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WIP: Developing a Virtual Information Literacy Training Program for a Multi-Disciplinary First-Year Engineering Program

Mr. Alexander James Carroll, Vanderbilt University

Alexander J. Carroll, MSLS, AHIP, is the Librarian for STEM Research at the Vanderbilt University Libraries. Alex serves as a liaison librarian for the School of Engineering and STEM academic units within the College of Arts and Science, supporting the research of faculty and developing curriculum-integrated information literacy instruction programs for students in the sciences.

Alex serves as an Assistant Editor for the Journal of the Medical Library Association (JMLA) and is a Senior member of MLA's Academy of Health Information Professionals (AHIP). His research interests include information seeking behaviors and data practices of STEM researchers and improving information literacy instruction for students in the sciences; he has published on these topics in journals such as College & Research Libraries, portal: Libraries and the academy,The Journal of Academic Librarianship, and theJournal of the Medical Library Association. His work in these areas has been recognized by the ALA Library Instruction Round Table with "Top Twenty" awards in 2018 and 2019.

Dr. Joshua Daniel Borycz, Vanderbilt University

At Vanderbilt University I help graduate and undergraduate students learn how to do research and succeed academically by introducing them to a range of tools, developing new tools, creating educational programs, and advocating for the use of library services. My goal is to help connect researchers to the tools and insights that can help them to integrate good data management practices and data sharing tools to improve scientific collaboration. I became interested in Library and Information science after my PhD in chemistry and decided to pursue a Master's Degree at the University of Tennessee, Knoxville. This degree connected me with many opportunities to act as an advocate for integrating library services into modern scientific research.

I was a computational chemist at the University of Minnesota, Twin Cities whose research has focused on performing quantum mechanical calculations on the utility of metal-organic frameworks for applications involving magnetism, carbon dioxide capture, and catalysis. My interest in fundamental research stemmed from my desire to gain a deeper understanding of processes used in industrial and energy generating applications. The computational nature of my research provides me a strong understanding of the theory behind these processes and has allowed me provide insight to and learn from experimental chemists and chemical engineers.

Dr. Julianne Vernon, Vanderbilt University

Dean Vernon works in the field of STEM educational research; some areas of focus include student retention and implementation of innovative pedagogy and technology. She is currently the Assistant Dean of Academic programs overseeing the First Year Courses, Study Abroad Programs, and International Initiatives at Vanderbilt University. She received her Bachelors in Chemical Engineering from the City College of New York and her Doctorate degree at University of Florida in Environmental Engineering. She has over 10 years of experience developing international and national research experiences for STEM majors, as well as project management.

Work in Progress: Developing a Virtual Information Literacy Training Program for a Multi-Disciplinary First-Year Engineering Program

Motivation

This Work in Progress paper describes an ongoing effort to integrate information literacy training into a multi-disciplinary first-year engineering program. Launched as a pilot project for the 2019-2020 academic year, this training program aims to use information literacy instruction to introduce students to the complex ecosystem of technical engineering information. This Work in Progress paper discusses changes made to this program in response to the lessons learned from the pilot stage of this project, how this program shifted to an online delivery model due to the COVID-19 pandemic, and preliminary results gathered during the fall 2020 semester.

Background on Problem Being Addressed

In the first-year engineering program at Vanderbilt University, students take a three-credit course in the fall of the first year called Introduction to Engineering. The Introduction to Engineering course is broken into three modules, each consisting of 14 sections. Because the program aspires to preview what students can expect to learn in each major and the possible career paths that could follow, students are encouraged to explore modules that align with their interests or that fall outside of their previous experiences.

While the design of each course section reflects the expertise and interests of the individual instructor who leads it, most sections include problem-based learning opportunities and some form of project-based learning developed around the National Academy of Engineering's Grand Challenges for Engineering [1]. The Grand Challenges for Engineering, which span a broad range of societal, real-world problems in need of technical solutions, effectively demonstrate to first-year engineering students how they can make an impact in the world by studying engineering [2]. While many of the fundamental courses students study in their first year may seem abstract and disconnected from real-world applications, the Grand Challenges for Engineering connect fundamental coursework to actual careers, industries, and broader societal problems [3]. Consequently, working within the framework of the Grand Challenges may help students envision which engineering fields might be best to pursue during the remainder of their undergraduate careers.

In many of the Introduction to Engineering sections at Vanderbilt, groups of four to five students complete a project-based learning assignment that requires them to explore one of the 14 Grand Challenges: 1) advance personalized learning; 2) make solar energy economical; 3) enhance virtual reality; 4) reverse-engineer the brain; 5) engineer better medicine; 6) advance health informatics; 7) restore and improve urban infrastructure; 8) secure cyberspace; 9) provide access to clean water; 10) provide energy from fusion; 11) prevent nuclear terror; 12) manage the nitrogen cycle; 13) develop carbon sequestration methods; and 14) engineer tools of scientific discovery. Prior to presenting their projects to their classmates via an oral presentation, each team is given approximately one month to conduct background research on their challenge and to receive peer feedback from other groups. Student groups are asked to create slides to accompany their presentation and are required to include a reference slide listing the resources they consulted during this process.

Project-based learning assignments like this one, in which students develop their own questions and propose potential solutions to real-world problems, often benefit from information literacy instruction (ILI) [4], [5]. Successful ILI interventions empower students to explore the contexts surrounding a problem and to synthesize the information they find in order to identify potential solutions. Partnerships between engineering educators and information specialists in upper-level courses involving project-based learning assignments are common [6], but these partnerships are comparatively rare within first-year engineering programs. The most effective information literacy programs feature highly contextualized instruction, which provides skills and knowledge that are directly relevant to students' authentic interests [7]–[9]. However, because first-year engineering programs must enroll every first-year engineer and provide a broad survey of the profession without further saturating the already overextended first-year curriculum, these programs' designs rarely align well with these ILI best practices [10]. Instead, many ILI programs for first-year engineering rely on transmission of knowledge via generic orientation sessions presented in high-capacity seating lecture halls [11].

Instructional Methods

Using the Grand Challenges inspired problem-based learning assignment as a catalyst, we sought to determine whether a highly contextualized ILI intervention tied explicitly to an inquiry-based assignment could lead to increased student achievement. During the first pilot stage of this training program conducted in the fall 2019 semester, an engineering librarian met with students in participating sections by visiting their classroom as a guest lecturer. During a 25-minute lecture, the librarian demonstrated how to use specialized information retrieval tools to locate technical information like journal articles and handbooks. In order to comply with institutional social distancing protocols to slow the spread of COVID-19, all librarian-led guest lectures at Vanderbilt were shifted to online only for the fall 2020 semester. This change necessitated the development of virtual instructional methods that could replace the in-person ILI program developed last year. To provide this ILI intervention to their students in the fall of 2020, faculty instructors could select one of two options: 1) an eight-minute video that was integrated into the learning management system; or 2) a 50-minute virtual guest lecture via Zoom. Because instructors were able to integrate the recorded video into their course's learning management instance without notifying us, we were unable to calculate the total number of participants versus non-participants in this pilot implementation. Anecdotally, multiple instructors reported assigning the video within their courses.

In each delivery medium, the ILI intervention opens by introducing the concepts of bench research (e.g., collecting data, analyzing data, drawing schematics, etc.) and background research (e.g., developing research questions, finding previously conducted studies, and synthesizing previous work to explain why a problem is worth solving). The ILI intervention then explains how bench research and background research inform and reinforce one another, and how students can use both research processes when completing their project-based learning assignment. The ILI intervention closes by modeling how to find contextual and technical information using licensed library resources, such as AccessEngineering [12] and Web of Science [13]. During the 50-minute live Zoom sessions, students were introduced to two additional topics: 1) strategies for reading journal articles effectively [14]; and 2) how to use citation management software [15].

Learning Outcomes Assessment

To conduct a preliminary analysis of the potential impacts of this program, our proposed learning outcomes assessment strategy sought to compare performance between students who had received the 50-minute guest lecture versus students who had watched the eight-minute video. However, to be included in the study, instructors needed to opt-in to both of the following: 1) receiving one of the two forms of the intervention; and 2) enrolling their students in the learning outcomes assessment portion of the study. Unfortunately, none of the instructors who assigned the recorded video lecture opted their students into learning outcomes assessment portion. However, three chemical engineering sections were eligible for inclusion, as the instructor opted into both a 50-minute guest lecture and the learning outcomes assessment portion of the study. Each of these three sections was led by the same faculty instructor, and each received an identical information literacy guest lecture via Zoom from the same engineering librarian.

To evaluate the effectiveness of this intervention, we evaluated presentation slides completed by student groups within the three eligible chemical engineering sections. We measured student achievement of three learning outcomes, referred to as Criterion 1, 2, and 3, by customizing a rubric previously developed for evaluating undergraduate research assignments [16]. Criterion 1, "Evaluate Information Sources Critically," measures students' ability to select a variety of appropriate information sources as part of their projects. Criterion 2, "Use Information Effectively," measures students' ability to synthesize multiple information sources within their presentations, as well as their use of in-text citations to bolster their claims with evidence. Criterion 3, "Use Information Ethically," measures students' ability to ethically use these sources of information as indicated by their inclusion of image credits and by providing a full list of complete references. The full rubric used is available in Appendix I. Students' citation patterns in their final assignments were also analyzed to measure the extent of their information use.

Preliminary Results

Table 1 reports the mean score for Criterion 1, Criterion 2, and Criterion 3 for student groups in each module. Table 1 also reports the mean of the total scores across all three criteria, along with the standard deviation (SD) and standard error of mean (SEM) for the mean total scores. The full rubric used for scoring performance across Criterion 1, 2, and 3 is available in Appendix I.

Table 1: Student performance in group presentations. n refers to number of student groups, each containing four to five students. Each criterion = three-point maximum score.

Module	Criterion 1	Criterion 2	Criterion 3	Total Score	Total SD	Total SEM
Module 1 (n = 7)	3.0	1.9	2.4	7.3	1.7	0.6

Module 2 (n = 7)	2.7	2.9	2.1	7.7	1.8	0.7
Module 3 (n = 7)	1.7	1.7	1.9	5.3	2.0	0.7
All Modules (n = 21)	2.5	2.1	2.1	6.8	2.0	0.4

Table 2 provides the results of the quantitative citation analysis of the sources cited within the student groups' reference slides, and includes the mean, standard deviation (SD), and range for each module.

Table 2: Student citation patterns in group presentations. n refers to number of student groups, each containing four to five students.

Module	**Sources cited (mean)**	**SD**	**Range**
Module 1 (n = 7)	8.6	1.2	4
Module 2 (n = 7)	7.9	2.7	8
Module 3 (n = 7)	5.4	2.2	5
All Modules (n = 21)	7.3	2.4	9

Discussion

In this second pilot phase, we sought to assess the viability of offering this ILI intervention via a remote teaching environment and to test the appropriateness of this rubric for measuring student performance in these research assignments. Because instructors were able to integrate the 8-minute recorded video without opting into the learning outcomes assessment portion of this study, we were unable to compare the results of the performance of students who received a live lecture against the performance of students who viewed only the recorded lecture. Moreover, because we did not include an experimental or quasi-experimental design within this pilot implementation stage, the scores of the students receiving the in-person lecture were not tested for significance across modules, as all students included in this pilot program received the same treatment. However, in spite of these limitations, these proposed learning outcomes assessment methods show promise for evaluating first-year engineering students' information use in inquiry-based assignments.

Future iterations of this study will include randomization, in which some groups enrolled in the study will not receive the guest lecture version of the ILI intervention. To determine whether this ILI intervention has measurable impacts on student performance, we will use one-way analysis of variance (ANOVA) to check for statistical significance across the groups' performance in the evaluation criteria as well as in the extent of their information cited. We will also use Pearson's correlation coefficient to evaluate the relationship between the number of citations and total score on the rubric. We hypothesize that student groups that receive an ILI intervention will achieve higher scores in all three criteria. We also anticipate that student groups who receive an ILI intervention will show increased information use as signified by the number of sources cited in their presentations. Our future results will be compared to previous studies reported in the literature, noting areas of convergence and divergence with previous findings.

Limitations and Future Work

Participation in this program is currently voluntary, with course instructors needing to opt-in to receive the guest lecture and to include their students in the program evaluation. By only including courses taught by instructors who chose to opt-in, our study population may reflect a selection bias, which may limit the generalizability of the results. Related to this limitation, one potential future avenue for this work is to investigate the motivations that cause instructors to either opt-in or opt-out from this information literacy intervention. There are several possible drivers of this behavior, some of which may stem from the limited amount of in-class time available for this one-credit course. Instructors who opt-in may have previously worked with an engineering librarian in another setting, and as a result may be more willing to dedicate class time to a guest lecturer that they trust will use the time effectively [17]. On the other hand, instructors who opt-out from this intervention may feel that they are better equipped to address this topic themselves [18], or may feel compelled to use lecture time to cover additional engineering conceptual content rather than science process skills like information literacy [19]. A survey or semi-structured interview with instructors could be an effective way of determining the barriers and facilitators to participation and could be of interest to both first-year engineering program directors as well as engineering librarians who are seeking to integrate information literacy or other science process skills into first-year programming.

While future iterations of this program evaluation will include randomization within participating sections, additional limitations in our learning outcomes assessment methods may be harder to address. Citation analyses like the one used in this study are a widely-accepted means of assessing the extent of students' information use [20]; however, others have noted the limitations of this approach [21], specifically that students may cite high numbers of less than authoritative sources in order to pad their bibliography, rather than using a handful of authoritative sources more effectively [22]. While our study design accounts for this limitation by also including a rubric analysis that qualitatively assesses whether students' cited sources are relevant, current, and authoritative, it is possible that this tension between extent and quality of sources cited could create noise within our data. Furthermore, this study currently does not include a survey component that asks students to note whether they have received information literacy training previously or concurrently in any of their other courses, such as their first-year writing course. For these students, practice effects may impact their performance [23].

We look forward to discussing this program's design, evaluation methods, preliminary findings, and study limitations with colleagues at the 2021 Annual Meeting. We will welcome feedback from members of the community on possible improvements we can make prior to the fall 2021 semester.

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Appendix I: FPD Research Assignment Rubric

	Capstone 3	Milestone 2	Benchmark 1
Evaluate Information Sources Critically Points ________	Chooses a variety of information sources appropriate to the scope and discipline of the research question. Selects sources using all the following criteria: relevance to the research question, currency, and authority.	Chooses a variety of information sources. Selects sources using basic criteria (such as relevance to the research question and currency).	Chooses a few information sources. Selects sources using limited criteria (such as relevance to the research question).
Use Information Effectively **Points ________**	Communicates, organizes and synthesizes information from multiple sources. Distinguishes between common knowledge and ideas requiring attribution, and indicates sources used through in-text citations. Intended purpose is achieved.	Communicates and organizes information from sources. Distinguishes between common knowledge and ideas requiring attribution, and indicates sources used through in-text citations. The information is not yet synthesized (i.e., multiple sources are not used in concert), so the intended purpose is not fully achieved.	Attempts to communicate information from sources. Attempts to distinguish between common knowledge and ideas requiring attribution, but in-text citations are incomplete, inadequate, or used irregularly. The information is fragmented and/or used inappropriately (misquoted, taken out of context, or incorrectly paraphrased, etc.), so the intended purpose is not achieved.
Use Information Ethically Points ________	Demonstrates a full understanding of the ethical use of information by including a reference list, through consistent use of a citation style that provides enough information for references to be retrieved by a reader, and by providing credits for any images used.	Demonstrates an understanding of the ethical use of information by including a reference list, which provides enough information for references to be retrieved by a reader	Demonstrates a limited understanding of the ethical use of information by including a reference list that does not provide enough information for references to be retrieved by a reader.

Total points:________________

Adapted from: Association of American Colleges and Universities (AAC&U), "Information Literacy VALUE Rubric," *Association of American Colleges & Universities*, 2009. [Online]. Available: https://www.aacu.org/value/rubrics/information-literacy. [Accessed: 12-Sep-2019]; Association of College & Research Libraries, "Information Literacy Competency Standards for Higher Education," Jan. 2000. [Online]. Available: http://www.ala.org/acrl/standards/informationliteracycompetency; A. J. Carroll, N. Tchangalova, and E. G. Harrington, "Flipping one-shot library instruction: using Canvas and Pecha Kucha for peer teaching," *Journal of the Medical Library Association*, vol. 104, no. 2, pp. 125–130, Apr. 2016.