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Lab-Integrated Librarians: A Model for Research Engagement

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This manuscript expands upon preliminary work presented at the 2017 ASEE Annual Conference & Exposition.

To gain firsthand insights into the daily workflows of researchers and to create opportunities to engage in the full research life cycle, engineering librarians at North Carolina State (NC State) University launched a pilot project to embed themselves into campus research groups by attending weekly lab meetings. This article provides details on the program's implementation, the ethnographic assessment methods used to capture the activities of researchers during weekly lab meetings, and an analysis of the data collected. Based on these findings, the authors provide potential implications for professional practice, offering suggestions for how this pilot program could be expanded into an enterprise-level service as well as areas for further research.

Introduction

In academic research libraries, subject specialist librarians have long filled an important public service role fostering connections between the colleges, schools, and departments and the library. While the day-to-day work of a subject specialist at many institutions has shifted away from deep domain knowledge and toward areas of functional expertise,[1] building relationships and facilitating meaningful partnerships with stakeholders across campus continues to be strategically important for academic libraries.[2] In addition to building instructional partnerships with teaching and learning programs, many library administrations in recent years have asked their subject specialists to shift their emphasis more toward supporting researchers across the full research life cycle, which Dempsey has called the "shift to engagement."[3]

As this shift has taken place, academic libraries have begun to offer new enterprise-level services aimed at supporting 21st-century research methods, with academic librarians building up skills in areas such as data science, data management, research impact, and open science.[4] However, these efforts to quickly realign the academic library's service offerings and subject librarian skill sets may not always include in-depth, qualitative investigations and analyses of what users need from their library and what services they would actually use. To design services that will be both effective and relevant to their user communities, subject librarians in academic libraries need to be able to answer a number of questions: how do researchers in this academic user community conduct their research? What does their research data look like, and how do they store and manage it? Do they practice open research and, if so, in what ways? Are there disciplinary differences in all of the above? Gaining insights into these questions is just as critical to the sustained relevance of academic libraries as changing the skill set of the subject specialist.

At NC State University, engineering librarians began exploring ways to connect with researchers to answer these questions and to build awareness of the library's growing service portfolio in the areas of data science and visualization. Since engineering researchers tend to work in secure lab environments that are not easily accessible to outsiders, this team of engineering librarians proposed joining select research groups for a defined period of time by attending weekly lab meetings. To identify prospective research groups, the authors identified several tenure-track faculty members from five different academic departments and from each rank (assistant, associate, and full professor). During individual, in-person conversations between a librarian and the prospective participant, the program was described, explaining the anticipated benefits for the University Libraries as well as potential benefits for the principal investigator and their lab. A total of six invitations to participate were extended, all of which were accepted.

This process began with a pilot launched in 2016, which has grown into a lab-integrated librarian program. During the pilot stage, the engineering librarian team used ethnographic approaches to capture the activities of these researchers, as well as to note when a librarian's expertise was used during a meeting. This article provides details on the program's implementation, the ethnographic assessment methods used to capture the activities of researchers during weekly lab meetings, and an analysis of the data collected. Based on these findings, the authors provide potential implications for professional practice, offering suggestions for how this pilot program could be expanded into an enterprise-level service, and areas for further research.

Literature Review

In her 2012 overview of the emerging skills gaps facing academic libraries, Auckland suggested that, to meet the changing needs of researchers, the primary responsibilities of subject librarians would need to shift from information-based activities into data-intensive activities.[5] When the role of academic libraries and research data services was examined by Tenopir et al. in the same year, they found that academic and research libraries were already responding to this anticipated need by reassigning current library staff into new research data roles.[6] A follow-up survey two years later by Tenopir et al. found that, while many subject specialist librarians wanted to offer research data services to their constituents, they felt they lacked the continuing education opportunities to provide this support.[7] Due to an increased interest in developing subject specialists' skills in these areas, opportunities for librarians to gain formal, postgraduate training in the skills and tools necessary to support the entire research life cycle are becoming increasingly widespread.[8] While these training programs offer valuable introductions to areas like research data management or data visualization, no training institute can provide subject specialists with actual opportunities to apply these skills within their local contexts. Without practice applying these skills in real-world contexts, subject specialists cannot be expected to gain the level of proficiency required to respond in real time to labor-intensive, time-sensitive requests from researchers.[9]

A review of the literature suggests that the most frequent method librarians have deployed to demonstrate and share their expertise in areas related to data science is by developing data-intensive researcher support services and workshops. During the last decade, the literature contains numerous examples of how libraries have invested in developing expertise in bibliometrics and research data management.[10] As some academic libraries have invested in building large-scale visualization spaces in recent years, librarians have in turn developed workshops aimed at supporting data visualization, including how to visualize data, hands-on training on specific visualization software, as well as data visualization consulting services.[11] While much attention has been paid to supporting data-intensive aspects of the research life cycle, the literature also reflects the continued popularity of library-hosted workshops for graduate students and faculty on scholarly communication topics, such as copyright, publishing, identity management, and research impact.[12]

Despite the increasing popularity of developing workshops that address aspects of the entire research life cycle, relying on workshops as the primary means of supporting digital research and demonstrating library expertise in these areas presents a number of limitations. Primarily, the literature is rife with examples of workshops designed to address a critical need for a target population that nevertheless generate low attendance figures.[13] While previous researchers have yet to identify a primary reason why library workshops suffer from low attendance, one possible reason is that the workshop model of instruction does not lend itself to promoting student learning. Education research suggests that creating contextualized learning environments that feature content relevant to learners is one of the most effective means of promoting student learning.[14] Meanwhile, librarians developing workshops often focus on broad topics to create content that will represent the vast array of research interests in their university communities.[15] Unfortunately, this non–domain-specific approach all but guarantees that the content will lack relevance or context for most learners, dampening interest in the topic.[16] While librarians may view topics on aspects of the research life cycle as self-evidently important and interesting, workshops where the utility of the content is not readily apparent to students and faculty will suffer from low attendance.[17] This lack of meaningful context is likely exacerbated for physical and life scientists who conduct research in wet labs, which stand in stark contrast from the clean, clinical orderliness of a library classroom.

The most substantial vulnerability in the workshop model is that libraries develop these programs with the assumption that students and researchers will come to the library to solve their data-related problems. Recent studies suggest that researchers are increasingly less likely to identify the library building as where the research life cycle begins.[18] While this trend has been observed across all disciplines, this effect is even more pronounced among applied physical scientists and engineers, whose workflows do not align with using physical libraries.[19] Delaney and Bates' recent literature review on the emerging roles of subject specialists puts it pointedly: researchers increasingly view themselves as nonlibrary users; to change this perception, librarians need to engage users in their own environments.[20] To bridge this gap, the literature contains a number of reports of librarians using the embedded librarian model to reach their communities, particularly in support of teaching and learning programs.[21] In particular, in the last decade, substantial attention has been given to embedding librarians into courses via learning management systems, which allow librarians to interact with students, and their assignments, directly and immediately within a virtual learning environment.[22]

Another service model that has addressed this limitation of physically bounded library services is the clinical medical librarian, or the informationist. The informationist role within healthcare settings arose as a proposed solution to closing the "literature-practice gap," the growing divide between the best available evidence in the literature and the actual practice of healthcare workers.[23] The informationist role differs substantially from remote or satellite reference services in that it does not recreate the passive reference model in a new location;[24] rather, it positions the librarian as an active, integrated member of the clinical team who can respond to information needs as they occur.[25] While the role and effectiveness of the informationist is well established in clinical settings,[26] successful examples of implementations of researcher-focused informationist services are relatively scarce, especially outside the health sciences. The case studies for these types of services represented within the literature usually rely upon external funding sources, in which researchers compete to secure an informationist on a temporary basis to work on a handful of specific projects or initiatives.[27]

Program Description

The library support model most often used for engineering looks similar to those used to support humanities and social science disciplines: a reference desk model that depends upon users contacting a librarian and often physically coming to the library. This model of information services for engineers and applied scientists has been pervasive and persistent throughout academic libraries for decades, despite the frequent attention this model's deficits have received in the literature.[28] Given this persistent challenge, the authors began to investigate whether the clinical informationist model could be adapted to support researchers in engineering. On the surface, the work life of clinicians and engineering researchers would appear to be vastly different, both in terms of each group's information needs and the setting in which those needs arise. However, in terms of information-seeking behavior and information needs, engineering researchers may be more like clinicians than not. For both groups, information needs often arise unexpectedly and require real-time answers drawn from a multitude of sources to support decision-making.[29] For practitioners with these types of information needs, seeking out a librarian via a reference services model of information retrieval will not align with the reality of their daily clinical or research workflows.[30]

Within any academic institution, faculty and students are typically affiliated with a particular college, school, or department, but researchers in STEM disciplines (science, technology, engineering, and math) may also be affiliated with specific research groups. Depending on the size and organizational structure, this group may also be known as a center, lab, or team. For many researchers, their research group, rather than their department or college, is their primary unit of identity. Members of a given research group often investigate complementary topics, with frequently overlapping expertise in terms of research methods and materials. Research groups are led by a faculty member known as the principal investigator (PI), and made up of graduate students, postdoctoral scholars, and sometimes undergraduate students. Membership will vary from year to year, as students graduate and staff members leave for new positions. While each group has its own specific culture for collaborating and communicating, most meet on a weekly basis and have a somewhat consistent meeting structure that includes research updates as well as discussions of basic lab business.[31]

In an ongoing effort to develop effective methods to support engineering researchers, the authors decided to test the informationist model by embedding librarians in several research groups. This study sought to determine whether this model could be used to effectively deliver information services at the point-of-need and to learn how these researchers find, use, and manage information and data by observing their professional practices.[32] The authors also anticipated that being physically present in these research-intensive small-group settings would promote the growth of deeper relationships with faculty and students.

A team of three engineering librarians recruited a total of six research groups to participate in this exploratory study from across NC State University's College of Engineering and the College of Textiles. These groups represented five different departments within these two colleges: Biomedical Engineering (BioMedEngr), Mechanical and Aerospace Engineering (MechEngr), Materials Science and Engineering (MaterialSci), Textile Engineering, Chemistry and Science (TextileChem), and Textile and Apparel, Technology and Management (TextileMgmt). While the librarians' domain expertise in engineering and textiles varied, each had worked as a science librarian for several years and furthermore had gained a baseline skill set in data science and data visualization through the NC State University Libraries' Data Science and Visualization Institute for Librarians.[33]

Because this study sought to learn more about these researchers' actual workflows rather than their perceptions of their workflows, the authors looked to ethnographic research methods for inspiration on how to capture what happens during these lab meetings.[34] The librarians embedded into groups as their capacity allowed—Carroll embedded into three groups, Eskridge into two groups, and Chang into one group. To promote consistent data capture across all three embedded librarians, the authors used a standardized form, which described who was in attendance at the meeting, the length of the meeting, what happened during the meeting, and any direct involvement of the embedded librarian in the meeting.[35] This standardized form was reviewed and approved for use by NC State University's Institutional Review Board. Prior to enrollment in the study, informed consent was obtained via a consent form that was signed by a research group's principal investigator. Prior to data collection, the study's purpose, design, benefits, and risks were explained to all members of a research group during an in-person meeting. Additionally, all study participants were provided physical and digital copies of a research study overview that explained the study's purpose, design, benefits, and risks. Over the duration of this study, the authors attended a total of 82 lab meetings across these six groups for a total of 5,795 minutes of lab-integrated engagement. Table 1 contains demographic information about each participating lab, as well as basic information about each group's general meeting structure.

TABLE 1

Demographic and Meeting Details of Research Groups

Group ID	PI Rank	Group Demographics	Meeting Frequency*	Meeting Duration (Mean, in minutes)	Meeting Attendees (Mean)
BioMedEngr-01	Assistant Professor	Postdocs: 2 G Students: 4 UG Students: 11 Staff: 0	Weekly	78	10
BioMedEngr-02	Assistant Professor	Postdocs: 0 G Students: 4 UG Students: 5 Staff: 1	Weekly	67	8
MaterialSci-01	Professor	Postdocs: 1 G Students: 8 UG Students: 3 Staff: 4	Weekly	80	10
MechEngr-01	Associate Professor	Postdocs: 0 G Students: 4 UG Students: 2 Staff: 0	Weekly	60	6

TABLE 1

Demographic and Meeting Details of Research Groups

Group ID	PI Rank	Group Demographics	Meeting Frequency*	Meeting Duration (Mean, in minutes)	Meeting Attendees (Mean)
TextileMgmt-01	Professor	Postdocs: 0 G Students: 2 UG Students: 0 Staff: 0	None**	60	2
TextileChem-01	Associate Professor	Postdocs: 1 G Students: 4 UG Students: 2 Staff: 0	Weekly	60	8

*Meeting frequency of entire research group

**Weekly 1:1 meetings between PI and individual students

Postdocs = Postdoctoral scholars
G Students = Graduate (Master's and PhD) students
UG Students = Undergraduate students
Staff = includes research professors, visiting scientists, and technical staff

Methods

To identify the most prevalent and prominent activities that occurred during the research group meetings the authors attended, this study used a modified grounded-theory approach for analyzing the data gathered via observation sheets. This qualitative research method allows theories to be formed based on data that has already been collected rather than using existing theories to gather data.[36] Given the exploratory nature of this program, the authors viewed this methodology as the optimal way to capture the authentic activities of this study's participants, which may or may not align with the authors' preconceptions as information professionals.

When analyzing the data, the authors used inductive coding, a cyclical process that enables identification of core themes and concepts within existing data.[37] To develop a consensus set of codes, the authors started with a sample dataset of nine observation forms drawn from three different research groups. The authors then reviewed the nine observation forms individually, identifying and compiling a list of descriptive codes that summarized the important themes and concepts within the sample data. Through discussion, these individual codes were consolidated into an initial list of 15 core concepts. As a group, the authors then used an additional six observation forms, drawn from two different research groups, to test the coverage of these codes, noting any gaps or redundancies in the existing consolidated list. Through this process, the authors identified four codes that overlapped substantially with other codes, resulting in a final list of 11 themes. The authors then drafted consensus definitions for each of these themes, noting keywords and incidents within the data that would exemplify each theme. Definitions for each of those themes are listed below:

1. **Point-of-Need Librarian Expertise:** During the lab meeting, the librarian actively contributes to the meeting by participating in group discussions or by sharing their relevant expertise at an appropriate time. Examples of this expertise observed in the data include: scientific communication, data visualization, reference managers, expert searching, citation norms, interlibrary loan, publishing, peer review, research impact, pedagogy, bioinformatics, research ethics, conflict of interest disclosures, copyright, open science, data management, data security, Institutional Review Board (IRB) and Institutional Animal Care and Use Committee (IACUC) processes, referrals to other campus resources, and technology lending.
2. **Lab Business and Lab Management:** Group shares announcements about the day-to-day operations of the lab. Issues discussed may include: new lab members, lab cleaning issues, lab safety, reagent ordering, scheduling updates, upcoming grant deadlines, upcoming abstract deadlines, upcoming oral examinations, awards won by group members, exchanging lab notebooks to attest each other's results, troubleshooting equipment issues, planned or unplanned infrastructure outages (power, network, etc.).
3. **PI and/or Librarian as Mentor:** PI and/or librarian provide advice, feedback, and suggestions on how to be a successful, professional scientist that do not relate directly to technical skills or scientific phenomena. Examples include: making the most of a conference; time management; project management; how to best use productivity software (such as Microsoft PowerPoint, Microsoft Word, Qualtrics, Refworks).
4. **Student Research Update Presentation:** Student presents a semiformal research update on the progress of their current projects, usually using PowerPoint to explain the background of the project as well as to explain their methods and share preliminary results. Feedback from the group focuses on the science of the presentation rather than the format or flow. Following these updates, the group may engage in a collaborative brainstorming session where the lab members try to provide suggestions on next steps or areas of improvement.
5. **PI as Teacher:** PI provides didactic instruction to a student or the entire group on a technical or scientific concept. This instruction may come in the form of planned lectures using PowerPoint, impromptu micro lectures, drawing schematics on a whiteboard or asking Socratic questions that push students to test the limits of their understanding of a particular concept or method.
6. **Round Robin Research Updates:** Each attendee at the meeting provides a brief update on their research project, including unexpected results or unforeseen hurdles. Following these updates, the group may engage in a collaborative brainstorming session where the lab members try to provide suggestions on next steps or areas of improvement.
7. **PI as Facilitator:** PI connects the various projects within the lab together, helping students understand how their projects fit together. PI makes suggestions of other researchers in different labs who are doing work that may be relevant to the current project. PI makes suggestions to consult the literature on a topic.
8. **Student as Teacher:** Students teaching other students scientific concepts and/or technical content. This content may be taught via formal presentations using PowerPoint, oral communication, and/or drawing of schematics and models on a whiteboard.
9. **Student Practice Presentation:** Student does a practice run through of an upcoming presentation (such as preliminary exam, qualifying exam, conference technical session). The research group provides feedback on both the scientific and technical aspects of the presentation but pays heavy attention to the structure of the presentation and provides suggestions on how to improve scientific

communication. Suggestions may include how to better use software (Microsoft PowerPoint, Microsoft Word), how to improve the effectiveness of tables and graphs, as well as how to change content order to improve flow.

10. **Journal Club:** Group reviews and critiques a journal article selected by a group member in advance. Attention is paid as much to the structure of the article (like formatting of tables and figures) as to the technical content and science. Journal club offers a rich opportunity for librarians to share their expertise, and it often reveals the limitations of traditional scholarly communication (such as the need for supplementary materials, images not translating well to paper).
11. **Librarian-led Session:** Librarian leads an invited didactic session as requested by the lab group on a specific topic, such as peer review, conflict of interest disclosures, research ethics, reference managers, the academic job market, and evidence-based pedagogy.

Results

Having created a final code list and definitions for each, the authors then used this second consolidated code list to review the data, noting each occurrence of a code during a given meeting (see table 2). Table 2 also reports the incidence rate for each code, or the number of times an event occurred divided by the total number of times a librarian met with that group. After reviewing the results in aggregate, the authors then analyzed the occurrence of each code for each research group to identify trends and differences that could be observed between the different groups.

TABLE 2

Total Incidences and Incident Rate of Each Code

Code	Total Incidences	Incident Rate (Percent)
Point-of-need Librarian Expertise	49	59.8
Lab Business and Lab Management	44	53.7
PI and/or Librarian as Mentor	42	51.2
Student Research Update Presentation	30	36.6
PI as Teacher	28	34.1
Round Robin Research Updates	19	23.2
PI as Facilitator	18	22.0
Student as Teacher	16	19.5
Student Practice Presentation	12	14.6
Journal Club	12	14.6

TABLE 2

Total Incidences and Incident Rate of Each Code

Code	Total Incidences	Incident Rate (Percent)
Librarian-led Session	6	7.3

Structure of Meetings

All but one of the groups included in this study met on a weekly basis, with a median meeting time of 60 minutes across all five groups. On average, these weekly meetings were attended by 8.5 students, staff, and faculty, inclusive of the principal investigator. PIs within this study dedicated the bulk of time during routine lab meetings to research updates from postdocs, graduate students, or undergraduate students. These updates predominantly were delivered in one of two ways: a lengthy research update from an individual lab member or a "round robin" style of updates from several lab members during a single meeting. Some groups almost exclusively featured one or the other, while other labs did a mix of both. BioMedEngr-01 and MechEngr-01 most often featured individual updates, while the meetings for MaterialSci-01 were dedicated almost exclusively to round robin updates, with 100 percent of the meetings observed using that structure. BioMedEngr-02 and TextileChem-01 had meetings built around both of these structures and would adopt the structure best suited to the needs of the group at any given time. For example, an individual with substantial results to share may get a full meeting to share their findings with the group, whereas some meetings may accommodate several smaller check-in updates.

TextileMgmt-01 represents the major exception within the study to this weekly meeting structure built around research updates. Rather than holding a full weekly meeting, the PI of the TextileMgmt-01 group met with graduate students individually on a weekly basis. When observing this group, the embedded librarian sat in on the one-on-one meetings. The authors theorize that this divergent meeting structure may reflect two major differences between this group and the other participants. Primarily, this group had a much smaller number of overall members, which likely would limit the utility of having a large meeting to discuss lab business or communicate results. Additionally, this group's research interests and methods also diverge substantially from the other groups, as this group largely conducts business intelligence and market research rather than applied science. Consequently, it is possible that this group's meeting structure reflects a disciplinary difference between social scientists and scientists. PIs of the other research groups within this study may also have had one-on-one meetings with individual members; however, the authors did not attend or observe these meetings for the study.

While the data suggest that research updates were the main feature of routine lab meetings for these groups, these meetings serve a wider utility within these groups by featuring a number of other noteworthy activities. In some groups, these weekly lab meetings functioned as an integral part of their information-sharing processes. Lab meetings included activities such as: lab members reviewing and signing each other's lab notebooks to verify results, lab inspections from environmental health and safety were announced, changes to reagent ordering were introduced, announcements of upcoming conference abstract deadlines were shared, and lab cleanup measures were coordinated. BioMedEngr-01, for example, rarely started out a meeting without dedicated time for general announcements (91.3 percent of meetings); these sorts of activities likewise were commonplace in MechEngr-01, TextileChem-01, and BioMedEngr-02, occurring 66.7 percent, 50 percent, and

46.1 percent of the time, respectively. On the other hand, for groups like MaterialSci-01, this was rarely a function of lab meetings at all, occurring in less than 25 percent of meetings.

For some groups, the lab meeting was also a space where primary literature was critically evaluated via journal clubs. The authors had the opportunity to observe and participate in journal clubs within BioMedEng-01, BioMedEng-02, MechEngr-01, and TextileChem-01, which occurred during 33.3 percent, 25 percent, 19.2 percent, and 13 percent of their meetings, respectively. The structure of these journal clubs could vary between groups and even from meeting to meeting. In some cases, a PI would assign a journal article ahead of time and ask students to explain the article. In other cases, a student would choose their own article, share it with the group, and then lead an evaluation of the article using presentation slides prepared in advance. Groups would usually pay particular attention to each of the figures, and would spend substantial portions of the period evaluating the data shared in the figures, as well as how the data was visualized. Even in groups like MaterialSci-01, which did not feature dedicated journal club sessions, the PI expected students to share a recent paper related to their current work as part of their round robin research update. Interestingly, groups somewhat routinely ran into issues when attempting to evaluate supplementary materials; members would rarely print the supplementary materials ahead of time and would express difficulty in accessing the materials online during the meeting.

One interesting overarching trend among the groups that participated in this study is that each lab has a brand closely associated with the reputation of the PI and the students they train, rather than the perceived prestige of the institution. As a consequence, the PIs and the members of these labs rightfully show concern with how the work of the lab is represented at conferences and symposia. As a result, in addition to general research updates, many of these groups dedicate substantial portions of lab meetings to practice presentation sessions, in which a lab member shares their draft version of an upcoming presentation or poster. These sessions are notably different from regular research update presentations, which function more as information-sharing and progress reports. Following these practice presentations, the research group provides feedback on the scientific aspects of the presentation but also critiques the structure of the presentation by providing suggestions on how to improve the effectiveness of the science being communicated. Suggestions often include how to improve the effectiveness of tables and graphs, as well as how to change content order to improve flow. These practice presentation sessions occurred in four of the five groups that met weekly (BioMedEng-01, BioMedEng-02, MechEngr-01, TextileChem-01), and not infrequently; each of these groups featured practice presentations in at least 12.5 percent of the meetings attended by the authors. In the two groups where students did not deliver practice presentations to the full group during meetings (MaterialSci-01 and TextileMgmt-01), these practice presentations instead occurred during individual meetings between a student and the PI.

Roles of Group Members

In addition to the baseline requirements of sharing updates on their research and leading an occasional journal club, junior researchers within these labs take on a number of additional responsibilities and roles during these group meetings. For example, in all five groups with weekly meetings, PIs expect that junior researchers not presenting a research update or leading a session will serve as attentive audience members and will provide insightful, constructive feedback to their colleagues. The active participation of other lab members is critical for facilitating information sharing between different projects, as well as to improving the quality of outputs such as presentations and publications. Other roles for junior researchers could vary from one group to another. In three of the groups (BioMedEng-01, BioMedEng-02, TextileChem-01), the PIs routinely asked junior members of the group to lead didactic sessions on a scientific concept. These sessions, which can be planned in advance or occur in a more impromptu fashion, serve three simultaneous functions, all of which are important to the long-term growth of the research group. Primarily, these student-led didactic sessions can confirm that the junior researcher has a solid understanding of the concept themselves. Additionally, by sharing this information with the other lab members, these sessions increase the overall scientific development of the lab, filling in gaps in the curricula. Finally, these sessions provide the junior researcher the opportunity to gain some teaching experience. While these sessions often cover a specific scientific concept, they sometimes address technical topics instead, such as how to use a specific piece of lab equipment or tips on specific software applications. For PIs that empowered graduate students to take on this role, it was a regular part of their lab meeting, occurring in 37.5 percent, 30.8 percent, and 26 percent of the TextileChem-01, BioMedEng-02, and BioMedEng-01 meetings the authors attended.

The PIs in these groups often hold multiple functional roles within these group meetings. While the library literature often portrays disciplinary faculty research as a solitary effort, the role of a PI in these groups is often to serve as a connector. Especially for the larger groups, the PI identifies areas of overlap between several related projects and helps each student researcher understand how their individual projects fit together as a part of a cohesive portfolio for the lab. This role occurred most often during BioMedEng-01 meetings (60.1%), as well as less frequently in TextileChem-01 (25%) and BioMedEng-02 (7.7%). Since the study did not find every PI doing this, it may be a more informal role that is largely dependent upon the personality of the PI, as well as the different junior researchers' projects.

One major takeaway from this experience was that, for PIs, research and teaching are not separate enterprises—they overlap and happen simultaneously. While librarians tend to think of teaching and research separately, in research groups the two are happening in concert; faculty are training their students to become researchers. In 34.1 percent of the meetings attended, the authors observed PIs adopting the role of teacher by providing instruction to a given student or to the entire group on a technical or scientific concept. This lab-based didactic instruction may come in the form of planned lectures using PowerPoint or impromptu micro lectures where the PI draws out schematics on a whiteboard. Additionally, several of the PIs in this study frequently relied on the Socratic method, asking the members of their lab pointed questions about their research that pushed a student to test the limits of their understanding of a particular concept or method. In the cases observed in this study, this teaching method was entirely good-natured and to the student's benefit; several PIs routinely reinforced the idea that the lab meeting was precisely the place to find errors, make mistakes, and identify gaps in knowledge. In this sense, research groups are not just a work space but also a pedagogical space that provides an experiential learning environment, which complements the instruction that students receive in classroom settings.

While PIs often taught technical concepts during lab meetings via planned or impromptu didactic sessions, much of what is taught during lab meetings was closer to professional mentoring and advice. These professional mentorship activities occurred in all six of the groups that participated in the study and covered various aspects of being a professional scientist, such as making the most of a conference, time management, and project management, among others. Many of these topics are also areas where librarians have expertise, and PIs in this study welcomed librarians sharing their experiences and thoughts in these areas. Anecdotally, each member of the project team reported that PIs mentioned that it was valuable to have a second voice reinforce their messaging during lab meetings.

Roles for a Lab-integrated Librarian

In addition to providing advice on topics like how to make the most out of an academic conference, these group meetings routinely provided ample opportunities for librarians to participate using a diverse array of skill sets. In 49 of the 82 total meetings attended, the librarian in attendance provided point-of-need assistance to the research group. A full list of the scenarios and topics observed in this study where a librarian may prove valuable to a research group is listed in the code definitions in the Methods section. The data in this study suggest that librarians can contribute to any meeting, whether a standard research update meeting or otherwise. Research update meetings present opportunities to offer assistance with designing a literature search or to discuss issues related to data management, while journal club meetings lend themselves to discussing issues related to publishing and research impact. Meetings that featured practice research presentations offered perhaps the highest return on investment. During these meetings, librarians can assist with issues related to citation norms and reference managers, and librarians trained in data science and visualization can offer feedback on how to improve the accuracy and readability of figures or charts. Most important, the lab-integrated librarian's unique status as a blended insider-outsider of the group can offer the group valuable insights into how a nonexpert audience may interpret the content being presented. This enables the librarian to ask questions that might not occur to other members of the group, who are more familiar with the specifics of the research. This blended role positions a lab-integrated librarian to offer useful suggestions on issues related to scientific communication or visualization of results, which may improve the quality of a research group's outputs.

After the embedded librarians in this program established their expertise through attendance and participation in meetings on a regular basis, several of the PIs in this study requested that their embedded librarian lead full-length lab sessions on topics. During this study, the engineering librarian team led a total of six sessions that discussed peer review, conflict-of-interest disclosures, research ethics, reference managers, the academic job market, and evidence-based pedagogy. While these are topics that some academic librarians already address within standalone workshops or curriculum-integrated sessions, these sessions occurring within the framework of the normal lab meeting structure is a noteworthy difference for two reasons. First, placing this content within a lab meeting lends it the credibility of the PI, who holds a substantial position within a junior researcher's professional ecosystem. Second, by occurring within an environment where research and teaching already regularly occur, these lessons can be richly and meaningfully contextualized for the lab members in attendance. When designing these sessions, the lab-integrated librarian can use examples from the lab's existing projects, highlight journals where future manuscripts might be submitted, or tie in the requirements of relevant funding agencies. While not every group invited a librarian to lead a session, every research group within this study presented at least some opportunities for the librarian to participate meaningfully. In four of the six groups, librarians provided information or data service expertise in more than 50 percent of the meetings attended.

Discussion

By exploring the research group meeting, the authors anticipated learning more about the unique data and visualization needs of this subsection of the NC State user community and being able to use those findings to design services around those needs. However, participation in these weekly meetings identified that these researchers' needs extend past data and visualization services—rather, they include the entire research life cycle. These needs include areas where librarians have traditionally provided support, such as literature searching, reference management, and scholarly communication, which continue to be topics that PIs want their students to master. This suggests that, in addition to creating opportunities to employ skills related to data science and visualization, integrating into research groups may also enable subject specialists to reframe traditional, core skill sets by placing these skills within context-rich environments with immediate relevance to their user communities. As user communities begin to see the immediate value of their subject specialists' skill sets within their own research workflows, additional opportunities for meaningful collaborations are likely to develop.

Lab integration is an effective method for conducting authentic user studies, as being a lab-integrated librarian is *in itself* a user experience study. Joining a research group allows a librarian to step into a researcher's world for a few hours per week, seeing and hearing things from their perspective. This ethnographic approach could become a tool in the academic libraries' user research toolkit, alongside space observations, surveys, and interviews. While the library profession long ago established the importance of user-centered services, as academic libraries seek to scale up services to better support researchers, librarians often resort to guessing at what those researchers need or relying on surveys or anecdotes from a few faculty champions. For example, while many librarians take courses in coding and data science, many may do so without knowing how their researchers generate, use, and manage their data. Joining a research group can help subject librarians prioritize the skills they need to develop first and to identify tools that may have the biggest impact on the needs of the group.

While joining research groups is a promising method for future needs assessment, the authors see its greatest value in terms of facilitating relationships between subject librarians and the researchers they support within colleges and universities. Ultimately, a subject specialist's work is about engagement and forming relationships. While relationships don't scale (they are built one at a time), they can still be built in an efficient and strategic manner. Lab-integration is an excellent way for librarians to build relationships that are based on meaningful and substantive interactions that are aligned with researcher workflows. Librarians participating in this program can become a part of researchers' weekly routines rather than relying exclusively on transactional, surface-level outreach activities like newsletters and check-in emails. They can share their skills and expertise, along with other service offerings from the library at the point-of-need, which is when it will be most valued. Offering librarian expertise and a library's services within researchers' authentic workflows transforms research support services from just-in-case, contextless, library-centered services into point-of-need, authentic, contextualized, user-centered services. Moreover, by placing themselves in an environment where research needs occur, lab-integrated librarians can "build business" for other library spaces and services, such as technology lending, high-performance computing, and instruction programs.

Lab-integration also provides an opportunity for librarians to get to know students in a way that is really unmatched in a librarian's experience. While all subject librarians get to know the students who work in the library, and the students who are "regulars" in the library, vast numbers of students who do not think to ask a librarian for help (especially STEM graduate students who practically live in their labs) never enter the library's doors or walk past a librarian's office. In the research group setting, a librarian is not only physically present in the student's academic activities, but they also can occupy a blended role of both insider and outsider. While the lab-integrated librarian is well-versed enough in their research topic to offer support and guidance, the student-to-librarian relationship contains substantially less fraught and less potentially problematic power dynamics than those between a student and their PI. This provides truly great mentoring possibilities, and the potential long-tail effect of these interactions represents an interesting area for future study.

In earlier descriptions of this program, the authors have acknowledged that this type of activity will not scale in the way that some library services do, as no institution can dedicate a librarian to every research group on campus every year.[38] However, since most library services are built around specific use cases, this type of service could scale in a way similar to well-designed curriculum-integrated information literacy instruction programs. Based on these findings, the authors suggest that lab integration can be folded into the existing subject librarian suite of services and can be offered in an organized, programmatic way. To create a program of lab integration, the authors would recommend the following best practices:

- *Make It Pervasive:* The best way to create a program of lab-integrated librarianship is to make it a part of every subject specialist's work. This may mean every subject librarian in a particular discipline or library, or it may extend to all the STEM librarians in a library system. This approach could be broadened to include every subject specialist within an academic library, with the caveat that further study is needed to measure whether this approach would align with the workflows of social scientists and humanists.
- *Make It Consistent:* In many libraries, there can be substantial differences in how librarians approach similar tasks, which over time can result in inconsistent service delivery. The authors recommend establishing a common approach by creating community norms that include clear expectations and deliverables.
- *Make It Strategic:* Just as it makes sense to integrate instruction into core courses, some research groups may be better choices than others. Consider developing a prioritized list of research groups to join and work through it systematically. Looking at departmental or college-level strategic plans can give insights into which groups may take priority. A group that is working on high-profile research or research of strategic importance to the college or department might be a better one to partner with. A multidisciplinary group that crosses departmental lines might be a good way to support interdisciplinarity in research. At a minimum, it would make sense to plan to join one group in every discipline or department over time.
- *Make It Routine:* Seek out research groups that hold a weekly or biweekly meeting most of the year and avoid joining any that meet less regularly. These groups will be well-organized, and it is much easier for a librarian to quickly become part of the membership.
- *Make It Annual:* Each librarian should plan to remain with a group for a full calendar year. One semester is not sufficient, as it takes time to learn a group's dynamics, as well as to build meaningful relationships with the PI and junior researchers. At the end of the year, the librarian should plan to move on to another group, as staying with one group for many years could change this service from a program into an activity that is viewed as an exception.
- *Make It Count:* Develop a centralized method for gathering data based on articulated goals for the program, and create forms or other infrastructure that allow embedded librarians to quickly and easily report their data from every research group meeting they attend.[39] These reporting mechanisms should capture data that will answer questions librarians have about their users' workflows, as well as potential needs a librarian can address within this setting.
- *Make It Possible:* While this activity may seem infeasible for an already overburdened subject specialist, even busy librarians should be able to manage joining two groups per year, which would amount to at most two extra meetings per week. To facilitate this, administrators should consider allowing librarians participating in this program to have release time from other weekly public services activities, such as hours on the service desk or other remote reference services.

Future Research and Conclusions

A gap and limitation of this ethnographic approach is that it does not include the voices of the study participants themselves and thus cannot provide insights into how researchers felt about or were impacted by this service. A follow-up study, featuring interviews, focus groups, surveys, or a combination of the three, could be conducted to assess how an embedded librarian in lab meetings impacts researchers. Two potential variables to consider could be how exposure to a librarian in this setting impacts researchers' professional practices, as well as how it impacts their perceptions of the skill sets of librarians. Insights into whether this engagement strategy can positively impact researcher behaviors and lead to stronger relationships between researchers and subject specialist librarians would provide useful information for library administrators interested in deploying this model beyond a pilot program stage. For administrators concerned about the value of a high-touch service implementation like lab integration, future studies may also consider tracking the amount of time research groups spend on given activities, rather than using this study's design of counting incidents.

Another area for inquiry is whether lab integration could be used as a strategy for expanding the science subject librarian pipeline. By gaining direct experience with what researcher workflows actually look like, subject specialists can gain in-depth knowledge of researchers' methodologies, as well as the associated technical jargon that accompanies these methods. This type of immersion within researchers' work environments may enable librarians who may not be coming from a STEM background to gain domain knowledge in their assigned areas more quickly. If MLIS students could participate in these programs as part of a field experience or internship, it may lead more emerging information professionals to consider a career within science libraries.[40] Moreover, by physically sharing their spaces, these programs also may make science librarianship a more visible career possibility to candidates outside the MLIS track, enabling the profession to recruit undergraduate and graduate students within STEM fields to a career they may not have considered otherwise.

While this study focused on integrating librarians into researchers' physical workspaces, librarians elsewhere have identified that computational science and digital scholarship have created opportunities to integrate into researchers' digital workspaces, as well. Several multisite studies conducted by Ithaka S+R in the last five years have noted that researchers across the sciences increasingly collaborate in digital, cloud-based environments.[41] This suggests that digital integration may be an equally promising means of understanding researcher workflows and offering support across the research life cycle. Within the literature, ideas on what these user-centered digital services could resemble have begun to emerge. For example, several within the profession have suggested that open science presents unique opportunities for virtual integration.[42] Building on that, Sayre and Riegelman note that the "reproducibility crisis" in particular offers librarians an opportunity to offer novel research support by combining their own data skills with their expertise in working with publishers and funding agencies.[43] While open science and data science initiatives may attract more attention, information management is increasingly an important competency for researchers, as well;[44] Hinks and Sinkinson suggest that citation managers like Mendeley and Zotero enable "participation and networking within [the] scholarly information landscape."[45] As these new services continue to emerge, library administrators may have to reconsider the core competencies of their subject specialists, perhaps even rethinking how much time an engaged subject specialist will spend working inside the library's physical spaces.[46] While the precise services and competencies that will emerge as new areas of functional expertise for subject specialists remain uncertain, subject specialists intent on engaging researchers will likely find that integrating into researchers' physical and virtual workspaces is essential.

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Notes

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