Designing and Evaluating Co-Curricular Information Literacy Sessions for Undergraduate Engineering Researchers

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Abstract

Undergraduate research experiences have been an area of increasing importance for the College of Engineering (COE) at North Carolina State University. Opportunities for undergraduate students to engage in research can be found within faculty and industry labs, honors track programs, research experiences for undergraduates (REU) programs, and co-curricular initiatives. While students pursuing these opportunities are ideal candidates for topic-specific information literacy instruction, they are often overlooked due to the absence of a centralized classroom structure associated with undergraduate research activities. This presentation will discuss how engineering librarians at the NC State University Libraries, in conjunction with COE faculty, created targeted, department-specific information literacy instruction sessions customized to support the unique needs of undergraduate researchers and conducted research on the effectiveness of the sessions.

To assess the undergraduate researchers' needs and the impact of the sessions, the librarians utilized pre- and post-session surveys to gauge the students' research experiences, expected research needs, and their confidence with finding and using specific resources. Subsequent sessions were then tailored to address identified needs and to match departmental research outcomes, based upon feedback from the departments' undergraduate research directors and advising faculty. A total of 81 students from eight sessions over the past 2.5 years completed the assessment. This presentation will discuss the structure of the information sessions, preliminary findings from the assessment, and strategies taken to incorporate the identified needs into future sessions.

Introduction

Information literacy support is well-established as a core component of university library services, with many institutions providing subject specific information literacy instruction. Within engineering librarianship, providing information literacy support via one-shot, classroom-based instruction is fairly common within senior design or project-based courses. However, librarians supporting undergraduate engineering research is not as widespread [1]. Our paper will discuss the development of library services for undergraduate engineering research at NC State University and the research we conducted to better understand the needs of these junior engineering researchers.

Previous studies have established the positive impact of both research experiences for undergraduates (REUs) and information literacy instruction for undergraduate students, specifically engineering students. In 2008, the Association of American Colleges and Universities published a report which outlined the importance of several high-impact practices within student learning and engagement, one of which is undergraduate research experiences [2]. Additionally, information literacy (IL) has been identified as an ideal learning outcome and a

necessary component of conducting undergraduate research [2], [3], since information finding, data collection, and scholarly communication are all key aspects of the research process.

Providing information literacy instruction to undergraduate researchers is a natural extension of the work librarians are already doing within classroom settings in introducing students to the resources provided by libraries and teaching them how to access and use these information sources. Research shows that library intervention with undergraduate research can improve retention [1], help students develop more profound research questions, and increase the complexity of their information searches [4]. For engineering students in particular, librarian intervention through IL instruction has been shown to improve research skills, the substance of research reports, understanding of subject material [5], and preparedness for advanced research topics [6].

To help address meeting this information literacy need within the specific context of undergraduate research, it has been suggested that integrating librarians into the instructional teams which support undergraduate researchers can help these students increase the development of their IL skills [3], [5]. Additionally, as a means of increasing library impact on campus, it has been recommended that libraries increase support to high-impact practices [7], [8].

Background

North Carolina State University (NC State), a land-grant university with a student enrollment of approximately 36,000 students [9], is considered the flagship science and technology institution within the University of North Carolina system. The College of Engineering (COE) has nine academic departments and an enrollment of more than 10,000 students, which includes roughly 7,000 undergraduate students [10].

In recent years, the strategic plans for both NC State and the College of Engineering have included undergraduate research as a high-impact educational experience that can increase student success[11], [12]. To this end, NC State offers research opportunities to undergraduates in a variety of environments. Students can conduct research through paid semester- or year-long lab-based experiences; department or college honors programs; credit-giving, research-based classes; internships on and off campus; independent research; and entrepreneurial activities and competitions. Thus, the majority of undergraduate research is conducted outside of the traditional classroom structure.

Historically, engineering librarians at the NC State University Libraries have provided ongoing information literacy support via recurring curriculum-integrated instruction sessions [13]. However, given the lack of traditional classroom structure surrounding undergraduate research at NC State, engineering librarians' support of undergraduate research has been sporadic and usually occurs in response to infrequent advisor requests.

The recent campus and College emphasis of prioritizing undergraduate research provided a new opportunity for engineering librarians to engage in dialogue with engineering departments about ways to support their junior researchers. An initial round of meetings with department heads and/or directors of undergraduate programs in several academic departments took place in the

summer of 2016 to learn how undergraduate research was handled in these different departments and to uncover any specific needs or concerns around information literacy and research skills support. One key initial finding was learning that undergraduate research was fairly decentralized, not only at the College level, but also within each department; initiating participation in research tended to take place at the individual level, e.g., students cold-calling faculty members for research opportunities, or faculty looking for interested students on their own. Another finding was that each department had their own expectations as to student outcomes, which could include giving a presentation or writing a report.

Approach

To establish library support for undergraduate engineering researchers, we approached the service with two objectives: provide specialized information literacy instruction sessions and further explore the students' needs while measuring the effectiveness of our IL sessions in order to better serve future students.

Workshop Creation & Implementation

From the initial conversations with directors and advisors, a team of three librarians identified general areas of weakness and opportunity including: literature reviews, identification of relevant resources, technical formatting, and citations. Due to the variation of needs among the departments, we decided to take a departmental approach, so that we could best align each workshop with a particular department's research focus, resources, needs, and research structure and output.

Each departmental workshop consisted of short lectures with corresponding, hands-on activities to encourage skill retention. Example lecture topics included selecting resources, effectively utilizing resources, conducting literature reviews, utilizing citation managers, technical formatting, and avoiding plagiarism. Example activities include pair-based scavenger hunts, think-pair-share plagiarism discussions, guided individual searching, search string development, and self-guided searching. Learning objectives and outcomes for each session were based on specific department needs. For instance, learning objectives for Chemical and Biomolecular Engineering (CBE) focused on resource utilization, while Civil Engineering sessions included writing literature reviews. The sessions were mainly held in the library and in departmental classrooms. Sessions ran for approximately 60-120 minutes, with sessions taking place in the following departments: Biomedical Engineering, Chemical & Biomolecular Engineering, Civil, Construction, and Environmental Engineering, Materials Science Engineering, and Mechanical and Aerospace Engineering.

Library Research & Assessment

To better understand the needs of these researchers, to help inform future sessions, and to gauge the effectiveness of the sessions we presented, we conducted user research simultaneously in the form of pre- and post-session surveys. IRB approval was obtained for both of these surveys prior to their deployment. Based on past work into successful forms of information literacy outcomes assessment [14], we settled on applying primarily summative assessment along with some

intermittent formative assessment. The pre-session survey was comprised of open-ended and Likert scale-based questions, fully shown in Appendix A. The open-ended questions were used to learn about students self-identified needs surrounding their research, independent of their expectations on library services to help guide our planning of future services. The Likert-scale questions focused on determining the effectiveness of the instruction through gauging attendees' confidence with finding and using specific resources, such as journal articles or standards, shown in Figure 1. Additional questions included non-identifiable demographics (i.e., department), students' previous use of resources, and their understanding of plagiarism. Additionally, during the session we conducted formative assessment via in-class activities, particularly utilizing online-based tools such as Google Forms, to gauge what concepts needed more clarification or discussion.

Figure 1. Pre-survey question asking students to rate their confidence in finding various resource types.

The post-session survey consisted of fewer questions, as shown in Appendix B, with the main goal of gauging changes in students' confidence in finding resources after the session. While gauging confidence with resources is not a definitive sign of effective instruction, we felt confidence in finding and using resources relates to comfort level in using the literature. Beyond non-identifiable demographic data, the post-survey included a Likert scale question on finding resources, identical to the pre-survey question.

Over the two and a half year timespan of research, we utilized two versions of the pre- and post-survey. Following our pilot workshops for CBE students, we determined the need to change the initial wording *Monographs/Edited Collections* to *Books/Monographs*, based on the students' unfamiliarity with the term "monographs" and to add the open-ended question about self-identified needs. Additionally, we included a question to indicate department affiliation, as we expanded the workshop to other departments based on the success of the pilot. Version 1 of the pre- and post-survey was used for two sessions, while Version 2 was used for the remaining six sessions. The full set of questions from Version 2 of the survey is included in the Appendix.

Findings

Demographics

Over the course of two and a half years, we taught a total of eight individual sessions to 81 students. Of these 81 workshop attendees, 50 were NC State students while 31 were students from other institutions who were participating in various NC State summer REU programs. A breakdown of the home departments of the students represented is shown in Table I. (Note that some students participated in research opportunities outside of their home departments.)

Table I. Number of attendees by self-identified departments

Department	**Number of Attendees**
Biomedical Engineering	5
Chemical and Biomolecular Engineering (CBE)	24
Civil, Construction, and Environmental Engineering	35
Industrial and Systems Engineering	1
Materials Science and Engineering	4
Mechanical and Aerospace Engineering	7
Other/unidentified	5

Use of Engineering Literature

Students' familiarity with different types of engineering literature varied considerably with document type as did their prior experience with these types of literature (see Table II). While nearly all students had heard of and used journal articles in prior class assignments or research, standards and government information tended to be less familiar and together with patents, ranked the lowest in students' experiences.

It is worth noting that in the first version of the survey, which was given to a pilot group of CBE students, it was initially surprising to find that nearly all of the students reported that they had not previously heard or used monographs. However, it is not unexpected that the term *Monographs/Edited Collections* is an unfamiliar one for students. This was subsequently changed in Version 2 of the survey to *Books/Monographs*, and resulted in more respondents reporting both familiarity and experience with using books.

Table II. Students' familiarity and prior experience with engineering literature

	Version 1 survey (n=9)		Version 2 survey (n=71)	
Literature type	**Which resources have you heard of?**	**What resources have you used?**	**Which resources have you heard of?**	**What resources have you used?**
Journal articles	8 (88.9%)	8 (88.9%)	70 (98.6%)	69 (97.2%)
Standards	1 (11.1%)	0 (0.0 %)	26 (36.2%)	14 (19.7%)
Patents	6 (66.7%)	2 (22.2%)	53 (74.6%)	9 (12.7%)
Handbooks/ Manuals	7 (77.8%)	6 (66.7%)	56 (78.9%)	28 (39.4%)
Technical Reports	8 (88.9%)	5 (55.6%)	50 (70.4%)	37 (52.1%)
• *Monographs/Edited Collections (version1) • *Books/Monographs (version 2)	1 (11.1%)	1 (11.2%)	53 (74.6%)	37 (52.1%)
Government Information	5 (55.6%)	3 (33.3%)	44 (62.0%)	25 (35.2%)
None	1 (11.1%)	n/a	1 (1.4%)	n/a

*Wording for this literature type was modified from *Monographs/Edited Collections* in Version 1 of the survey to *Books/Monographs* in Version 2.

Tables III and IV show responses collected from both versions of the surveys of the students' confidence levels in their ability to find these different types of literature, as reported immediately prior to the workshop and then at the end of the workshop session. Not surprisingly, the pre-workshop responses indicate that when students are familiar with and have used a particular literature type in the past, they tend to be more confident in their ability to locate that type of publication. For example, nearly all of the students surveyed had used journal articles in the past and over 80% of these students had confidence in their ability to find these resources. On the other hand, far fewer students had prior experience with engineering standards or knowledge of where to search for standards, with only ~21% of all students expressing confidence in being able to find standards.

Table III. Students' self-reported confidence levels in locating literature by type (a) prior to and (b) after workshop sessions (Version 1 survey).

(a)

Literature type	Very unconfident	Unconfident	Neither confident nor unconfident	Confident	Very confident	number of responses	% unconfident	% neither	% confident
Journal articles	0	2	0	3	4	9	22.2%	0.0%	77.8%
Standards	0	5	4	0	0	9	55.6%	44.4%	0.0%
Patents	0	4	2	2	1	9	44.4%	22.2%	33.3%
Handbooks/Manuals	0	2	2	5	0	9	22.2%	22.2%	55.6%
Technical Reports	0	0	5	4	0	9	0.0%	55.6%	44.4%
Monographs/Edited Collections	1	4	3	1	0	9	55.6%	33.3%	11.1%
Government Information	0	3	1	4	1	9	33.3%	11.1%	55.6%

(b)

Literature type	Very unconfident	Unconfident	Neither confident nor unconfident	Confident	Very confident	number of responses	% unconfident	% neither	% confident
Journal articles	0	0	0	4	4	8	0.0%	0.0%	100.0%
Standards	0	2	1	3	2	8	25.0%	12.5%	62.5%
Patents	0	0	1	4	3	8	0.0%	12.5%	87.5%
Handbooks/Manuals	0	0	1	4	3	8	0.0%	12.5%	87.5%
Technical Reports	0	0	1	5	2	8	0.0%	12.5%	87.5%
Monographs/Edited Collections	0	0	2	4	2	8	0.0%	25.0%	75.0%
Government Information	0	0	2	4	2	8	0.0%	25.0%	75.0%

Table IV. Students' self-reported confidence levels in locating literature by type (a) prior to and (b) after workshop sessions (Version 2 survey).

(a)

Literature type	Very unconfident	Unconfident	Neither confident nor unconfident	Confident	Very confident	number of responses	% unconfident	% neither	% confident
Journal articles	3	5	4	30	29	71	11.3%	5.6%	83.1%
Standards	14	16	23	14	3	70	42.9%	32.9%	24.3%
Patents	7	32	21	7	4	71	54.9%	29.6%	15.5%
Handbooks/Manuals	4	12	22	25	7	70	22.9%	31.4%	45.7%
Technical Reports	4	10	22	23	12	71	19.7%	31.0%	49.3%
Books/Monographs	5	9	9	30	18	71	19.7%	12.7%	67.6%
Government Information	9	13	18	21	9	70	31.4%	25.7%	42.9%

(b)

Literature type	Very unconfident	Unconfident	Neither confident nor unconfident	Confident	Very confident	*number of responses	% unconfident	% neither	% confident
Journal articles	4	0	0	22	30	56	7.1%	0.0%	92.9%
Standards	1	4	15	28	8	56	8.9%	26.8%	64.3%
Patents	1	3	14	27	11	56	7.1%	25.0%	67.9%
Handbooks/Manuals	3	0	10	29	14	56	5.4%	17.9%	76.8%
Technical Reports	1	0	9	28	16	54	1.9%	16.7%	81.5%
Books/Monographs	3	0	4	26	23	56	5.4%	7.1%	87.5%
Government Information	3	4	10	25	14	56	12.5%	17.9%	69.6%

The post-workshop results show a marked increase in these same students' confidence in being able to locate all document types, with confidence levels ranging from 64% for standards and over 93% for journal articles, shown in Figure 2. Although not all literature types were covered equally in the workshop sessions (i.e., the majority of the time was spent on searching for journal articles), exposure to previously unfamiliar literature types boosted the students' comfort level with being able to find these sources on their own. The marked difference in students' pre-session responses between Versions 1 and 2 for *Monographs/Edited Collections* versus *Books/Monographs* indicates that simply understanding the definition of a literature type is important to these students' self-efficacy. It was also a reminder for us that library jargon can be confusing to our patrons.

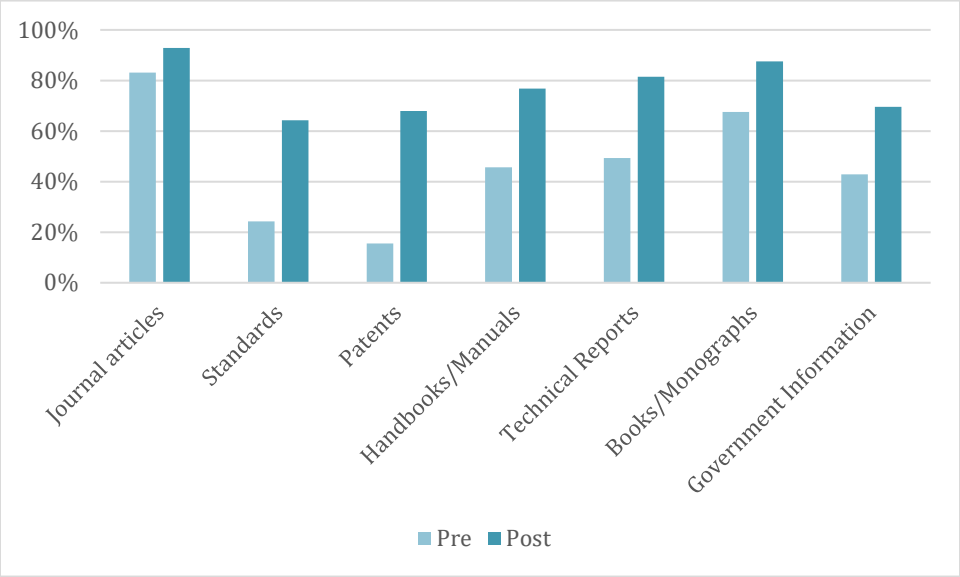

Figure 2. Comparison of pre- and post-survey confidence levels (Version 2 results only)

Self-identified needs

Sixty-five students responded to the open-ended question, "What types of information, skills or tools do you foresee needing to conduct your research project? Include anything that comes to mind." An inductive coding process was used to analyze these responses, which identified six general categories of need: information, information skills, coding skills and software, scientific/technical skills, laboratory resources, and general professional skills. Table V lists these categories along with examples of some specific needs that emerged in each category. (Note that this is not an exhaustive list of all needs that were expressed.)

Table V. Students' self-identified needs for their research projects

Needs areas	Examples
Information	• Engineering literature (e.g., journal articles, books, standards) • Datasets • Experimental methods • Equipment manuals
Information skills	• Literature searching • Literature reviews • Citations • Reading literature critically / understanding the literature
Coding skills & software	• Coding/programming skills (e.g., MATLAB, Python) • Modelling software and skills • Access to specific software programs
Scientific/technical skills	• Data analysis • Critical thinking • Experimental design
Laboratory resources	• Access to specific laboratory equipment and tools • Materials for experiments • Lab skills/web lab skills
General professional skills	• Communication skills • Presentation/public speaking skills • Time management/productivity skills • Writing skills

In terms of information and information skills, several of these matched up well with the content of the workshops, such as introducing students to resources for engineering literature, conducting effective searches, conducting a literature review, and managing citations. However, there were also several topics that could be useful to incorporate into future sessions, such as resources for datasets and by extension, basic data management skills. It could also be useful to help students understand where they can search for information regarding different experimental methods.

Some of the categories are clearly outside of the Libraries' scope, such as laboratory resources, design of experiments, and certain types of programming or modeling and simulation. However, there are other areas that overlap with learning opportunities that our Libraries currently provides, such as introductory workshops in MATLAB and Python. In addition, some of the general professional skills mentioned could be areas where we could explore adding library resources (e.g., items to our collections) or help increase students' awareness of campus resources that address these areas.

Outcomes

Following the eight workshops, we gained better insights into the effectiveness of library intervention for undergraduate research and the needs of the students. Based on the positive shifts in confidence ratings before and after the sessions, we can assume that students benefited from the sessions. Going forward, we will use our findings as the basis for future iterations. The

iterative approach to our instruction is already taking place, as the findings from the initial CBE workshops have led to changes in both the survey tool and the session structure. Following the pilot we incorporated more hands-on activities, more discussion of resource types based on in-the-moment needs, and we adapted the survey to be more understandable and broader in scope.

The responses we gathered surrounding self-identified needs are helping us better understand student perceptions of what they need in order to be successful at their research. While our sessions clearly address two categories, information and information skills, going forward we can connect students with library and/or campus resources to address the other categories. Knowing what students need will help us develop new content as well, as we can use these initial survey results as a starting point to begin adjusting future sessions.

As we move forward, we can consider new forms of information delivery, perhaps working with other library departments to offer multi-session support, or providing multiple topic modules for students to select from. Additionally, going forward we can shift our research focus from the effectiveness of the sessions to the impact of the content of the session on their research. Potential avenues for conducting this research include implementing longitudinal surveys at the end of the REU, collecting more feedback from program directors, and working with advisors to compare previous and future research outputs.

Throughout the planning and assessment process we learned valuable lessons that will help guide our future work. In particular, planning long-term assessment within a program can be challenging due to participant willingness, differing time constraints within programs, and shifting priorities for students. As a next step, we plan to work with each program director to explore ways to implement longer-term assessment of the products of research products, such as papers or presentations.

Conclusion

Overall, while this assessment is still in a preliminary phase, the findings thus far confirm that "standard" IL instruction is needed for undergraduate researchers. The results also highlight that there are other areas not typically covered in standard one-shot instruction where libraries can take part such as supporting more advanced topics like data management, scientific reasoning, and coding/software skill development.

As we continue to expand our support, next steps will include expanding sessions, shifting assessment to a content focus, partnering with new departments, and exploring new forms of assessment. Regardless of the structure of content and the mode of research, we have learned that co-curricular support can help solidify the Libraries' role in supporting undergraduate research.

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Appendix A: Pre-Survey Questions (Version 2)

Q1 Is North Carolina State University your home institution?

- Yes
- No

Q2 Select your department

- Biological and Agricultural Engineering
- Biomedical Engineering
- Chemical and Biomolecular Engineering
- Civil, Construction, and Environmental Engineering
- Computer Science
- Electrical and Computer Engineering
- Industrial and Systems Engineering
- Materials Science and Engineering
- Mechanical and Aerospace Engineering
- Nuclear Engineering
- Textile Engineering, Chemistry and Science
- Other (please specify)

Q3 What types of information, skills, or tools do you foresee needing to conduct your research project? Include anything that comes to mind.

Q4 Which of these resources have you heard of? Please check all that apply.

- Journal Articles
- Standards
- Patents
- Handbooks/Manuals
- Technical Reports
- Books/Monographs
- Government Information
- None

Q5 In your research and assignments what resources have you used? Please check all that apply.

- Journal Articles
- Standards
- Patents
- Handbooks/Manuals
- Technical Reports
- Books/Monographs
- Government Information
- Research done by Adviser or labmates
- None
- Other (please specify)

Q6 Where did you find those resources?
Please check all that apply.

- Adviser or lab mate gave them to me
- From the library (online or in-person)
- From the general internet
- From a class
- Other (please specify)

Q7 Please rate your confidence in your ability to find the following resources for completing research assignments:

- Very Unconfident (1)
- Unconfident (2)
- Neither confident nor unconfident (3)
- Confident (4)
- Very Confident (5)
    - Journal Articles
    - Standards
    - Patents
    - Handbooks/Manuals
    - Technical Reports
    - Books/Monographs
    - Government Information

Q8 How comfortable are you with formatting a technical assignment, paper, or report?

- Very Unconfident (1)
- Unconfident (2)
- Neither Confident nor Unconfident (3)
- Confident (4)
- Very Confident (5)

Q9 In one sentence, please explain why you think citations are important.

Q10 How often has a librarian guest lectured in one of your engineering classes?

- Never (1)
- Once (2)
- More than once (3)

Appendix B: Post-survey questions (Version 2)

Q1 Is North Carolina State University your home institution?

- Yes
- No

Q2 Select your department

- Biological and Agricultural Engineering
- Biomedical Engineering
- Chemical and Biomolecular Engineering
- Civil, Construction, and Environmental Engineering
- Computer Science
- Electrical and Computer Engineering
- Industrial and Systems Engineering
- Materials Science and Engineering
- Mechanical and Aerospace Engineering
- Nuclear Engineering
- Textile Engineering, Chemistry and Science
- Other (please specify)

Q3 Please rate your confidence in your ability to find the following resources for completing research assignments:

- Very Unconfident (1)
- Unconfident (2)
- Neither confident nor unconfident (3)
- Confident (4)
- Very Confident (5)
    - Journal Articles
    - Standards
    - Patents
    - Handbooks/Manuals
    - Technical Reports
    - Books/Monographs
    - Government Information

Q4 How comfortable are you with formatting a technical assignment, paper, or report?

- Very Unconfident (1)
- Unconfident (2)
- Neither Confident nor Unconfident (3)
- Confident (4)
- Very Confident (5)

Q5 In one sentence, please explain why you think citations are important.