25) said they contact their librarian often, which was defined as 3 or more times per academic year (Figure 5). Most of the survey participants (61.2%, n = 115) have contacted their librarian at least occasionally.

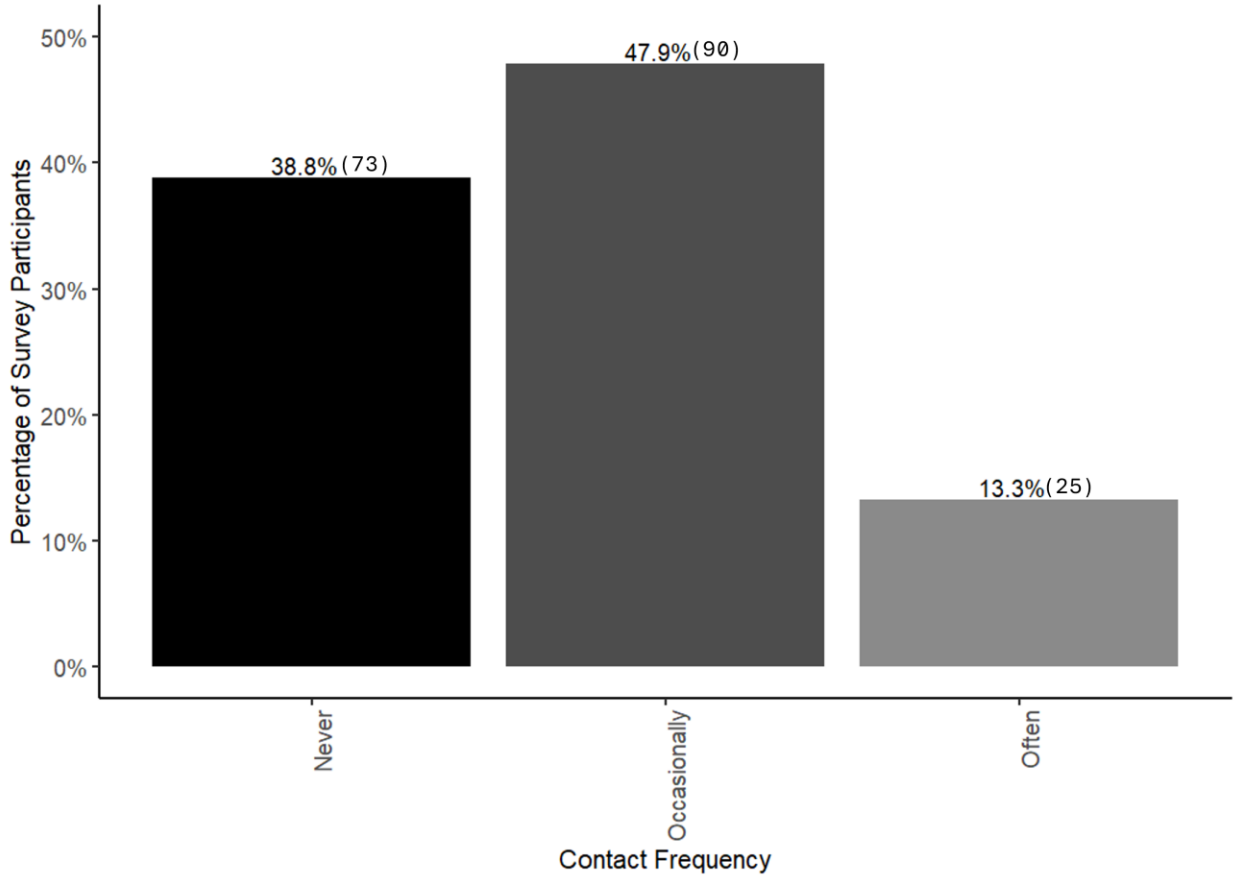

Figure 5. Contact frequency with the librarian (How often do you interact with your librarian?)

Q9. How Often Do You Encourage Your Students to Reach Out to the Librarian for Research Help? Participants were asked to estimate the frequency with which they refer students to a librarian for research help. Most participants (61.7%, n = 116) never encourage their students to contact a librarian. 28.7% (n = 54) of participants said they occasionally encourage their students to seek help from a librarian, and only 9.6% (n = 18) indicated that they encourage their students often (two or more times per semester) to contact a librarian (Figure 6). A little over a third of participants (38.3%, n = 72) have encouraged their students to contact librarians for research help at least occasionally.

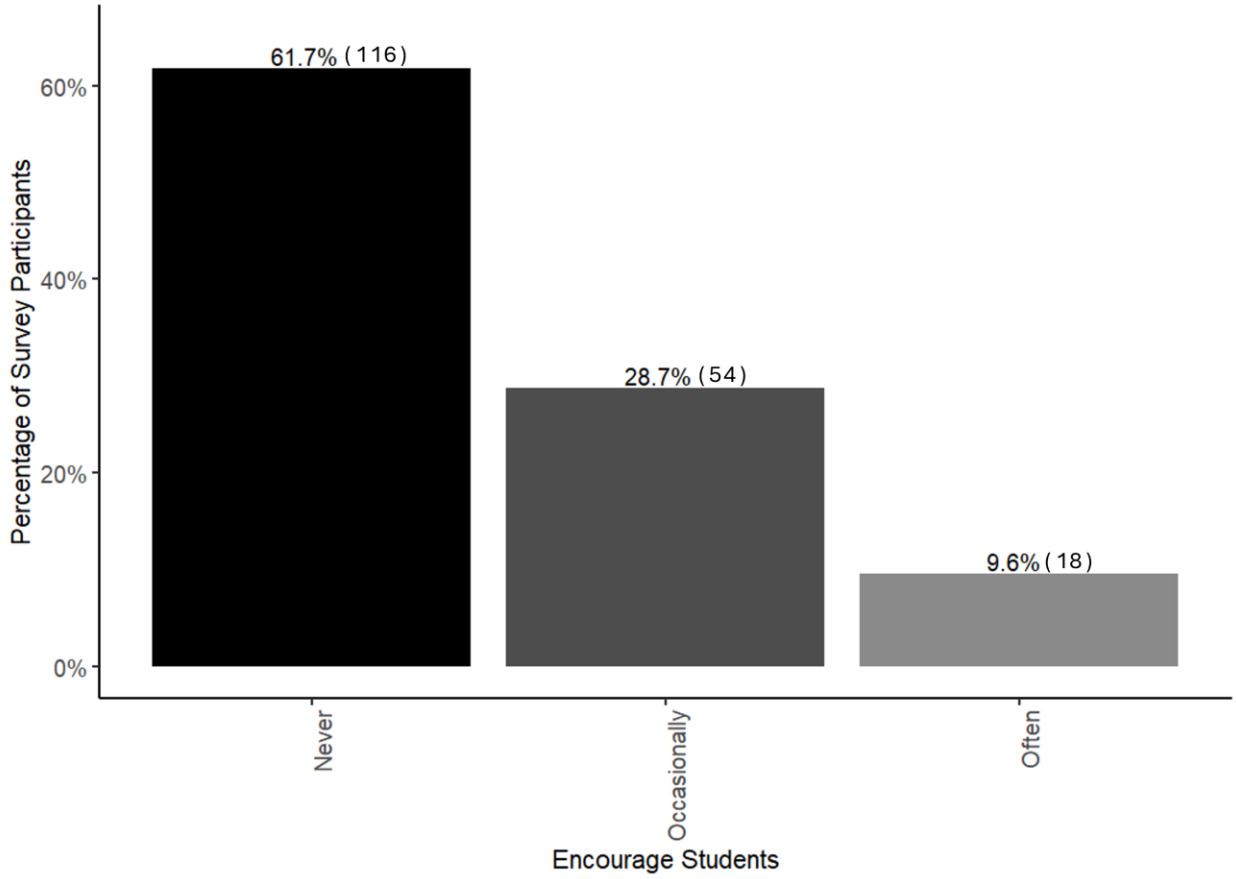

Figure 6. Frequency of encouraging students to contact librarians for research help

Q10a. What Materials Do You Use to Teach Your Courses? Select All That Apply. Participants were asked to identify the materials they use to teach their courses. Participants could select all relevant materials and could use an open response option to add additional materials not listed in the question. This question and all other questions that requested participants to 'select all that apply' resulted in two variables each in our dataset. One variable was from selecting all the applicable values from the list of values provided in the survey. The second variable was if the participants selected "other" from the list, they could enter any other value that was not listed in the survey.

For the first set of values, each participant had multiple selections from the given list. All the values selected by each participant were separated and processed to identify the frequency of each different value provided in the list. For example, under this question, the listed values were separated and the frequencies were computed to answer 'how many use textbooks?', 'how many use OER?', etc. The material most frequently used by participants was textbooks (34.4%, n = 164), followed by Open Educational Resources (OERs, 21.6%, n = 103), then websites (20.1%, n = 96) (Figure 7).

In the "other" category (8.6%, n = 41), survey participants listed a variety of additional resources, including participants' self-created, original teaching materials such as notes, self-written works, and a chatbot. The following materials were also mentioned by at least one participant: movies, software, online homework systems, articles, and press releases. For a complete list of "other" resources used by participants, please see Appendix D.

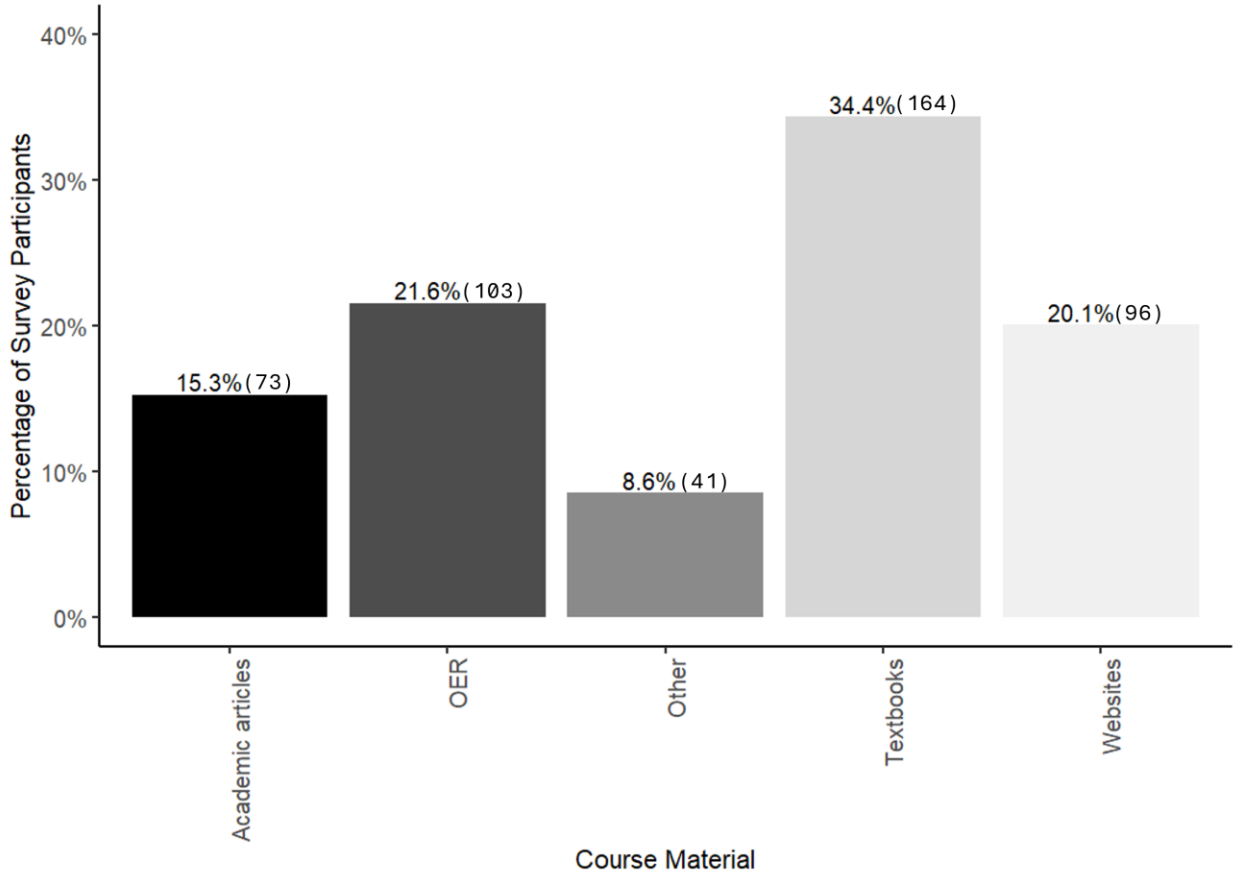

Figure 7. Materials used to teach courses

Q12a. Do You Work With Your Librarian for In-Class or Online Instruction Sessions? Participants were asked if they worked with librarians to provide in-class or online instruction sessions. Only 8% (n = 15) indicated that they did so, while 89.4% (n = 168) did not work with a librarian for instruction. 2.7% (n = 5) of the participants answered 'N/A' to the question (Figure 8).

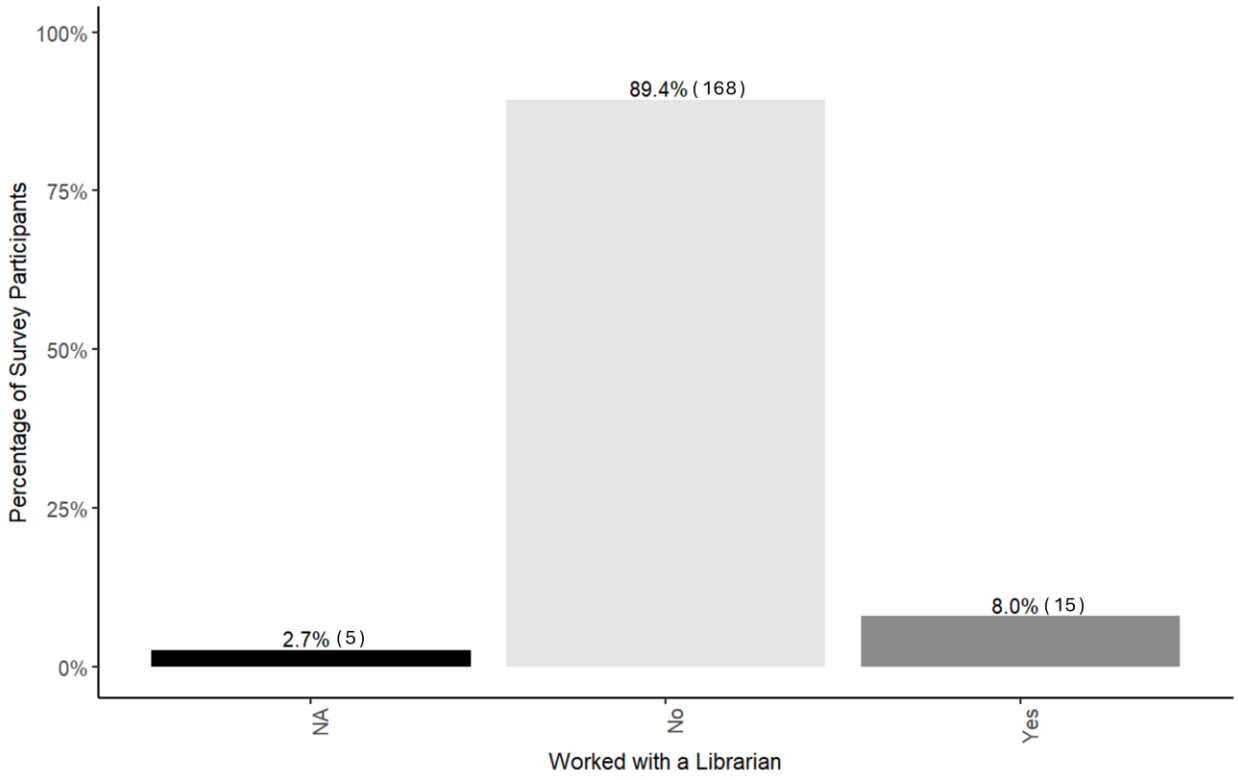

Figure 8. Frequency of working with the librarian for in-class or online instruction sessions

Q12c. What In-Class or Online Instruction Services Do You Request From Your Librarian? Select All That Apply. The 15 participants who indicated "yes" to working with their librarian to offer instruction were then asked what sort of instructional session (or materials) they requested. 14 participants indicated that they used various instructional services, including library instruction sessions (n = 11), creating online guides (n = 6), and developing online tutorials (n = 1). Note that this was also a 'select all that apply' question and data were processed similar to 'materials used to teach courses.'

In the "other" category, participants included collaborating with librarians to provide workshops about writing research papers, receiving help from librarians to find journal articles for class materials, and that librarians provided information to their classes about fair use and interlibrary loan.

Q12d. Why Do You Not Work With Your Librarian for In-Class or Online Instruction Sessions? Select All That Apply. Most participants (89.4%, n = 168) indicated that they did not request instruction sessions from a librarian. The reason most often selected for not having librarians teach instruction sessions was that students do not use library resources in the participant's course (46.3%, n = 88), followed by not knowing that librarians offered instruction (18.9%, n = 36), as shown in Figure 9 below. 15.8% (n = 30) of this group indicated that they did not have time in their class for library instruction (Figure 9).

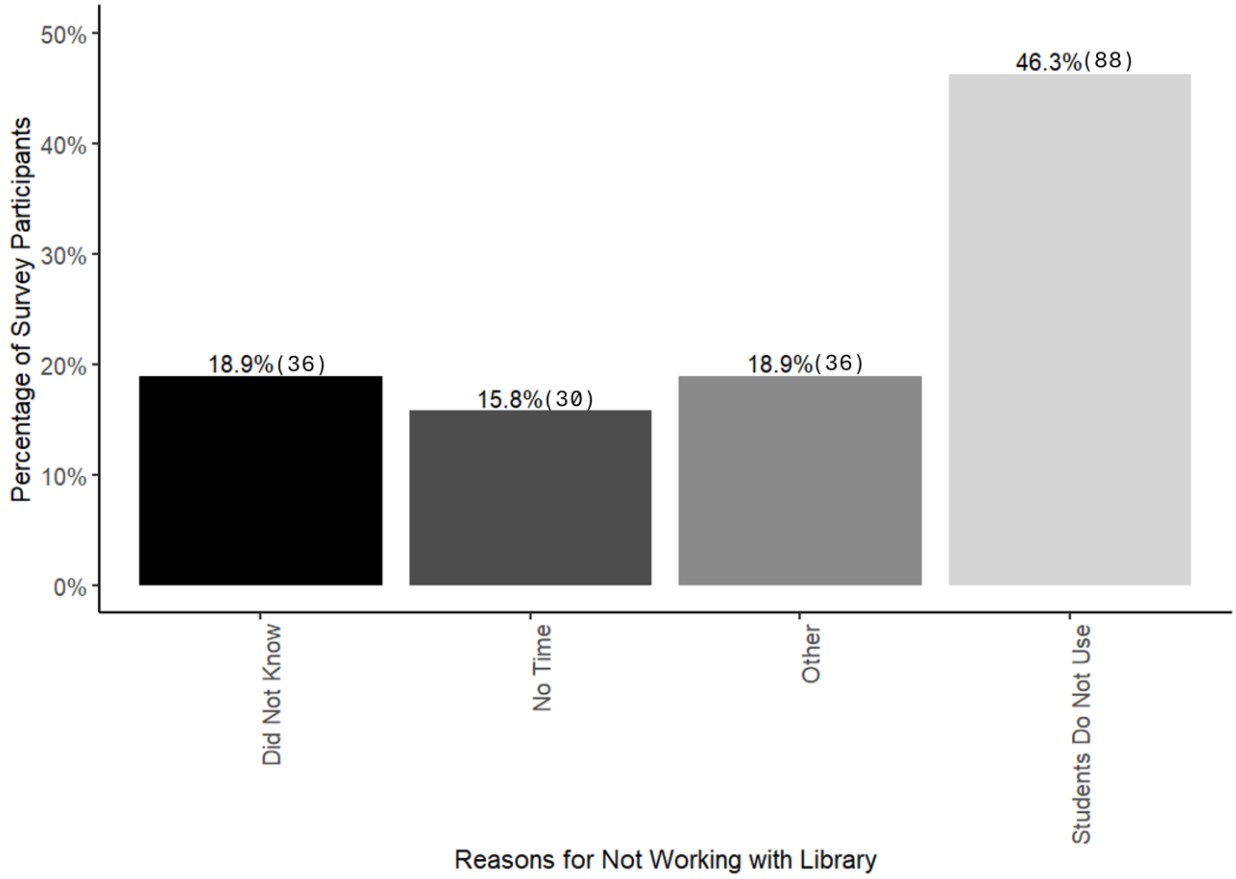

Figure 9. Reasons for not working with the librarian (Select all that apply)

18.9% (n = 36) of participants selected "other" and used the free response option to explain their reasons. Of the 36 participants who selected the "other" option, 5 participants provided no additional text in the free response box. Eleven participants indicated that they thought librarian instruction was unnecessary, six made statements that indicated they did not know what sort of instruction a librarian could provide, five participants stated they could provide such information themselves. Other responses included that they believed librarians lacked the necessary subject knowledge (n = 3), and that students could learn on their own (n = 3). One participant each stated that they had never considered such a session, were unsatisfied with past services from their librarian, and used other specific services in the library.

Q13. What University Services or Center Do You Use in Your Research and Publishing Process? Select All That Apply. Participants were asked which university services they use for their own research and publishing work. Note that this is also a 'select all that apply' question and data were processed similar to 'materials used to teach courses.'

The services most often selected include interlibrary loan (ILL) (44%, n = 128) and getting help finding research articles (21%, n = 61). 6.9% (n = 20) of participants indicated that they used data support services (such as data management plans, locating data sets, archiving data). Fewer participants, 5.5% (n = 16), each selected other services they used, such as publishing support, systematic review services, and writing centers (Figure 10).

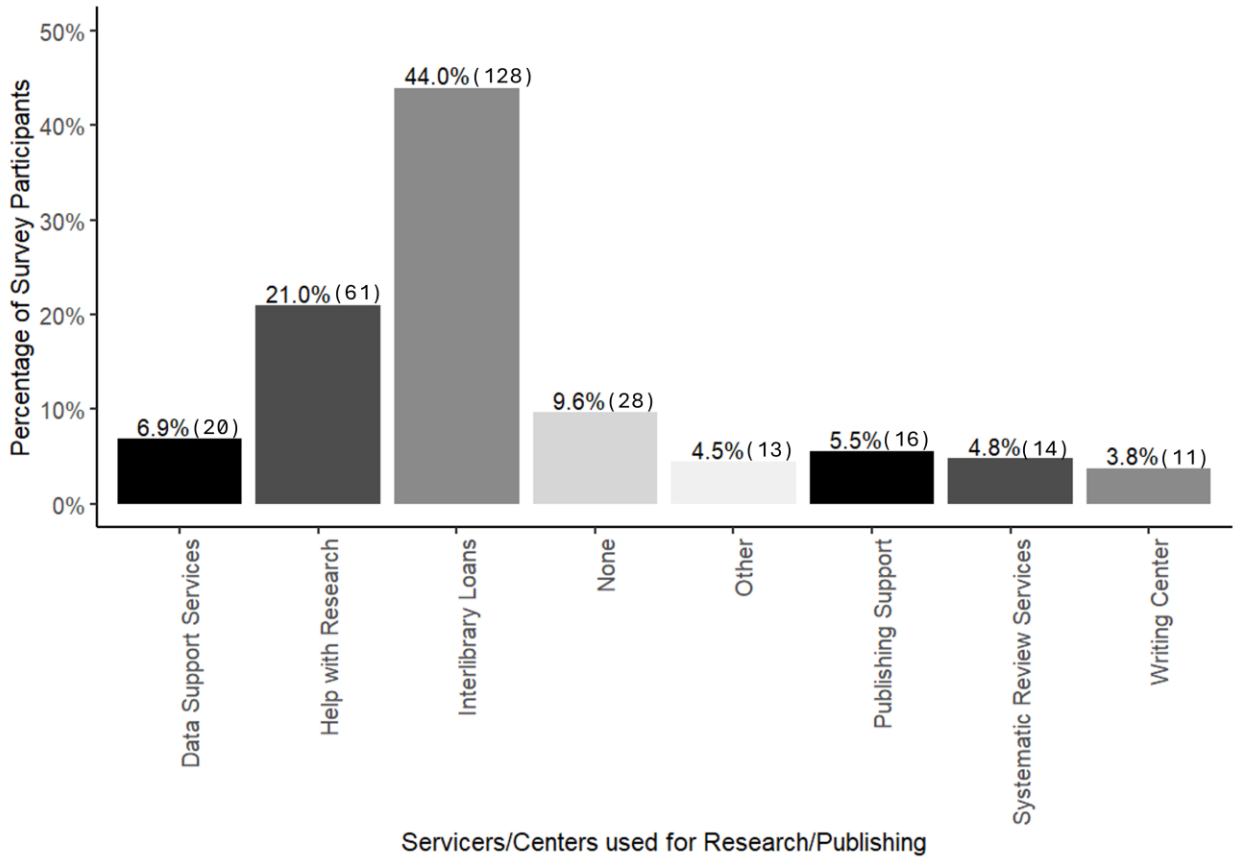

Figure 10. University services and centers used by participants for research and publishing (Select all that apply)

Q15. Is There Anything Else You Would Like to Share About Your Relationship With Your Academic Librarian and/or Library? (Open-Ended Question). 75 participants responded when given the opportunity to share their thoughts about this relationship. 36% (n = 27) said they liked their librarian or academic library. 8% (n = 6) participants commented that they were not aware of the services provided by their librarian or academic library. The remaining responses were generally positive and included comments about working collaboratively, having positive interactions, or that they used library services or equipment.

Some participants who responded to this question (13.3%, n = 10), however, expressed disappointment or frustration with their librarian or library, mentioning issues such as a lack of communication, trouble getting access to off-site materials, and that the materials or librarians were underfunded or did not meet their needs. One participant felt that their librarian was nice but unaware of basic databases and repositories relevant to mathematics. A few comments mentioned concern about institutional leadership undervaluing libraries and librarians.

Q11. If Cost Were No Issue, Are There Resources You Wish the Library Had That Could Support Your Teaching or Research? (Open-Ended Question). This question was answered by 61.7% (n = 116) of the participants. When asked what resources they wished to have in the library if cost were not an issue, the majority responded with journals (38.8%, n = 45) and books (29.3%, n = 34) in different formats. Seven faculty

requested textbooks, followed by six faculty who specifically wanted more e-books. The top 10 wished-for resources are available in Appendix E.

Comparing Multiple Aspects of Library Interactions

Q3. What is the Estimated Total Student Population That Your Institution Serves? VS Q8. How Often Do You Interact With Your Librarian? When looking at the three categories of interaction ('Never,' 'Occasionally,' 'Often') with their librarian, the participants from small institutions with a student population under 10,000 had the highest number of librarian interactions in each category as seen in Figure 11 below. This is not surprising as most of the participants were from small colleges with a student population under 10,000 students. Due to response bias, institution size (which was determined by institution's estimated student population) cannot be clearly tied to the frequency with which faculty interact with librarians, but as shown in Figure 11, participants from small institutions interacted with librarians more than at larger institutions.

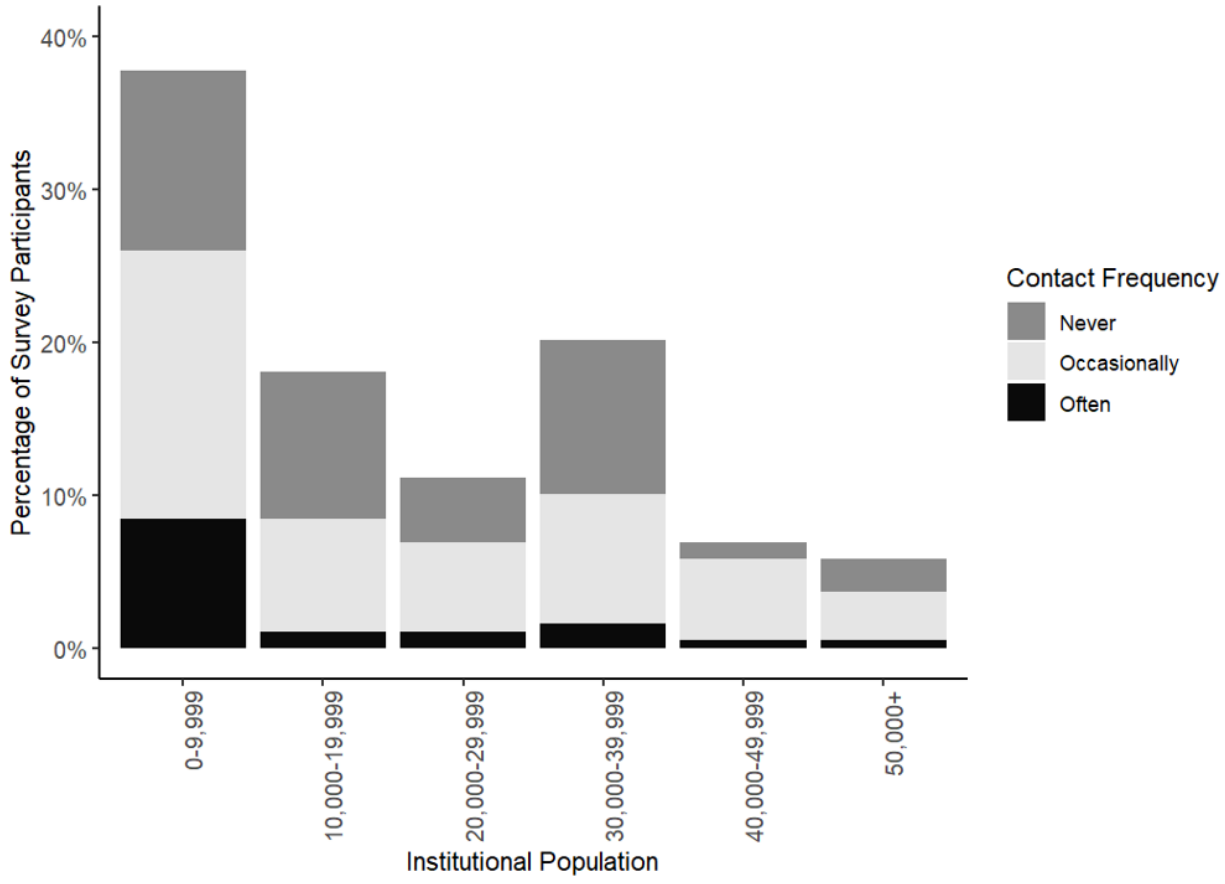

Figure 11. Institutional population and contact frequency (How often do you interact with your librarian?)

Q6. What is the Primary Area of Mathematics You Teach? VS Q8. How Often Do You Interact With Your Librarian? 97.9% (n = 184) of the participants indicated their teaching area; a small minority (n = 4) selected 'N/A.' Most of the participants teach upper-level mathematics (61.9%, n = 114) followed by participants teaching lower-level mathematics courses (20.1%, n = 37) and then those who teach both levels (17.9%, n =

33). Participants teaching upper-level mathematics showed the highest proportion in the three categories of contact frequency as shown in the Figure 12 below. Because they are the ones dominating all the categories of contact frequency, the authors cannot say for certain whether there is an effect of the teaching area on contact frequency.

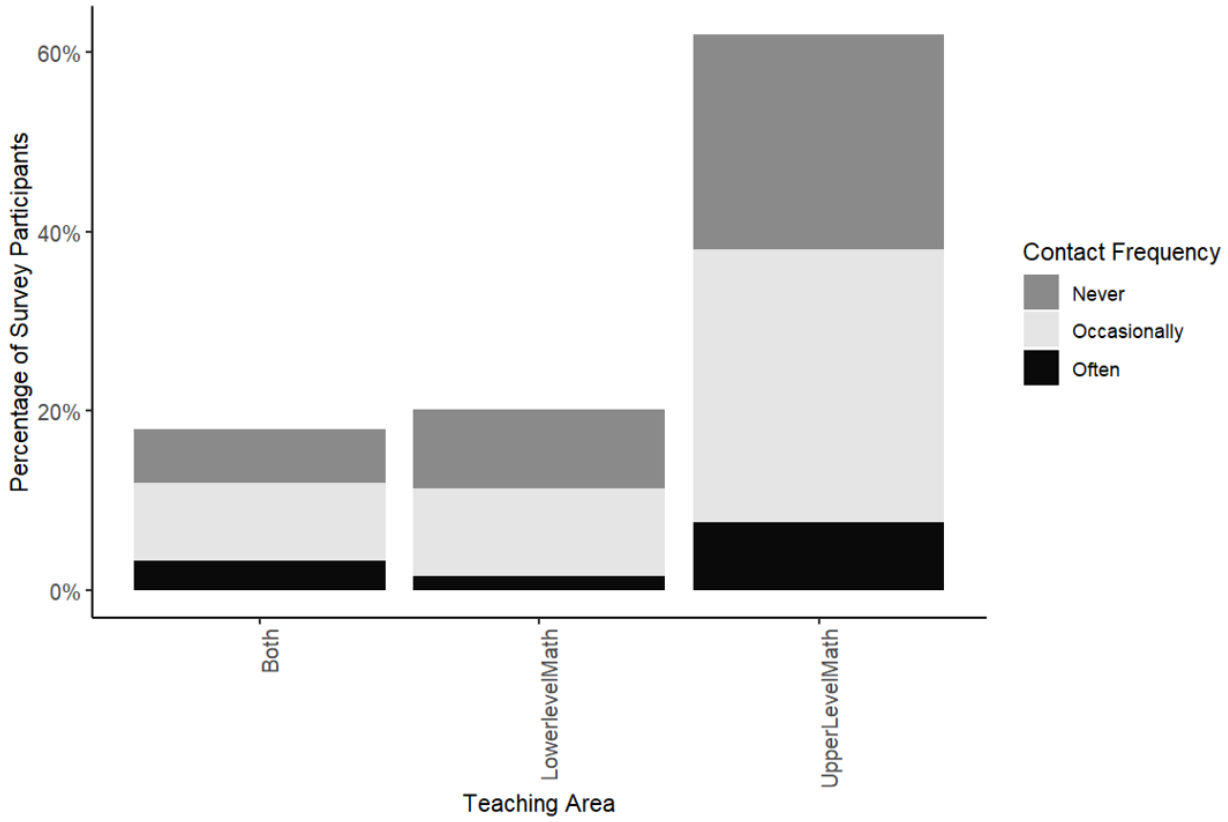

Figure 12. Teaching area and contact frequency (How often do you interact with your librarian?)

Q5. Institution Category VS Q8. How Often Do You Interact With Your Librarian?
The majority of participants were from public universities (59.6%, n = 112), with a smaller percentage from private universities (approximately 40%, n = 72). Although the participants from public universities were most represented in the survey data, the researchers observed that public and private university participants showed similar distributions of frequency of interaction with their librarians. Response data shows that in both groups the majority indicated that they "Occasionally" (1–2 times per academic year) interacted with librarians, followed by a smaller group that selected "Never," with the least-chosen group being those who selected "Often" (3+ times per academic year).

Instructors from private institutions indicated somewhat more frequent contact with librarians, with 65.3% (n = 47) having said they interacted with the library 'occasionally' or 'often,' compared to 58.0% (n = 65) from public institutions (Figure 13).

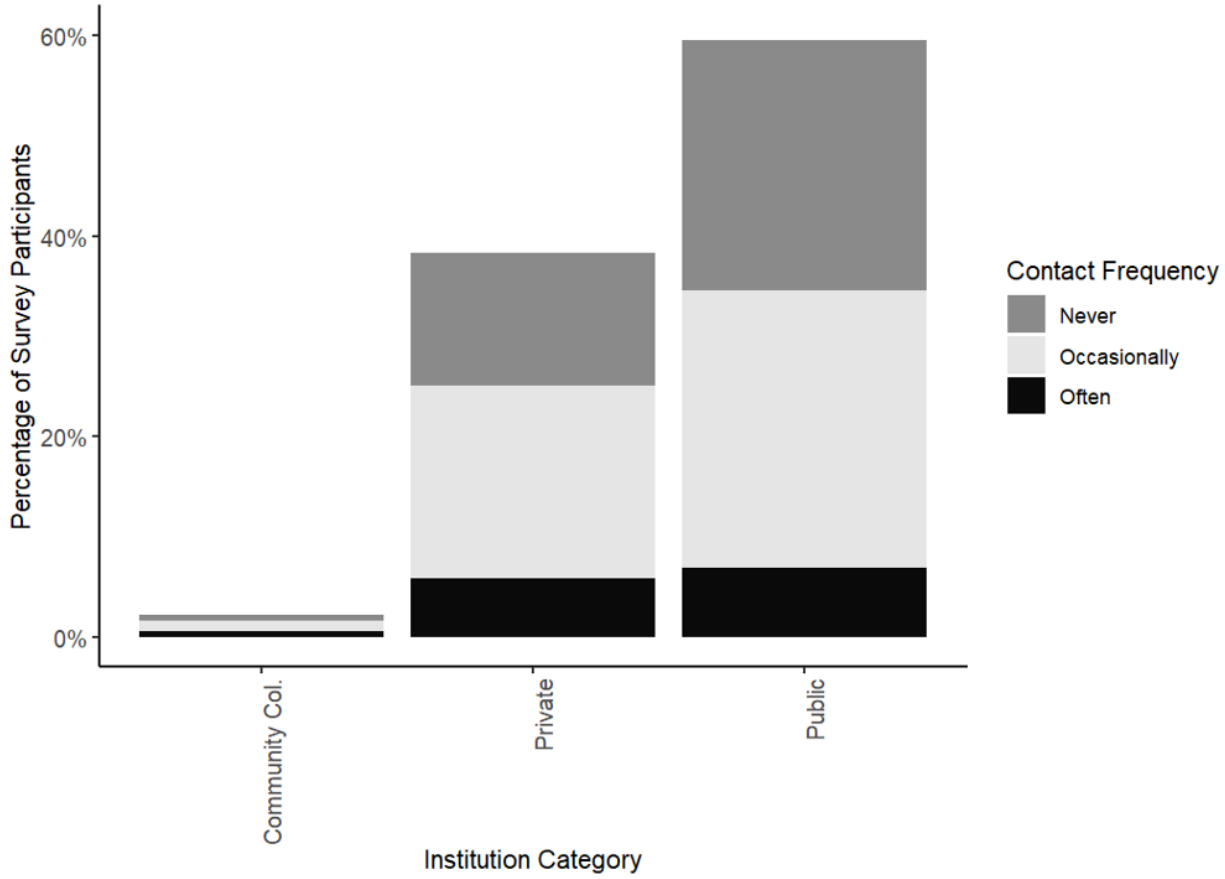

Figure 13. Institution category and contact frequency (How often do you interact with your librarian?)

Q8. How Often Do You Interact With Your Librarian? (Contact Frequency) VS Q9. How Often Do You Encourage Your Students to Reach Out to the Librarian for Research Help (Encouraged Students)? As seen in Figure 14 below, about 82.2% (n = 60) of participants who said they never interacted with the librarian also indicated that they have 'never' encouraged their students to reach out to a librarian. Out of the participants who said they 'occasionally' interact with librarians, 91.5% (n = 43) have 'occasionally' or 'often' encouraged their students to reach out to a librarian. Similarly, out of the participants who said they 'often' interact with the librarian, 64% (n = 16) have encouraged their students 'occasionally' or 'often' to reach out to the librarian. This shows that among the survey participants, the majority of those who interact with the librarian in some way, have encouraged their students to reach out to the library compared to those who 'never' interact with the library.

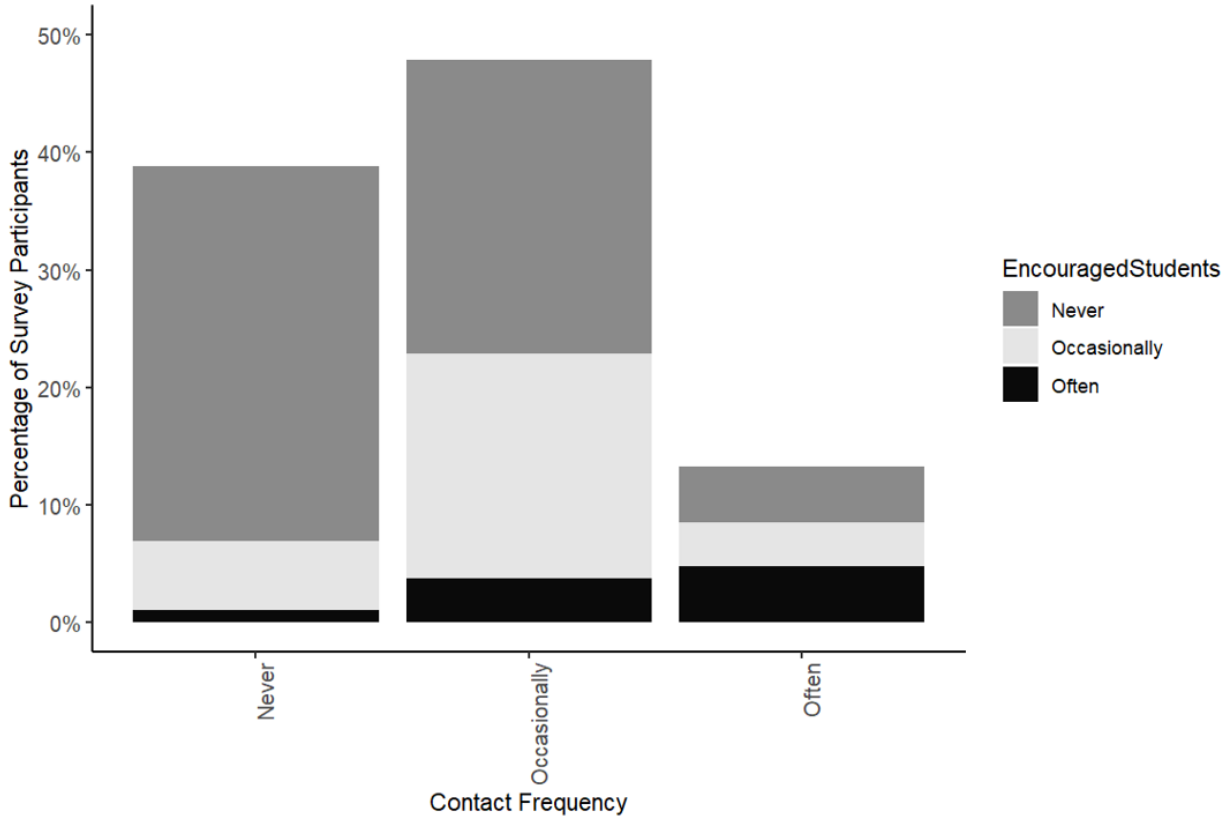

Figure 14. Contact frequency (How often do you interact with your librarian?) and encouraged students (How often do you encourage your students to reach out to the librarian for research help?)

Discussion

How Often Do Mathematics Faculty Interact With Academic Librarians?

The results of this study support the findings of previous LIS scholarship, finding that the majority of mathematics faculty and instructors do not have regular contact or collaboration with their subject librarians. More than a third of survey participants reported that they had never contacted their librarian, very few had worked with a librarian to provide IL instruction, and almost two-thirds had never encouraged students to contact a librarian for help.

Although some participants commented that they use librarian help to find things, such as articles for classes or high-quality OERs, most participants expressed that they prefer to find materials independently. This was reflected in statements such as, “99.9% of resources I use are available online and I use online materials available through the library. This is why I do not interact with librarians. I interacted twice in the last 10 years,” and “I really like my department's library liaison, and I feel kind of bad that I don't use her services more. But, I just don't need them 99% of the time.”

Additionally, participants clearly expressed their lack of interest in IL instruction; many reported that they feel able to teach students about IL without librarian help, they had no time for topics outside of the curriculum, and that mathematics courses generally do not use or need library resources. They expressed these sentiments in statements such

as, “I can instruct students on how to find materials myself,” and “[t]he library is an excellent resource, but typical lower-level math courses do not need to make much use of it,” and commented that IL instruction “would not be useful for the course material,” “doesn't seem relevant,” and is “not necessary.”

Another reason participants gave for their lack of interest in IL sessions in their classes was that, due to a challenging curriculum, they had too much course material to include topics that were not clearly relevant to class topics. For example, one participant wrote, “I do not view it [library instruction] as especially relevant, and we already have very limited class time.” A few participants also expressed that IL skills could be learned outside of class, which was demonstrated in comments such as, “I assume that if I direct students to a library resource that they will use their own time to learn to access the resources,” and “I expect students to seek help from the library personnel on their own.”

A theme revealed by the survey data is that many participants had little knowledge of librarians’ skill and expertise and did not know how IL instruction would support students in their mathematics work. This general lack of knowledge was expressed in statements such as, “I'm not sure what resources the librarians could offer that would be helpful in my class,” “I don't know what they could do,” “I’m not sure how librarians in-class instruction could help,” and “I don't know what services there are that would be helpful to math courses, to be honest.”

Highlighting the complexity of their subject area, these individuals argued that librarians’ lack of subject expertise precludes their ability to offer helpful instruction or assistance. Examples of such comments include, “Librarians do not have the requisite familiarity with mathematical research methods” and “math is too advanced and technical for a librarian typically to deliver independent insight on mathematical topics.” Such comments demonstrate that at least some participants do not understand what librarians mean by “information literacy instruction,” and seemed to have incorrectly assumed that librarians were suggesting that they could assist them in teaching mathematical skills or theory.

Although many participants expressed a lack of knowledge, some expressed interest in learning more about what librarians do and what they could offer students and researchers. For example, one participant wrote, “I did not realize that librarians can support in the ways mentioned above. I have traditionally done all these things myself. I believe that if our librarians made it more clear how they would interact with us and we had a more familiar relationship, I would be interested in utilizing them more.” It is noteworthy that a lack of knowledge about librarianship is not unique to mathematics departments; LIS research shows that many academic departmental constituents do not fully understand librarians’ roles on campus, nor do they know about the full extent of the services, skills, knowledge, and support librarians offer (Becksford, 2022; Fagan et al., 2021).

To counter this lack of knowledge and increase interest in collaboration, librarians must continue to educate and inform their departments about their knowledge, instruction, resources, and services. Finding ways to effectively communicate about these offerings

could significantly increase departmental interest and contact. However, given the low levels of contact reported by survey participants, librarians may need to change their outreach, communication tactics, or even the language being used.

Some LIS researchers argue that IL skills are more valued and frequently integrated into STEM curricula when perceived as integral to the scientific research process (Buljung et al., 2023; Coil et al., 2010). Buljung et al. (2023) noted that the use of library-specific terminology deters STEM faculty from incorporating IL instruction into their courses. Similarly, Mercer et al. (2020) found that the use of alternative terms such as "critical appraisal" evokes a "critical mindset around information," which they find to be more relevant to STEM faculty (p. 147).

Another strategy would be for librarians to focus their outreach efforts on departmental partners, such as graduate and undergraduate chairs, research lab coordinators, curriculum coordinators, and support staff, who may be more open to learning about library services and could increase librarian visibility. Librarians could also utilize a top-down approach by enlisting the assistance of library deans and directors to communicate directly with other departments' leaders, which could result in new communication channels and opportunities for collaboration.

An excellent way librarians can raise awareness of the value of libraries across campus is to participate in institution-wide committees, which provide opportunities for them to develop relationships with faculty members across different disciplines. If this is not required or possible, librarians can volunteer to participate in other institutional groups such as committees, boards, professional working groups, and learning circles that take place outside of the library.

Other unconventional methods to build connections could include participating in field research for supported departments, offering assistance in projects where a teaching assistant may not be available, becoming a student club sponsor, or applying for faculty-in-residence, a program in which a faculty member lives in a student residence hall and actively engages with students. Such activities and efforts may serve to increase the visibility of librarian skills and knowledge as well as library services and resources through increased contact and positive association.

For What Purposes Do Mathematics Faculty Interact With Academic Librarians?

The survey results indicated that mathematics faculty and instructors have little interest in librarians providing IL instruction in their classes; however, participants utilized the library for other needs such as databases, ebooks, and other information resources. The vast majority of faculty indicated a desire for more access to both online and physical materials such as journals, books, ebooks, and textbooks. Most participants (61%) reported having interacted at least occasionally with their librarian in some way. Additionally, a fifth of participants (21%) indicated that they had assistance finding a resource, and almost half (44%) had used Interlibrary Loan (ILL) services. Some participants indicated that they use specific library services, such as data support services, publishing support, systematic review support, and writing centers.

Despite many survey participants reporting low levels of contact and collaboration with their librarians, some expressed the opposite sentiment: that they value working with their librarians. Although small (8%), this group offered ways they have found librarian support helpful. Of this group, several commented that they appreciate the contributions of librarians' IL instruction, others reported encouraging their students to seek help from their librarians when conducting literature searches, and some appreciated librarian expertise when planning the readings for their courses.

One participant wrote about the many ways their librarian was helpful:

> I personally find the librarians a very valuable resource for both myself and the students. Most of the classes I teach have some research component, and I encourage students to consult the librarians on their literature searches. I request aid from the librarians each year to help set up my reading list (with links in LMS) and course reserves. In terms of research, the librarians are helpful at navigating open-source journals and publishing pre-prints.

Another mentioned the value of having a subject librarian who was familiar with mathematics resources:

> Our academic librarian…. reaches out to us regularly, and is a fantastic resource. I've started collaborating with her more on my classes in the last year, and am excited to do more in the future. Having disciplinary librarians is SO valuable for math departments.

Scholars have noted an increased demand for library support in technical services such as data management, geographic information systems (GIS), standards, open educational resources (OERs), and guidance on scholarly communication and publication (Bishop et al., 2023; Reed & Butkovich, 2017; Sterner, 2020; Tenopir et al., 2015). Librarians can shift their focus from IL instruction to providing desirable services, such as offering training in coding, such as Python and R, or demonstrating how to use LaTeX or Github.

Perhaps most significantly, librarians have the opportunity to participate in critical conversations taking place across academia about artificial intelligence (AI). Academic libraries and librarians are well-positioned to offer leadership and insight into AI-related issues such as bias, academic integrity, copyright, privacy, corporate influence on information access, among so many others. Already, librarians have been called upon to help untangle this complex new development in the information environment (Coffey, 2024). Many libraries are beginning to offer panel discussions and presentations about AI and information literacy. This opens additional opportunities for collaboration with multiple disciplines, including mathematics.

What Resources and Services Do Mathematics Faculty Use for Their Research and Instruction?

Some participants commented about their appreciation for library resource discovery tools; for example, "I use the library for my own research, but this is mostly through electronic resources since I am almost always searching for a very specific academic paper in a paywalled journal," and:

> I tell everyone about the Article Database. I love looking through books and am really happy that so many texts are available online. The process is already quite simple...but I think this is such a valuable resource for students, that it should be integrated even further into their education.

15% of participants said they used academic articles in their courses, whereas 34% used textbooks, 22% used open education resources, and 20% used websites. A small percentage of participants offered personalized comments about course materials. Of these, many stated that they develop or find their own materials, and made comments such as "...we are aware that the library exists and that academic librarians exist, but there is little time to navigate the library. Now that most resources are online, most interaction with anyone in the library is behind the scenes". In addition to using ILL and utilizing their library's catalog for their own research, some participants (6.9%) indicated that they used data support services, which the survey defined as consisting of data management planning, locating data sets, and archiving data. As funding agencies continue to require data management plans and the open access publication of research and datasets, collaborations with librarians to meet these requirements will likely increase.

In addition to learning about what library services and resources participants currently use, the research team was interested in what resources participants would like their libraries to have if cost were no issue. Participants mentioned a wide variety of desired materials, such as access to expensive software like Overleaf (an online LaTex editor) and NVivo (qualitative data analysis software), virtual lecture rooms, more study rooms for students, and one participant wanted a license to The Great Courses as supplemental course material. Some participants made suggestions for additional library services, such as the library providing the funds for article publication charges (APCs), libraries extending open hours, librarian support for OERs and systematic review services, as well as library-provided writing support for graduate students. Interestingly, a few participants mentioned IL sessions and more collaboration with their librarian as "wished for" resources.

Limitations

This research project contains several limitations. First, due to the unknown number of people who received the survey, no exact response rate could be calculated. A specific challenge in distributing the survey came through mathematical organizations not allowing the survey to be distributed through their main listservs. Both the American Mathematical Society and American Society of Engineering Educators allowed the survey to be disseminated in their librarian divisions as the librarians could then

contact their supported departments. The Mathematical Association of America would not allow their listserv to be used, which would have gone directly to mathematics faculty. Additionally, it is unknown how many direct contacts further distributed the survey.

A second limitation is that due to the methods of survey distribution, the mathematics faculty who participated were self-selecting. The majority of those who participated were from the United States, identified as being on the tenure track, and worked at PhD granting institutions. The prevalence of this demographic in the data prevented the research team from learning about the relationships between librarians and faculty at other types of institutions and with non-tenure track faculty. Additionally, the survey did not ask participants if they had achieved tenure (associate professor) or were working towards tenure (assistant professor), so the study cannot speak to differences between those with and without tenure.

A third limitation of this study is that a disproportionate number of participants came from Colorado and Indiana. The research team attributes this to the professional connections in these states, which allowed us to reach more mathematics faculty in these areas.

A fourth and final significant limitation to this research is that the final number of responses, after removing missing values in some variables, were insufficient to run some statistical models. The research team's plan was to apply statistical models to the dataset to identify the impact factors, however, the team estimated that less than 1% of all mathematics faculty working in the United States and Canada responded to this survey. Therefore, the information, data, and conclusions of this study are speculative and cannot be generalized.

Conclusion

Many of the themes that emerged in the survey responses involved communication and the need to build both relationships and faculty awareness of academic librarians and libraries. Given that when asked why they do not work with the library, nearly a fifth of participant responses indicated that they were not even aware that the library offered instruction, communication efforts could be improved. Libraries must continue to be creative in their outreach and connection efforts.

Additionally, some participants felt that librarians did not have the discipline-specific knowledge to be able to assist their students in research. To become more aware of what Mathematical Sciences departments and professionals are researching and utilizing, librarians should seek professional development opportunities within the mathematics field. This could include upskilling in data practices, AI, and software or even attending math specific conferences, webinars, courses, and lectures. Such efforts can help librarians understand new developments in the departments' fields, develop effective common language for more effective communication, and create a stronger awareness of the materials, resources, software, and skill sets that mathematics departments are utilizing.

There are several potential research topics that became apparent throughout this project, including the exploration of relationships between math faculty and librarians at a variety of different types of institutions of higher education, such as at two year/community college/associate degree granting institutions. It may be relevant to investigate if non-tenure track faculty and instructors have different attitudes towards and relationships with librarians in comparison with those on the tenure track. Additionally, further research based on the suggested alternative outreach and marketing strategies could be investigated.

Acknowledgments

Thank you to our many readers for their input and assistance with this text.

- Dr. Jonathan Webster, Associate Professor of Mathematics and Actuarial Science, Department of Mathematical Sciences, Butler University
- Amanda Rybin Koob, Assistant Professor, Literature and Humanities Librarian, University Libraries, University of Colorado Boulder
- Sue Wiegand, Scholarly Communications Librarian, Cushwa-Leighton Library, Saint Mary's College

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Appendix A

Survey Text and Questions

Mathematics Faculty Information Survey

Introduction:

If you are a faculty member in a mathematics department in an institution of higher education in the United States or Canada, we invite you to participate in our research by completing a brief online survey. The purpose of this study is to gather feedback from faculty about how academic librarians can better support them and their departments. This survey contains up to 20 questions and will take approximately 10 minutes to complete. We appreciate your participation and input.

Benefits: As a participant in this study, there may not be any direct benefit to you; however, information from this study may benefit academics in the future.

Risks and Confidentiality: There are no known risks to participate in this study. The information obtained in the study may be published in scientific journals or presented at scientific meetings, but your identity will be kept strictly confidential.

Participant information will be stored in a password protected survey platform (Qualtrics). Access will be restricted to the research team. Data will be anonymized and stored on a secure Google Drive account. Any data made public in an open repository will be anonymous.

If you choose to include your name or email address to be contacted for future research, your information will be kept confidential and only provided to the research team. Such data will be stored in Qualtrics or a secure and access-restricted computer file.

Costs: No compensation will be provided for your participation.

Participation: Your participation is voluntary. You may refuse or discontinue at any time without penalty or discrimination by closing the survey window. By participating, you indicate that you consent to all stated conditions.

Age of Consent: 18 years of age or older

Questions: If you have any questions about this study now or in the future, you may contact: Jennifer Burke (jburke1@butler.edu).

For questions about your rights as a research participant or to discuss problems,

complaints or concerns about a research study, or to obtain more information, or offer input, contact Jennifer Burke (jburke1@butler.edu).

If you wish to retain this information, please print this page for your records.

Are you 18 years of age or older and consent to participate in this survey?

o Yes (1)

o No (2)

Skip To: End of Survey If Are you 18 years of age or older and consent to participate in this survey? = No

1. In what US State or Canadian Province do you work?

▼ AL (1) ... Canada - Saskatchewan (63)

2. Select your age category:

o 18-29

o 30-39

o 40-49

o 50-59

o 60+

3. What is the estimated total student population that your institution serves?

o 0-9,999

o 10,000-19,999

o 20,000-29,999

o 30,000-39,999

o 40,000-49,999

o 50,000+

4. What category closest matches your role/rank:

o Teaching Assistant/Research Assistant/Graduate Assistant/Doctoral Student

o Post-Doctoral Position

o Instructor/Lecturer - FTE (Non-Adjunct)

o Instructor/Lecturer - PTE (Non-Adjunct)

o Tenure-Track Professor (Assistant/Associate/Full)

o Non Tenure-Track Professor (Assistant/Associate/Full)

o Adjunct Instructor/Professor

o Visiting FTE Faculty

o Emeritus Faculty

5. What category closest matches your institution:

o Private College/University

o Public College/University

o Community college/2-year college

o Technical college

6. What is the primary area of Mathematics you teach?

_____

7. What is the primary area of Mathematics you research?

_____

8. How often do you interact with your librarian?

o Never

o Occasionally (1-2 times per academic year)

o Often (3+ times per academic year)

9. How often do you encourage your students to reach out to the librarian for research help?

o Never

o Occasionally (1 time per semester)

o Often (2+ times per semester)

10a. What materials do you use to teach your courses? Select all that apply:

▢ Textbooks

▢ Open Education Resources (OER)

▢ Academic articles

▢ Websites

▢ Other _____

10b. What materials do you use to teach your courses? Select all that apply: = Websites

What websites do you use for instruction?

_____

11. If cost were no issue, are there resources you wish the library had that could support your teaching or research?

_____

12a. Do you work with your librarian for in-class or online instruction sessions?

o Yes

o No

12b. Do you work with your librarian for in-class or online instruction sessions? = Yes

What in-class or online instruction services do you request from your librarian? Select all that apply:

▢ Creating online research guides

▢ Presenting library instruction session(s) to students

▢ Developing online tutorials

▢ Other _____

12c. What in-class or online instruction services do you request from your librarian? Select all that

Please list course names and level (undergraduate or graduate) for which you work with a librarian:

_____

12d. Do you work with your librarian for in-class or online instruction sessions? = No

Why do you not work with your librarian for in-class or online instruction sessions? Select all that apply:

- ▢ Students do not use library resources in my courses
- ▢ I have no time for a library session
- ▢ I did not know librarians could offer instruction
- ▢ Other _____

13. What university services or centers do you use in your research and publishing process? Select all that apply:

- ▢ Data support services (i.e., data management planning, locating data sets, archiving data)
- ▢ Help with searching for research articles (i.e., finding specific databases, keyword development)
- ▢ Interlibrary loan/ILL (requesting articles/books from other libraries)
- ▢ Publishing support (i.e., publisher agreements, identifying predatory journals, access to citation metrics)
- ▢ Systematic review services (i.e., creating and/or running search strategies, reviewing literature)
- ▢ Writing center (i.e., copyediting, formatting assistance, citation help, writing development)
- ▢ None
- ▢ Other _____

14. What conferences do you attend?

15. Is there anything else you would like to share about your relationship with your academic librarian and/or library?

_____

Optional Contact Information

16. If you are willing to be contacted for a follow-up interview regarding your partnership with your academic librarian, please provide your name and email below:

_____

Appendix B

List of Contacts Used By Mathematics Faculty Participants for Instruction

Library Organizations:

- American Library Association (Association of College and Research Libraries)-Community and Junior Colleges of Library Sections listserv: CJCS
- American Library Association (Association of College and Research Libraries) Science and Technology Section listserv: STS
- Association of Christian Librarians (ACL)
- Association of College and Research Libraries: College Libraries Section
- Association of College and Research Libraries: Instruction Section
- Association of College and Research Libraries: New Jersey Librarians Chapter
- Philadelphia area Science Technology Engineering Librarians (PASTEL)
- Physics-Astronomy-Mathematics Division of the Special Libraries Association listserv (PAMnet)
- Private Academic Library Network of Indiana (PALNI) Community Announcement Webpage
- STEM Librarians Collaborative #general Discord Channel

- STEM Librarians and/or Library Department Heads at: Case Western Reserve University, the Colorado State Library, Goshen College, Grace College, Maryville University, Purdue University, Regis University, University of California Berkley, University of Denver, University of Michigan, University of Northern Colorado, University of Southern Indiana, and the US Naval Academy.

Mathematics Organizations:

- American Mathematical Society (AMS) Newsletter for Librarians*
- Canadian Mathematical Society
- Engineering Librarian Division of American Society of Engineering Education* listserv: ELDnet-I
- Isolated Statisticians listserv
- Department Heads and/or Faculty members of Mathematics Departments at: Ball State University, Butler University, Colorado State University, Community College of Denver, Front Range Community College, Marion University, Oklahoma State University, Robert Morris University, University of Colorado Boulder, University of Colorado (Colorado Springs), University of Colorado Denver, and Texas A&M University Mathematics departments
- Mathematical Association of America*

Appendix C

Definition of Mathematics Faculty Research Areas

How the researchers understand these areas:

Pure Mathematics is, in simplest terms, math for math's sake. Pure math explores abstract concepts, complex theories and never-before-solved problems. The field is more about study and research than solving a particular real-world issue. (https://www.northcentralcollege.edu/news/2023/01/11/pure-mathematics-vs-applied-mathematics)

Applied Mathematics combines mathematical concepts with specialized knowledge from various disciplines to solve practical problems. (https://www.cmich.edu/blog/all-things-higher-ed/pure-math-vs-applied-math)

Mathematics Education is the study of how people learn and teach mathematics meaningfully. (https://math.asu.edu/research/math-ed)

Appendix D

What materials do you use to teach courses?

Course Materials - Other	**Count**
Instructor Created	20
News	3
Online HW System	3
Software	2
Custom Reading	2
Audio Visual	1
Institution Course Reserve	1
Online Notes	1
Popular Books	1
Sum	34

Appendix E

Mathematics Faculty Survey Participants' Top 10 Wished Resources

Wished Resources	Count
Journals	40
Books	14
Textbooks	7
EBooks	6
Class Set of Textbooks	4
Topic Request	4
Better Discovery Tool	3
Ejournals	3
Printbooks	3
Software	3