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BUILDING THE STEM LIBRARIAN SKILL SET:

An Exploratory Study to Identify Skills Needed by STEM Librarians

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Subject specialist positions in Science, Technology, Engineering and Mathematics (STEM) often emphasize an understanding of the subject as well as knowledge of librarianship. Masters of Library Science (MLS) students and newly graduated librarians without formal STEM backgrounds can find it difficult to gain the skills or experience desired for these positions. The authors are designing a certification program curriculum to supplement the formal MLS curriculum. The goal of the program is to better equip MLS students and new professionals with the skills to be a good STEM librarian. Students will gain practical knowledge of a range of science and engineering disciplines to better understand their working environment. To inform the development of the program, the authors performed an investigatory analysis of the skills necessary for success as subject specialists, with a review of the literature, analysis of job ads, and a survey of current STEM librarians' responsibilities and backgrounds. This analysis supports the position that a subject background is an asset for STEM librarians, providing the knowledge to enhance their performance, communicate more effectively with users, and broaden their choices in the job market. A STEM certification program for librarians can provide a unique and valuable continuing education experience in this area.

INTRODUCTION

When hiring for subject specialist or liaison positions, libraries usually desire librarians with educational or practical experience related to the subject. In the case of Science, Technology, Engineering and Mathematics (STEM) librarianship, this typically includes formal education in a STEM subject, STEM-related work experience, or STEM librarian experience. It can be challenging for MLS students and new librarians to gain the experi-

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ence required to be competitive candidates for STEM librarian positions, particularly positions that seek familiarity with a STEM discipline. This can be one of the most daunting aspect for many new librarians. In many job environments, STEM librarianship isn't simply knowing which books to acquire or databases to use, but being able to converse with scholars in a discipline to assess and address their information needs.

Four STEM librarians at the Colorado School of Mines (Mines) Arthur Lakes Library aim to create a certificate program that will help MLS students and newly graduated librarians address this skills gap. This program will equip MLS students and new professionals with skills in STEM librarianship through orientation in science and engineering disciplines and their literature, mentoring, and opportunities for practical experience in applying this knowledge. The program will help students gain a better understanding of STEM subjects and the roles of faculty and students in these fields. The curriculum will also be packaged as an open educational resource for libraries to use with MLS students, new hires, and librarians seeking to further develop these skills.

The first step in designing the curriculum is an investigatory in-depth analysis of the skills necessary for success as STEM subject specialists. That is the focus of this contributed paper. A mixed-method study was completed that includes an analysis of the literature, a review of recent job openings for STEM librarian positions, and a survey with current STEM librarians about their backgrounds and responsibilities. This exploratory analysis will inform a curriculum outline and initial development of the certification program.

LITERATURE REVIEW

The topic of work as a STEM librarian has been explored in the literature periodically over the past several decades. Studies have included explorations of skills and knowledge necessary for the work, experiences of librarians in these types of positions,[1] and the overall state of the specialized role.[2] For this project, the team focused on literature published over an approximately twenty-year period, from 2000 to 2021. The narrower scope allows the team to focus on the needs and experiences of 21st librarians and incorporate recent trends in job responsibilities, especially scholarly communication including familiarity with data management, LaTex, electronic lab notebooks and other tools.[3]

Broadly, the literature on the subject can be broken into two categories, the examination of librarians with a STEM degree or STEM experience and those without. For STEM librarians without a STEM background, some reported that they feel they can be or are successful in their position.[4] There are many good STEM librarians out there who do not have a STEM degree or experience. However, some librarians without experience expressed a wish to have more STEM knowledge to apply to their roles.[5] Others describe feelings of "STEM anxiety" (feeling negative towards or intimidated by science and engineering), or something similar to imposter syndrome where they lack confidence or feel they don't understand enough STEM for their positions.[6] Both can negatively impact a librarian's success and/or confidence in their work.

The literature contains significant discussion about the attitudes of STEM librarians who came to the profession with a relevant degree or developed expertise in the field, and generally supports the position that having a subject background is an asset for a STEM librarian (as do the experiences of the authors). The reported benefits of this background can be grouped into three categories: Understanding the context of their work; enhanced interactions with faculty and students; and as colleagues and professionals.

Understanding the STEM context. This category has the greatest variety of comments from the literature. Librarians with STEM backgrounds feel that they have a better understanding of how STEM works, including an understanding of the scientific method and the "academic science culture".[7] The librarians have experience with research workflows, research ethics, and the role of responsible research, and "can understand some of the pain points that users may encounter during the process of conducting research."[8] In a recently published study, Palumbo, Bussmann and Kern found that "for traditional activities, such as collection development, instruction, and reference, as well as newer functional ones, such as data management, science subject knowledge was perceived as being a necessary to important requirement."[9] Their survey respondents felt that having a STEM background supports success in assisting patrons through the variety of tasks inherent in modern STEM librarianship positions.

Librarians with STEM backgrounds expressed advantages in teaching information literacy to a STEM audience as they have a deeper, user-centered knowledge of journals and databases and knowledge of concepts like author-

ity and methodology within the context of their discipline. In Hackenberg and Chu's follow-up to Hackenberg's 2000 study, one participant noted, "I have no sci-tech background, but it definitely would have helped if I had done some research in chemistry or engineering. I would have been aware of the pitfalls in hunting down certain types of info."[10] Concepts can vary wildly between disciplines across STEM. Take for example the use of the word model, "'Model' is probably the most ambiguous word in science. Mathematical, statistical, experimental, observational, theoretical, computational, analytical, verbal, legal, mental, graphical, geometrical, structural, and workflow models all have different meanings. Almost every field will have its own interpretation… ."[11] Background in the discipline, or a related one, can help STEM librarians better understand the nuances of users' instruction needs.[12]

Connecting with users. Librarians with STEM backgrounds expressed the feeling that they are better equipped to connect with their users. They can more easily communicate, don't need as much explanation of the topic from the user while assisting with research questions, and perceive that patrons are more comfortable in discussing their needs. Some indicated that they know how scientists think and can make more meaningful recommendations related to information research.[13] Again, a benefit of understanding the terminology is improved communication. According to Hackenberg's study in 2000, many of her survey respondents noted that "they felt more comfortable and familiar with scientific terminology and that their knowledge helped them communicate with clients/patrons." As Peterson and Kajiwara describe, "Science, more than most disciplines (excepting perhaps music), has a large and incomprehensible vocabulary which becomes a barrier for a non-science librarian who is trying to answer a science question."[14]

As colleagues and professionals. Along with the advantages in being better able to communicate with users, librarians indicated that they felt they were better able to meet faculty and students "on their own turf," that they were held in greater respect for their expertise and had credibility because of their STEM background.[15] Additionally, librarians perceived that the additional level of expertise in STEM makes them more marketable and competitive in the profession.[16] Multiple studies found that job advertisements for positions across STEM librarianship require or prefer applicants with a background in a related subject area.[17] For example in 2015 Trei's analysis of job advertisements found, "advertisements required individual STEM experience skills in under 30% of the postings, 60% of the positions required some kind of the defined STEM experience, and it was preferred 89.5% if the time."[18]

The discussion in the professional literature mirrors the authors' personal experiences, as two authors have degrees in STEM (physics and geology respectively) and two are STEM librarians who have gained knowledge and expertise while working as professionals. We have experienced the benefits described above, as well as some of the disadvantages that a lack of discipline-specific knowledge brings when we're outside of our areas of expertise. These findings in the literature demonstrate the advantages of and need for a STEM-centric curriculum like that in the proposed Mines certificate program.

METHODOLOGY

To inform curriculum development, the team analyzed a current selection of job advertisements for STEM librarian positions and gathered survey data from librarians currently working as STEM librarians.

The job ad analysis was designed to supplement and compare with those more comprehensive surveys in the literature. 43 ads were collected from lists and email notices over a time period from October 2018 to early February 2021. Ads that lacked information sufficient to determine the job qualifications were excluded from the study. These were advertised positions in academic libraries that focused on the physical, life and applied sciences. The positions themselves ranged from tenure-track faculty to library staff positions. Approximately 90% of the ads originated from Carnegie Class R1 and R2 institutions, both public and private; our data therefore is strongly weighted towards institutions heavily engaged in research. Since much of the time frame for job ad data-gathering overlaps COVID-19 pandemic-related disruptions in higher education, it is very possible that this data is biased towards representation by R1 and R2 institutions as having more resources, more continuous research activity, and/or a more focused need for STEM librarian positions.

The team also sought to gather information and feedback from practitioners who work with STEM disciplines on a daily basis. Utilizing the library's LibWizard platform, the team designed a survey that would al-

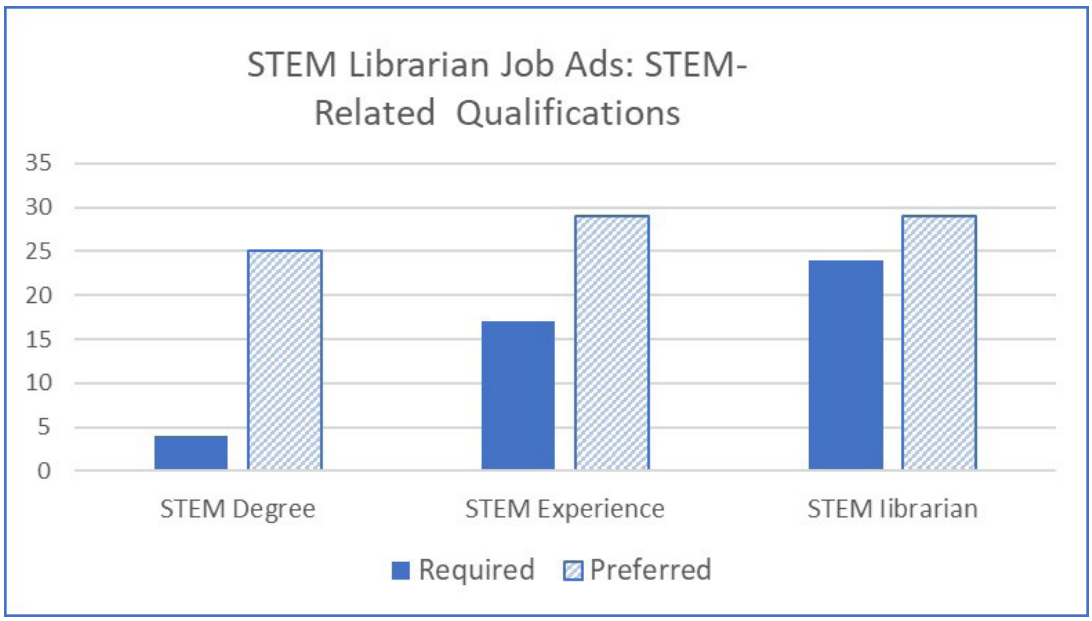
low participants to describe their academic background, professional responsibilities and methods for staying informed about their liaison disciplines. Ultimately, the survey comprised 23 fields, including demographic information, all of which were optional for participants to complete. The first section helped the team to gather demographics information, including educational background, current job title and years of experience as a STEM librarian. The second section focused on job duties, including liaison departments, and professional responsibilities. The final section gathers input on participants' perceptions of the knowledge and skills needed to be successful in the field. A full list of survey questions can be found in Appendix A. The survey was sent to a variety of professional discussion lists, including: PAMnet, ELDnet, STS-L and GEONET and was open for a little over a month in October and November of 2020. The team received a total of 221 responses.

DATA AND ANALYSIS

Job Ads Analysis

The focus for this paper was to examine STEM qualifications: A STEM degree; STEM experience; and STEM librarian experience. These categories were defined to not overlap. STEM experience is defined for this study as work experience including lab work or field work, or significant STEM coursework.

As anticipated, almost every ad included some sort of STEM-related qualifications. The few exceptions were ads for upper administrative posts, for example dean or library director, which focused on managerial qualifications.



Graph 1. STEM Librarian Job Ads: STEM Related Qualifications

In Graph 1, there is a comparison between required and preferred qualifications for advertised positions. Required qualifications—those we must have for the job—are shown in solid blue. The requirement for STEM librarian experience is the most common; then descending, that of STEM experience and then a STEM degree. Preferred qualifications—those we want for the job—are shown in patterned light blue. The desire for a STEM background in the candidates is much more in evidence here. Almost 70% of job ads preferred candidates with STEM experience, about the same number as those preferring STEM librarian experience. A significant almost 60% preferred candidates with a STEM degree.

Additional findings from the job ad analysis: The majority of the ads were for positions serving multiple sci-tech communities in a range of disciplines—for example "physical science library" or "engineering library". This

conforms with the trend of consolidating subject specific libraries (chemistry, geology, materials engineering, physics) into a larger "science library" or "engineering library".[19] The authors will note here that in our experience, familiarity with a specific STEM subject often includes a beneficial amount of carry-over knowledge to understanding related disciplines. For example, having a strong understanding of biology can help you navigate medicine or agriculture. Having a strong understanding of geology can support you in chemistry, environmental science, or oceanography.

Finally, we found that in examining the advertised position's responsibilities in four areas—liaison work, collection management, research and reference, and instruction—over half of the ads described the STEM position having responsibilities in all four of these categories. Almost all of the ads (90%) described responsibilities in at least two of the categories. Additional STEM knowledge can be applied in all of these areas.

The data from the environmental scan of job ads indicates that librarians with additional STEM qualifications are in demand; that candidates with strong STEM backgrounds are eligible for a wider range of positions; that librarians with STEM backgrounds have a competitive advantage in the job market; and STEM knowledge can be applied across many positions' responsibilities. A good background in STEM goes a long way.

SURVEY ANALYSIS

The survey distributed through STEM-focused librarian discussion lists garnered 221 responses. Many of the questions gave respondents the ability to provide free form text, while other questions gave the respondents checkboxes of options to select. While the authors looked at and considered the responses from all of the questions, the focus of the survey is on STEM qualifications. The tables and graphs below show those responses.

Q. Which of the following describe your background and interests in Science, Technology, Engineering and Math disciplines? (Check all that apply) [221 responses]

TABLE 1

Survey Responses, Backgrounds & Interests	
134	Professional development as a librarian
130	Undergraduate Degree
129	Personal interest and exploration
66	Non-librarian professional work experience
62	Graduate Degree
49	STEM-related coursework while completing your MLS
12	Certificate program or continuing education completed

Q. What is your current job title? [221 responses]

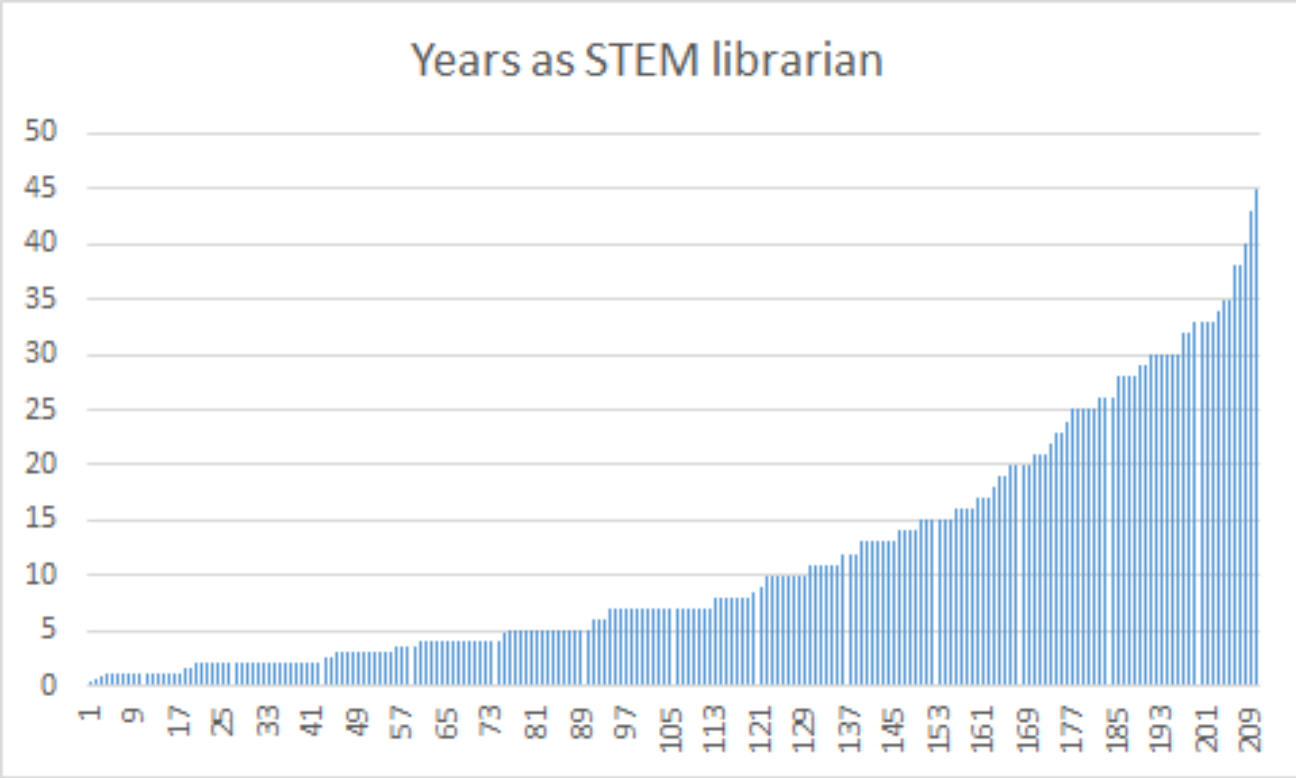
Most people reported a title of librarian, library director or library manager of some sort. If they did not have a word starting with librar* in their job title, they listed a title such as Assistant Professor or Coordinator. Table 2 includes words (or partial words) in respondents' job titles. This table shows that we received responses from librarians in a variety of science and engineering fields.

TABLE 2

Survey Responses, Current Job Titles	
Librar* (library or librarian)	196
science	88
engineering	46
research	31
STEM	23
liaison	20
head	16
instruct	14
physic	13
prof	11
inform	11
Referen*	11
chem	9
assistant	9
life	8
bio	7
data	7
Assoc*	7
director	6
health	6
applied	3
senior	3
outreach	3
scholarly	2

Q. How many total years have you been a STEM librarian? [210 responses]

As illustrated by Graph 2, the years of experience ranged from three months to 45 years. The average length of time of experience for a respondent was 11 years, while the median length of time served was seven years. Well over half of the respondents had ten or less years of experience.



Graph 2. Survey, Responses, Reported Years as STEM Librarian

Q. Name one skill related to your STEM librarianship duties that you wish you'd learned in library school. [180 responses]

This question allowed respondents to respond with free form text. Table 3 shows the skill concepts that gathered 5 or more mentions from survey respondents. If the skills of "teaching" and "instruction" are combined to total 17 mentions, this combined concept is ranked fourth in frequency. When "data management" was mentioned by respondents, that mention was assigned to both the "data" skill and the "management" skill. Interesting responses that were mentioned only once included: leading a meeting, and salesmanship. No one mentioned marketing of library resources as a skill respondents wished they'd learned.

Q. Which of the following areas do you consider to be the most challenging part(s) of your job? Rank these choices from most to least challenging. [202 responses]

- Connecting with faculty in assigned disciplines
- Following faculty and student interests, research output and/or needs of my assigned departments
- Information literacy instruction
- Outreach and engagement

- Research dissemination and impact
- Data literacy, data management and/or data visualization
- Citation management
- Collection development and database recommendation
- Specialized product acquisition or promotion (ex. Overleaf, electronic lab notebooks)

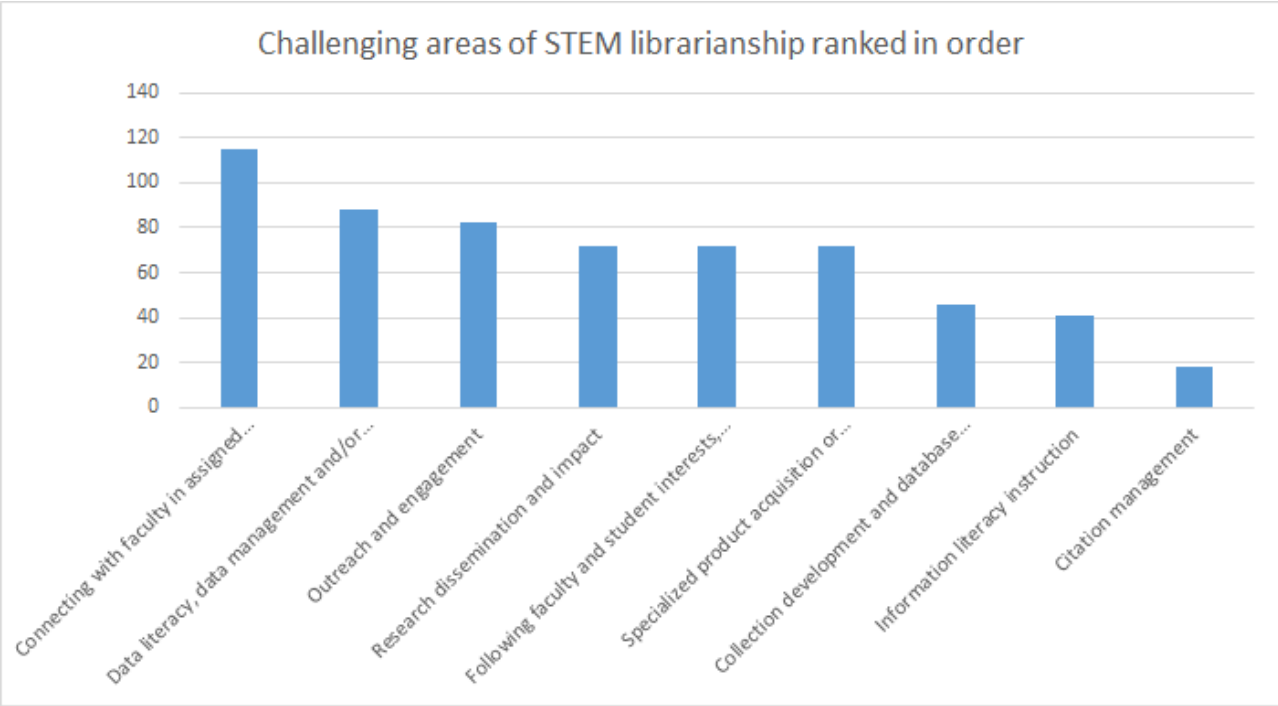
Of the nine choices listed, Graph 3 shows the frequency with which the choices were ranked in the top three by respondents as the most challenging areas.

"Connecting with faculty" is the most commonly identified challenge. It should be no surprise to STEM librarian colleagues that connecting with faculty, keeping abreast of research developments, and maintaining those connections, especially in multi-disciplinary settings or when addressing multiple responsibilities, is challenging. "Data literacy, data management and/or data visualization" is also identified as a challenging area to support—this is a relatively new and evolving field for subject librarians, and data management can vary significantly across subject disciplines. "Outreach and engagement" shares some of the same issues with "Connecting with faculty. The authors note that not all of the librarians who responded to the survey work at academic institutions; those non-academic STEM librarians who see making connections with clients or patrons as challenging may have categorized this as an "Outreach and engagement" challenge.

TABLE 3.

Survey Responses, Skills Librarians Wished They'd Learned

data (management, visualization, etc.)	38
research (design, methods, sets, etc.)	24
management (of budget, of collection, of data, etc.)	20
collections	12
(data) visualization or viz	11
instruction	10
outreach	8
teaching	7
chemical or chemistry	7
standards	6
liaison	6
coding	5
citation	5
database	5



Graph 3. Survey Responses, Comparison of Most Challenging Job Areas

Even though teaching and instruction were listed as skills many librarians wished they had learned more about in library school, the topic of "Information literacy instruction" was not seen as a particularly challenging area by many respondents. One interpretation is that librarians see themselves as proficient enough in providing information literacy instruction, but they know that they could be more engaging and effective if they had more training in that area.

Overall, the authors found that the soft skills of connecting with faculty (or with core patrons) as well as outreach and engagement continue to be a challenge, even for librarians with extensive experience working in STEM libraries and those with STEM backgrounds and degrees. As one learns more about science and technology, it may become easier for the librarian to relate to the problems faced by the patrons of the STEM library. All forms of librarianship concerning the management of data are also a challenge. The authors will take what was learned from the survey and apply it to the construction of the curriculum for the certification program.

AN INITIAL CURRICULUM OUTLINE

These in-depth analyses have informed the development of an initial curriculum outline for the program. It will be hosted on the Mines Canvas learning management system and ultimately made available as an open educational resource for use by other libraries and independent learners. The curriculum will equip MLS students and new professionals with knowledge in STEM through mentoring and opportunities for practical experience in applying discovery tools, managing collections, and reviewing the STEM literature. It is our hope that the program will help students gain a better understanding of STEM subjects and the roles of faculty and students in these fields.

The curriculum has been organized into 12 units, each designed to be covered in a week [Appendix B]. Primary goals include increasing participant knowledge of STEM disciplines and nuances and providing them with the opportunity to engage with the discipline through activities and readings. Also, students will compile a portfolio of their work throughout the program; a tangible product they can take into the workforce. After publication as an open educational resource, adoptees can expand or adapt the curriculum to suit their local needs. It can be expanded to more closely match a 16 week semester or content can be added focusing on disciplines that are important locally, such as aerospace engineering or ocean engineering.

The first three units of the curriculum provide an introduction to the program as well as discussion of the role that STEM plays in higher education and academic research. These early units provide a foundation for the discipline-focused work in units four through nine. Each unit introduces participants to a single discipline, such as geology, or set of closely related disciplines, such as physics and astronomy. Each unit will include a brief introduction to the topic, overview of the top databases in the field, discussion of nuances or specificities for researching in the subject, and include active learning assignments. Students will engage with the discipline and reflect on how their understanding of that discipline has changed. Units 10 and 11 help students to engage with STEM beyond academia, namely in government research and popular science. These units will give participants practical skills and tools they can use to continue building awareness in STEM disciplines. The final unit allows students to reflect and present on what they've learned. Completed portfolios can be used by students after the program in looking for and preparing for jobs as STEM librarians. Presentation and reflection by the students will also help the team to assess and improve the curriculum over time.

A strength of the curriculum is the combination of general coverage in units 2, 3, 10 and 11 with disciplinary focus in units 4-9. Students are more broadly prepared for work across STEM, such as reference questions from disciplines beyond their liaison focus or interdisciplinary research. They are also more specifically prepared to begin work in whatever discipline(s) they may be assigned in their first job. They will be comfortable exploring the discipline and learning about local researcher needs. They will be better positioned to start a new job successfully.

CONCLUSIONS

Utilizing the environmental scan of job ads and the practitioner survey, the research team found that background and experience with STEM beyond STEM librarianship is helpful, particularly to librarians without a

formal STEM degree. These findings largely mirror the existing literature and confirm the need for a curriculum that helps students and early-career librarians develop a better understanding of STEM.

The next step in the project will be to build out the full curriculum for the certification program. The team will leverage suggestions provided in the survey, feedback from ACRL conference participants and external review to further evaluate the curriculum prior to implementation. Then, the curriculum will be used with a cohort of MLIS students and early career librarians to further refine content and assess its effectiveness before it is shared with the larger professional community as an OER.

APPENDIX A. SURVEY QUESTIONS

BACKGROUND AND DEMOGRAPHICS

1. Which of the following describe your background and interests in Science, Technology, Engineering and Math disciplines? (Check all that apply)
    - Undergraduate Degree
    - Graduate Degree
    - Certificate program or continuing education completed
    - Non-librarian professional work experience in a STEM discipline
    - Personal interest and exploration (ex. Following blogs or watching PBS Nova)
    - Stem-related coursework while completing your MLS
    - Professional Development as a librarian (ex. STEM boot camp)
    - Other
        1. B. If you checked undergraduate and/or graduate degree in STEM for question #1, please list them here:
        1. C. If you checked "Non-librarian professional work experience" for question #1, please tell us how many years of experience and in what discipline(s):
        1. D. If you checked "STEM-related coursework during your MLS" for question #1, please describe it here:
2. What is your current job title?
3. How many total years have you been a STEM librarian?
4. Are you considered faculty at your institution?
    - Yes, tenure track
    - Yes, promotion only track
    - No, not faculty
    - No, I'm a corporate librarian
    - Other

JOB DUTIES

5. What STEM disciplines and/or departments are you connected to or assigned to liaise with? (Check all that apply)
    - Aeronautical and Aerospace engineering
    - Agriculture
    - Astronomy and Astrophysics
    - Atmospheric Sciences
    - Biological and Biomedical Sciences
    - Chemical engineering
    - Chemistry
    - Civil engineering
    - Computer Science
    - Electrical engineering
    - Engineering Technology
    - Engineering or STEM education
    - Environmental engineering or Environmental science
    - Geology and Earth sciences
    - Humanitarian engineering
    - Materials science

- Mathematics (including Statistics)
- Mechanical Engineering
- Medical and Health disciplines
- Mining engineering
- Naval Architecture and Ocean engineering
- Petroleum engineering
- Physics
- Systems engineering
- I also have non-STEM liaison departments
- Other (please list)

6. If you are connected to multiple disciplines, which are you most comfortable with in terms of you knowledge of that discipline, and which are you least comfortable with?
7. What are your other responsibilities? (Check all that apply)
   - Information literacy instruction
   - Outreach and engagement
   - Research dissemination and impact
   - Data literacy, data management and/or data visualization
   - Citation management
   - Collection development and database recommendation
   - Specialized product acquisition or promotion (ex. Overleaf or Electronic Lab Notebook)
   - Other (please describe)
8. How do you maintain your own awareness in your STEM subject areas? (Check all that apply)
   - STEM library journals or blogs
   - STEM discipline-specific journals or blogs
   - STEM professional organizations (ex. ACM, IEEE, etc.)
   - STEM education organizations and journals (ex. ASEE)
   - Video (ex. Ted Talks, Youtube, documentaries)
   - Continuing education courses
   - National Events (ex. Conferences and meetings)
   - Local Events (ex. Student presentations, campus lectures)
   - Other (please describe)
9. Which of the following areas do you consider to be the most challenging part(s) of your job? Rank these choices from most to least challenging.
   - Following faculty and student interests, research output and/or needs of my assigned departments
   - Connecting with faculty in assigned departments
   - Information literacy instruction
   - Outreach and engagement
   - Research dissemination and impact
   - Data literacy, data management and/or data visualization
   - Citation management
   - Collection development and database recommendation
   - Specialized product acquisition or promotion (ex. Overleaf or Electronic Lab Notebook)
   - Other (please describe)

KNOWLEDGE, SKILLS AND ABILITIES OF STEM LIBRARIANS

10. How has your knowledge of STEM helped you as a librarian?
11. Has a lack of knowledge of STEM hindered your performance as a librarian? How so?
12. Name one skill related to your STEM librarianship duties that you wish you'd learned in library school:
13. What professional skills would you specifically look for in a new STEM specialist hire?

14. What is one piece of advice about STEM that you'd give to an MLS student interested in pursuing STEM librarianship?
15. What is your favorite popular STEM resource to explore (ex. How Stuff Works, NOVA, Because Science, etc.)?
16. A significant focus of our project is to help MLS students interested in STEM librarianship become more comfortable with the disciplinary and technical aspects of their roles, especially if they don't have a formal educational background in a STEM discipline.
    If we were to offer a continuing education certificate on STEM for STEM librarianship, what advice would you give us? (topics to cover, resources to use, etc.)
17. Is there anything else you'd like to share with us?

APPENDIX B. PRELIMINARY CURRICULUM OUTLINE

The program will be personalized according to the participant's existing STEM education, practical knowledge and, to some extent, interests. Each module helps participants:

- Develop a basic understanding of a discipline in the physical sciences.
- Improve their knowledge of scholarly communication and student and faculty research.
- Explore STEM in the context of librarianship and their own understanding.

Deliverables: The successful participant will have:

- A Continuing Education Certificate from the Colorado School of Mines Library.
- A portfolio of products to inform their future work with STEM disciplines.
- A grounding in fundamental aspects of STEM higher education, research, discovery and publication practices in one or more of the physical sciences.

Week 1. Introduction

Week 2. STEM in Higher Education. Focuses on the makeup of university STEM programs; undergraduate curricula and research; library research and instruction services.

Week 3. STEM in Academic Research. Focuses on graduate and faculty research pathways; programmatic impacts; core scholarly resources.

Weeks 4-9. Program objectives through the exploration of specific disciplines. Focuses on subject orientation; features of discipline research; popular science; making connections through core resources and scholarly communications.

Week 4. Chemistry, Materials Science

Week 5. Physics, Astronomy

Week 6. Geology

Week 7. Environmental Sciences

Week 8. Energy

Week 9. Engineering, Student Design

Week 10. STEM in Government Agencies. Focuses on federal and state government involvement with STEM; information dissemination, use, accessibility.

Week 11. STEM in the Public Eye. Focuses on the impacts of STEM and scientific discoveries through scholarly and popular information resources.

Week 12. Capstone Project; Conclusion

NOTES

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