



Information-seeking behavior among first-year engineering students and the impacts of pedagogical intervention

Dr. George James Lamont, University of Waterloo

George Lamont teaches Communications in the Engineering Profession at the University of Waterloo. George specializes in developing engineering-communications curricula with authentic, discipline-specific materials in partnership with engineering firms and clients.

Dr. Kari D. Weaver, University of Waterloo

Kari D. Weaver holds a B.A. from Indiana University, an M.L.I.S. from the University of Rhode Island, and an Ed.D. in Curriculum and Instruction from the University of South Carolina. Currently, she works as the Learning, Teaching, and Instructional Design Librarian at the University of Waterloo Library in Waterloo, Ontario, Canada. Her research interests include co-teaching, information literacy perceptions and behaviors of students across disciplines, academic integrity, professional development education for librarians, and censorship.

Mrs. Rachel Figueiredo, University of Waterloo

Rachel Figueiredo holds a BA from the University of Waterloo and an MLIS from Western University. She is currently the liaison librarian for Engineering and Entrepreneurship at Waterloo. Rachel's research interests include core competencies for entrepreneurship librarians, research practices of engineering scholars, and how libraries can reshape their services in the world of information overload.

Dr. Kate Mercer, University of Waterloo

Kate Mercer has been the liaison librarian for Systems Design Engineering, Electrical & Computer Engineering and Earth & Environmental Sciences at the University of Waterloo since 2015. Kate's main duties include providing instruction and research services to students, faculty and staff. Kate graduated with a MI from the University of Toronto in 2011, and completed her PhD at the University of Waterloo's School of Pharmacy. Most of Kate's publication history revolves around how health and technology interact, and her primary research focus is on how people are accessing, understanding and disseminating information.

Dr. Andrea Jonahs, University of Waterloo

Andrea Jonahs, Ph.D., MFA, is a lecturer at the University of Waterloo. She teaches professional communication to students in STEM fields.

Dr. Heather A Love, University of Waterloo

Heather Love is an Assistant Professor of English at the University of Waterloo (Ontario, Canada), where she conducts interdisciplinary research on topics related to engineering, technology, literature, and culture. Her current book project argues that early twentieth-century experimental literature is an important part of the "cultural pre-history" of mid- and later-century cybernetics work. She teaches first-year communication courses to students in the electrical and computer engineering and the life sciences programs. She is also an elected Member-at-Large on the IEEE's Society on Social Implications of Technology (SSIT) Board of Governors, a position she has held since 2018.

Dr. Brad Mehlenbacher, University of Waterloo

Brad Mehlenbacher is an Associate Professor of Rhetoric and Communication in the Department of English Language and Literature at the University of Waterloo in Canada, and author of the award-winning *Instruction and Technology: Designs for Everyday Learning* (MIT Press, 2010). He has published extensively on human-computer interaction, communication design, and online instruction.

Carter Neal, University of Waterloo



Carter Neal is an Instructor in English at the University of Waterloo, where he teaches communications courses in the sciences and Engineering.

Dr. Katherine Zmetana, University of Waterloo

Katherine Zmetana teaches Communications in the Engineering Profession at the University of Waterloo. She has taught communications and technical writing in the health and science professions for over 20 years.

Dr. Rania Al-Hammoud P.Eng., University of Waterloo

Dr. Al-Hammoud is a Faculty lecturer (Graduate Attributes) in the department of civil and environmental engineering at the University of Waterloo. Dr. Al-Hammoud has a passion for teaching where she continuously seeks new technologies to involve students in their learning process. She is actively involved in the Ideas Clinic, a major experiential learning initiative at the University of Waterloo. She is also responsible for developing a process and assessing graduate attributes at the department to target areas for improvement in the curriculum. This resulted in several publications in this educational research areas. Dr. Al-Hammoud won the "Ameet and Meena Chakma award for exceptional teaching by a student" in 2014 and the "Engineering Society Teaching Award" in 2016 and the "Outstanding Performance Award" in 2018 from University of Waterloo. Her students regard her as an innovative teacher who continuously introduces new ideas to the classroom that increases their engagement.

Information-seeking behavior among first-year engineering students and the impacts of pedagogical intervention

Authors: Lamont, George; Figueiredo, Rachel; Mercer, Kate; Weaver, Kari; Jonahs, Andrea; Love, Heather; Mehlenbacher, Brad; Neal, Carter; Zmetana, Katherine; Al-Hammoud, Rania.

Abstract:

This is a complete paper - evidence-based practice. ABET accreditation criteria specifically require engineering students to demonstrate the ability to research broad contexts informing engineering problems and emerging technical developments to facilitate solutions. Such research fundamentally underpins engineering students' ability to succeed in design projects, and this research is even more crucial to their professional activity. As a result, engineering programs incorporate diverse interventions to professionalize engineering students' information-seeking approaches to filtering out unreliable sources and identifying credible ones. Programs generally assume that these approaches equip students for the information needs of engineering careers. However, relatively little is actually known about what first-year engineering students do when they seek information and whether interventions have any effect on this behavior. Recent research has demonstrated that professional engineers rely on professional networks and non-scholarly media for their information, and then invest heavily in resource evaluation to verify information and mitigate risks of error. Some emerging research suggests that engineering students may use similar strategies to seek information, but there is a lack of consensus about why first-year engineering students select certain sources and how they evaluate the credibility of these sources. To address this gap in understanding, we conducted a multi-stage reflective case study of 279 first-year engineering students' information-seeking behavior in a mandatory engineering-communications course. We established the students' baseline information-seeking behavior in a pre-research task, a librarian conducted a workshop to teach engineering research practices, students submitted a design project with evidence of their research activities, and then we evaluated the extent to which course interventions had any impact on the students' information-seeking behavior. Our results have significant implications for the design of engineering-design and engineering-communications courses in Canadian and U.S. engineering programs to meet the intent of accreditation criteria and the demands of the engineering industry.

Introduction

Information-seeking skills that lead to informed decision making are so crucial to engineering education that three of the seven American Board of Engineering and Technology (ABET) student outcomes directly call for them. Criterion 1 mandates "an ability to identify, formulate, and solve complex engineering problems" which ABET defines as "involving wide-ranging or conflicting technical issues, having no obvious solution, addressing problems not encompassed

by current standards and codes” [1]. Criterion 4 further mandates “an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments,” and criterion 7 further calls for “an ability to acquire and apply new knowledge as needed, using appropriate learning strategies” [1]. The ABET criteria strongly imply that engineering students must understand how to research a diversity of sources, distinguish credible sources from less reliable sources, and make informed decisions to facilitate design choices and implementation that the public depends on not only for practical benefits but also for safety.

Engineering programs deploy diverse programming to interpret these mandates and fulfill accreditation criteria for rigorous inspections. Designing curricula to teach the relevant research skills to meet student outcomes is less centrally defined in the ABET criteria, which identify “communications” briefly in individual program criteria, and only explicitly name “research skills” or “citation” as key learning objectives. As a result, engineering programs incorporate training in research methods and the communication of those methods to varying extents and in varying ways. Some programs incorporate such training in first-year engineering content courses, others incorporate research-skills training in higher-level courses, and still others conduct stand-alone communications courses with learning outcomes to train students in research skills and citation. Current teaching methods proceed on the assumption that first-year engineering students lack information-seeking skills and that teaching these skills brings about a durable improvement in these abilities.

However, those who research these student behaviors and those who teach these skills do not yet have a clear picture of what first-year engineering students do on their own when they search for information, or whether teaching these skills in courses actually changes their practice. Recent work examining information behavior among engineering undergraduates has demonstrated that students improve these skills in professional contexts, but first-year students do not consistently evaluate sources for credibility if they do not perceive an authentic engineering-specific value to this activity. Research into design thinking in engineering courses has indicated that coupling research activity with design can foster meaningful student learning of research skills, but that results still vary widely by course and teaching style. The information-seeking behavior of professional engineers is well-understood, but educators are still working to develop collaborative models between librarians and course instructors to teach these skills effectively to first-year students.

To understand how students’ initial information-seeking behavior evolved in our first-year engineering-communications course, we conducted a pedagogical reflective case study of our 279 students in thirteen sections of the course. We assessed the students’ initial information-seeking behavior with a pre-research task, a librarian delivered training in source-evaluation strategies to accommodate students’ uses of diverse source types, students created a final project in which they investigated a real engineering problem and proposed future design work to

address that problem, and we evaluated the final projects to determine whether the students had used credible sources and whether they had improved their use of such sources in the course. Some of our results surprised us, revealing that students' initial information-seeking behavior can accommodate credible sources but that students may not be actively evaluating them; additional results demonstrated that teaching these skills in a first-year course can be considerably effective, but there remain unanswered questions about exactly what such teaching accomplishes. These insights will certainly influence how we improve the design of future versions of this course, and suggest valuable opportunities to improve this kind of teaching in engineering programs and clarify accreditation criteria to support such teaching in the future.

Review of Relevant Literature

There is relatively little research about how and where first-year engineering students seek information, and whether interventions have any effect on their strategies. While colloquial examples of "I just Google it" abound, research in this field is still emerging [2]. Similarly, various methods for instructional intervention with engineering students have been investigated including active learning [3], flipped classrooms [4], and online modules [5]. This field is also still emerging, although it has been demonstrated that strategic educational interventions can improve student outcomes [6]. The existing literature investigating how, when, and where engineering students seek information is centered in three main areas: Information Behavior of Engineering Undergraduates, Design Thinking in Engineering Courses, and Communication Skills in Engineering Curricula and Practice, which are described below. These three areas provide a brief context that grounds the necessity for further research into this area to provide a cohesive picture of information seeking done by undergraduate engineering students.

Information Behavior of Engineering Undergraduates

There is limited information around undergraduate engineering students' information and technical communication skills [7]. Fosmire [8] indicates students benefit from explanations of how practicing engineers use information and communication in professional practice. This aligns with the idea that, in cooperative education scenarios, students model themselves off of the engineers they are working with [9], which carries over to their information-seeking practices as well. Earlier research indicates that addressing information behavior in the classroom enhances professional practice and develops communication, teamwork, and problem-solving skills [10] which again aligns with Fosmire's idea that engineering students benefit from professional context. However, Wertz et al. [11] identify that students in first-year engineering courses are unlikely to gather high-quality sources of information to support arguments without direct instruction on why and how such actions are important.

Design Thinking in Engineering Courses

Design courses form the foundation of many engineering programs, and the engineering curriculum makes heavy use of information sources and technical communication skills [12], [13]. Introducing information and communication skills early in an engineering curriculum, and highlighting these skills through the use of design challenges or solutions, has been demonstrated to have a positive effect on student work [12]. If presented well, such instruction is regularly replicated in more advanced coursework where information and communication are natural outcomes of the design process [14]. Considerations of information behavior and communication fluency are particularly critical for successful design outcomes, as much of the end product must be developed from collaborative team work [15].

Communication Skills in Engineering Curricula and Practice

Practicing engineers identify that information retrieval and evaluation are well known, with several articles identifying the amount of time practicing engineers devote to information seeking and use [16-20]. Leckie and Fullerton [21] investigated the engagement of faculty in the development of information literacy and communication skills across science and engineering disciplines. The study found faculty would prefer librarians take the lead in teaching information literacy skills, and expect students to be able to integrate what they learn about locating and evaluating information into their written or presented work. These research and communication skills become critical in a curriculum where students engage in experiential or project-based learning methods as their academic careers progress [9], [22].

Methodology

This project is a reflection upon existing teaching methods and does not subject students to experimentation or assign any student to a control group. All elements of this teaching had been used in previous versions of the course, including elements of pre-research, the library workshop, and the final project. Students' identities were kept anonymous by individual instructors, who tabulated the data together, but students were given codes in the data tabulation so that only each student's instructor could tabulate overall course data. All of these results were examined only after all grades were submitted, the course was complete and closed, and no outstanding student petitions were in process. None of these data or analysis could have been applied to the students' grades.

Stage 1: Observing existing information-seeking behaviors among incoming first-year engineering students

In our institution, students in civil, environmental, geological, electrical, and computer engineering take a mandatory communications course in the first term of their first year. The timing of the course means that students are generally relying on information-seeking behavior learned in secondary school. To gather a baseline of the students' information-seeking practice, instructors had students complete a "Pre-Research Worksheet," which prompted them to locate sources related to an engineering topic of interest to them (guidelines did not direct their behavior), to record the sources found, and to compose a reflection in which the students explained their source-selection approach.

The Pre-Research Worksheet's first prompt instructed students, "Do some initial research: use whatever sources that you would generally use to start exploring a topic. Find at least 3 of these sources." The wording was given to prompt the students to find and report their sources without suggesting any preferred source or method of selection. Students were then asked in the worksheet to report the title of the source, the authors, the topic, the main information content, the conclusions given in the source, and the location. These prompts would allow the instructor to determine the type of source and whether the student had read the source. The worksheet's second prompt instructed, "Engineers must communicate their processes to others as part of the design process. Briefly explain how you found your sources, why you selected them, and what you might do differently to find information at the next stage of this project." This prompt was designed to minimize pseudo-transactional writing by linking the task to an engineering-specific activity. Also, this prompt directed students to consider and report their information-seeking practice in order to evaluate whether students focused on relevance or also considered credibility in their selections.

After grades for the course were submitted and the course was complete, the students' responses to the first prompt were tabulated and sorted into categories to answer our first reflection question: What kinds of sources did students select? These results were sorted first into whether students selected internet vs. paper sources. The results were then sorted into types of internet sources: websites (including Reddit and other forums, Quora, corporate websites, blogs, and general information websites that do not fall into the other categories), magazine articles, video (such as YouTube or Vimeo), government websites, news, online encyclopedias (such as Wikipedia), academic books, and peer-reviewed research articles. For all results, students were assigned alphabetical codes by their individual instructors in order to preserve their anonymity and then these results were entered into a common spreadsheet workbook for tabulation.

The students' responses to the second prompt, in which students reflected on and reported the reasons for selecting their sources, were tabulated to answer our second reflection question: Did

the students report evidence that they assessed their selected sources for reliability, not only relevance? Student responses were analyzed and tabulated according to five descriptors:

1. Not present: The student does not demonstrate that credibility played a role in their selection process. E.g. “I selected them because they will help me in the next stage of the project,” or the sources provided “brief and understandable information.”
2. Limited: The student shows a general awareness of the need to filter sources, such as by using a library database, but does not identify any criteria otherwise to establish credibility. E.g. “Relied on Google scholar, then sorted by relevance,” or “I selected those sources because they seemed quite authentic.”
3. Adequate: The student describes at least a general policy of seeking credible sources, not merely relevant sources. E.g. “I tried to choose academic journals or articles from reputable publishers” or “Wikipedia articles were used... Then, sources cited in the articles were read.... In the next stage..., I would find sources from scholarly journals....”
4. Significant: the student describes an active process of considering specifics about sources, including investigating the type of publication, the background of the author, or the date or age of the article. E.g. “I tried to find websites run by organizations that I would recognize ... I also looked for info on the authors to see how qualified they are.”
5. Extensive: the student specifically names enough criteria that the student is already employing the majority (3 out of 5) of the RADAR criteria: Rationale, Authority, Date, Accuracy, Relevance.

These descriptors were shared among all authors assessing the students’ responses, and these descriptors contained example responses that represented the extent of the students’ assessment of credibility. These examples were gleaned from an initial review of student responses, and then written into these descriptors to aid instructors in differentiating students’ responses. During evaluation, key phrases or sentences from each student’s response were recorded beside the data table, but redacted by the author to remove details that could reveal the details of the topic and possibly reveal the student’s identity, even though the datasheet was kept confidential among the authors only.

Stage 2: Library intervention to train students in basic techniques to evaluate sources for credibility

Students were required to submit the Pre-Research Worksheet to their instructors, followed by a library intervention. The library intervention consisted of a single seventy-minute interactive presentation and opportunity for students to apply introduced content. Librarians typically provided instruction during the first four weeks of the term, with the aim that this intervention would position students to be more successful in upcoming assignments. Three librarians collaborated to create one lesson on the importance of critically appraising information sources, in order to ensure consistency across classes. The Pre-Research Worksheet provided a catalyst for conversations about students’ existing schemas for evaluating a resource to determine if it is

appropriate for use in an academic setting. Following some discussion, librarians presented the RADAR Framework as a means of formalizing these schemas and filling in knowledge gaps where necessary [23]. RADAR is a commonly-used framework for evaluating information that probes students about specific criteria related to the acronym headings. For example, under the Rationale heading students are prompted to answer questions about the reasoning behind why a resource was created: Why did the author or publisher make this information available? Is there a sponsor or advertising? Who pays to help make this information available? There are no right or wrong answers within the RADAR Framework. Rather, the goal is to motivate students to think critically about how information was produced, what biases might be exposed, and what their information needs are within a given context. The RADAR Framework was selected because it is adaptable to various professional contexts and does not demand that the information under analysis conform to traditional scholarly paradigms. In an academic classroom setting, students should be able to determine if a resource is considered credible for upcoming assignments.

Following the presentation of the RADAR Framework, students were given class time to evaluate two different sources using this formalized criteria. Students were encouraged to revisit one resource from their Pre-Research Worksheet and find a new resource using the Library's collection. In the librarian-led discussions following this activity, students generally concluded that it took more time and effort to evaluate resources found outside the academic Library collection; however, it took more time and effort to determine how to perform a search in the previously unfamiliar Library resource. One aim of this intervention was to expose students to the world of scholarly resources found within the Library's collections, outside the realm of Google, so that they would be motivated to consult these resources for upcoming assignments. However, regardless of where information was found, the RADAR framework provided students with the necessary information to effectively evaluate resources before including them in academic assignments.

The emphasis placed on expanding the approach to and tools of information seeking is central to the presentation and classroom discussion in the library intervention. Asking students to build from their place of knowledge, searching in Google, and apply those skills to a new context mirrors the approaches seen in practicing professional engineers within the workplace who must survey information broadly to address problem and design tasks. Additionally, the presentation connects information seeking and critical appraisal of sources to the ethical obligations engineers have to the people who ultimately use their designs. These components are essential to the efficacy of the intervention as they align with the curricular approach of the entire course and fit within the expectations students bring of the direct connection between their coursework and their future working lives.

Stage 3: Students create final projects that must use relevant and credible sources

All course sections discussed in this reflection included a final project that required students to demonstrate relevant engineering graduate attributes of problem-solving, investigation, and communications skills. Students were assigned an independent project early in the course, in which they found evidence of an engineering problem, demonstrated the social or market need to address that problem from an engineering perspective, researched current practices for dealing with that problem, and recommended action that would further address or mitigate that problem. This task explicitly prompted students to apply their learning about selecting sources and use citations to demonstrate that they were engaging in a clear practice of using reliable sources in their engineering work.

Stage 4: Evaluation of final projects to assess student improvements in using credible sources

After grades for the course were submitted and the course was complete, the students' final projects were assessed for evidence that the students used sources to support their claims, and whether these sources were reasonably credible. The students' final projects were assessed separately from their pre-research reflections in order to minimize bias by comparing the two results. These results were used to answer our final reflection question: "What evidence do the final projects show that students are using reliable sources to support their claims?" Student responses were analyzed and tabulated according to five descriptors designed to be parallel to those of the second reflection question (evaluating their pre-research approach to selecting sources), in order to facilitate comparison:

1. Not present: The student does not use sources, or does not use reasonably reliable sources to support the final project.
2. Limited: The student uses some reliable sources, but not enough to show a clear practice of supporting claims with reliable sources. Reliable sources are a minority of sources used, or are used very little to support claims that require citation.
3. Adequate: The student uses reliable sources enough to make the evidence generally persuasive in this final project and show a clear practice of supporting claims with reliable sources.
4. Significant: The student shows a practice of regularly using reliable sources to support the final project. The majority of sources are reasonably reliable, or the project depends primarily upon the reliable sources cited.
5. Extensive: The student shows a consistent practice of using reliable sources to support the final project. Although some sources cited in the project may be less reliable, the student clearly uses reliable sources to support the claims extensively. Either a large majority of cited sources are reasonably reliable, or the final project depends heavily on reliable sources to support claims.

Results

Our findings suggest that the majority of students did not consider or at least report that they much considered credibility when they selected sources for their project at the first stage. However, we also report that a large majority of students did use credible sources at least adequately in their final projects.

What kinds of sources did students select on their own before the intervention?

Reflection question 1 asked what kinds of sources students selected when they were pursuing a topic of their interest and relying on their existing information-seeking behavior. We recognized that students might begin their learning about a topic by exploring a variety of sources, and we did not anticipate that students would resort immediately to peer-reviewed articles or academic books. However, the Pre-Research Worksheet asked students to select the first three sources that they would use to begin their formal research. In this way, students were not required to report the first three sources they viewed, but rather the first three sources they intended to use to understand their project. Students reported 836 sources in total. After examining each reported source, we found that students relied overwhelmingly on the Internet to locate sources: students reported 835 Internet sources and only 1 paper-based source.

More interesting are the numbers of each type of source that students selected. Following their pre-existing practice, students selected the following:

Table 1: Types of sources selected and reported by students as initial research sources.

Media type	Number of sources used	Percentage of whole
Websites	437	52.27%
Magazine articles	16	1.91%
Video	6	0.72%
Government sites	48	5.74%
News	142	16.99%
Online encyclopedias	17	2.03%
Academic books	4	0.48%
Peer-reviewed articles	166	19.86%

It was not surprising to the authors that students consulted so few books, since librarians and course instructors widely observe student disinterest in reading lengthy sources, especially early in a project. However, three results here surprised the authors and challenged many common preconceptions of student information-seeking behavior. First, very few students presented content from video-streaming sites such as YouTube, Vimeo, and others as research sources. At a time when more educators are resorting to online video to reach students and audiences, students did not select these as their initial formal research sources. The observations did not

account for student perceptions of instructor bias, so whether the students deliberately avoided reporting video sources is not discernible in this study.

Second, only 2.03% of reported sources were online encyclopedias such as Wikipedia. Mercer, Weaver, and Stables-Kennedy [7] reported in their 2019 scoping review that professional engineers often resort to online encyclopedias as a first step in learning about new engineering topics, and the library workshop explained that online encyclopedias can be evaluated for reliability, but students in these courses did not report them as initial formal research sources. Again, the study could not discern whether this reflects a lack of student use of such sources or a conscious decision by students to anticipate instructor resistance to online encyclopedias.

Third and most surprising, however, was the students' use of peer-reviewed journal articles and technical articles in engineering disciplines. Of the 836 sources reported by students in the Pre-Research Worksheet, 166 were peer-reviewed journals or papers, which amounts to 19.86% of all sources reported. However, this method of measuring this result does not tell the whole story. When the number of individual students who reported at least one peer-reviewed article or paper was calculated, it was revealed that 95 of the 272 students who submitted the Pre-Research Worksheet had resorted to peer-reviewed research before they were trained in research methods by the instructor or exposed to the library intervention. This amounts to 34.93% of students in this large sample who used peer-reviewed sources without any explicit or implied prompt to do so. The Pre-Research Worksheet and prompt were designed to elicit the student's baseline information-seeking behavior, but this study again cannot determine whether implicit student perceptions of instructor expectations influenced this outcome.

How did students characterize their baseline information-seeking behavior?

Reflection question 2 asked what students wrote about their information-seeking behavior when they reflected on their research process in the Pre-Research Worksheet. The prompt was developed in consultation with the librarians in this team to encourage the students to find sources as they usually would do so, and avoid implying instructor expectations. The prompt read, "Engineers must communicate their processes to others as part of the design process. Briefly explain how you found your sources, why you selected them, and what you might do differently to find information at the next stage of this project." Students wrote between a few sentences and as much as two paragraphs in response, and their reflections were evaluated for whether the students demonstrated evidence of a practice of evaluating sources for credibility.

Table 2: Assessment of baseline student information-seeking behavior.

Descriptor	Students	Percent
1. Not present: The student does not demonstrate that credibility played a role in their selection process.	97	35.66%
2. Limited: The student shows a general awareness of the need to filter sources, but does not identify criteria to establish credibility.	74	27.21%
3. Adequate: The student describes at least a general policy of seeking credible sources, not merely relevant sources.	67	24.63%
4. Significant: the student describes an active process of assessing credibility, including publication type, author background, or date.	32	11.76%
5. Extensive: the student names multiple criteria and employs any majority (3 out of 5) of the RADAR criteria.	2	0.74%

The students' characterizations of their approaches to selecting sources present a different picture from the students' reports of sources they selected. For instance, very few students selected resources generally regarded as having limited credibility (e.g. only 6 [0.72%] reported using video-streaming sources, and only 17 [2.03%] reported using online encyclopedias), which could suggest that students are making deliberate decisions not to rely on them for information. However, the students' own characterizations of their selection practices do not demonstrate that enough students are evaluating the credibility of their sources to explain the avoidance of video-streaming sites and online encyclopedias. Only 37.13% of students reported considering credibility at all, and just over 35% of all the students did not explicitly address credibility at all in their reflections. Although there is not a firmly established connection between the avoidance of video-streaming sites or online encyclopedias and active evaluation for credibility, these data also reveal that students' decisions not to use certain types of sources do not easily correlate with how the students evaluate the credibility of their sources.

Perhaps most notably, however, a surprisingly high number of students included at least one peer-reviewed article compared to the number of students who reported an active process of assessing credibility. Peer-reviewed articles tend to be highly technical and challenging to read, so we anticipated that students would not resort to them without any prompt or incentive to do so. Only 34 students (12.50%) reported an active process of evaluating one credibility criterion (significant) or more (extensive), which we anticipated might coincide with relatively few uses of peer-reviewed journal articles. However, as reported above, 95 students (34.93%) selected at least one peer-reviewed article or paper. Again, although there is not a firmly established connection between student attitudes towards evaluating credibility and the use of peer-reviewed journal articles, these results also demonstrate that the number of students employing peer-reviewed articles in this study did not easily correspond to students' characterizations of whether and how they evaluate sources for credibility.

How much did students employ reliable sources in their final projects?

Our final reflection question asked whether students improved or expanded their use of reliable sources in their final engineering projects. Our intention was to observe whether this engineering communications course had prompted any change in the students' information-seeking behavior, or whether the students' practice of selecting sources had largely remained the same. To assess this, descriptors were devised to be as similar as possible to those used in the evaluation of sources selected for the Pre-Research Worksheet to enable comparison. Instructors assessed students for how much the final projects employed credible or questionable sources to support the students' factual claims and arguments. 279 students completed the final project, an increase of 7 from the 272 students who completed the Pre-Research Worksheet. This number appears to be the result of additional student enrollments in individual sections after the deployment of the Pre-Research Worksheet but before the university's course-addition deadline. We report that the students demonstrated a very noticeable shift in their employment of reliable sources in this final project:

Table 3: Assessment of student information-seeking behavior in final engineering project.

Descriptor	Students	Percent
1. Not present: The student does not use sources, or does not use reasonably reliable sources to support the final project.	11	3.94%
2. Limited: The student uses some reliable sources, but not enough to show a clear practice of supporting claims with reliable sources.	33	11.83%
3. Adequate: The student uses reliable sources enough to make the evidence generally persuasive in this final project.	82	29.39%
4. Significant: The student shows a practice of regularly using reliable sources to support the final project.	82	29.39%
5. Extensive: The student shows a consistent practice of using reliable sources to support the final project.	71	25.45%

Instructors did note that some students did not employ reliable sources in their final projects as much as their reflections characterized in the Pre-Research Worksheet, but such instances were extremely rare. The authors did not set out to demonstrate this improvement, but rather simply to measure what happened, without concern for how the results would appear. The results suggest that students used credible sources in their final projects far more than they characterized their practice of doing so in the Pre-Research Worksheet:

Table 4: Comparison of Pre-Research Worksheet results and final project results.

Descriptor	Pre-Research	Final Project
1. Not present	35.66%	3.94%
2. Limited	27.21%	11.83%
3. Adequate	24.63%	29.39%
4. Significant	11.76%	29.39%
5. Extensive	0.74%	25.45%

Discussion

Our goal was to assess whether students would improve or extend their consideration of the credibility of their sources in engineering work within the framework of a first-year engineering communications course. Our findings suggest that structuring teaching and a library intervention as conducted in this course facilitates a valuable improvement in first-year engineering students' attention to evaluating credibility of sources in engineering projects. When students first engage in the pre-research process and the reflection of characterizing their practice of assessing sources, they develop awareness that they are making choices about how they select some sources over others. When students then receive training in the library intervention and in class to assess sources without relying on typical filters or categories of sources, students expand their use of reliable sources. This is particularly important in engineering projects because students generally express anxiety about reading highly technical information. This outcome also directly connects to ABET accreditation criteria, which require engineering students to demonstrate the ability to research engineering problems and emerging technical developments to facilitate solutions. All of this helps engineering students avoid duplicating past work and failing to understand the complexity of what is already known.

This reflection upon teaching this large and diverse sample reveals that the majority of incoming first-year engineering (62.87%) students did not think actively about evaluating selected initial research sources for credibility, and that only a minority (37.13%) made any explicit reference to evaluating sources for credibility. However, our observations also demonstrate a key discrepancy between the sources that students selected and their own awareness of their practice. When very few students selected online encyclopedias or video-streaming content, this result could imply that the students' baseline information-seeking behaviour was to avoid such sources because they present limited credibility. However, these results must be interpreted cautiously. Although more than 97% of students did not select online encyclopedias as their sources in their pre-research worksheets, only about 39% of students explicitly stated that they considered credibility in their information-seeking behaviour. A similar discrepancy arises from the observations that 34.93% of students selected at least one peer-reviewed journal article or paper, but only 12.50% considered any criterion for evaluating credibility other than using a library search engine or Google Scholar. These discrepancies could signify that students are not reporting their practice

accurately, which calls for more sophisticated assessment of baseline information-seeking behaviour, or it could signify that students are avoiding and selecting sources in university research projects for reasons other than their actual credibility. Future reflections and possible research projects could investigate the reasons for these discrepancies, in order to determine whether students are responding to perceptions of instructor preferences without actually evaluating potentially useful sources for credibility. Future work should investigate whether students are anticipating instructor expectations or under-reporting their baseline information-seeking behavior.

Most importantly, this reflection shows strong evidence that this large sample of 279 students who completed final project did improve their information-seeking behavior to assess credibility. In the final project, only 11 students of 279 did not display any evidence that they had attempted to use reliable sources, whereas 97 of 272 students on the Pre-Research Worksheet did not report any attempt to assess the credibility of these sources. At the pre-research stage, only 34 of 251 students explicitly applied at least one criterion to assess credibility, but 153 of 279 students at least significantly used reliable sources to support their final projects.

Conclusions and Future Work

This pedagogical reflection on this pilot project reveals some important limitations. Since this is not a research project, we did not create a control group, since doing so would deprive some students of the originally planned pedagogy of the course, which was central to accreditation learning outcomes. Also, we cannot confidently explain the discrepancy between the considerable use of peer-reviewed sources and the limited awareness of assessing credibility in the students' initial reflections. This reflection also cannot discern whether students internalized the practice of assessing credibility or did so in response to instructors' prompts.

Despite these limitations, this reflection strongly suggests that the pedagogical framework of the Pre-Research Worksheet, the library intervention, and the teaching in preparation for the final project considerably enhance first-year engineering students' use of credible sources to support their engineering work. This outcome has important implications for the design of first-year programs and the arrangement of communications content in engineering curricula. Because research skills are crucial to success in upper-level engineering courses and projects, teaching resource-evaluation practices in first-year engineering prepares students to succeed when they need to focus on learning engineering content, not academic skills. This outcome also illuminates the value of interdisciplinary teaching in first-year engineering, as communications specialists and engineering librarians can make significant contributions to first-year engineering programs in ways that other first-year content courses may not have the time or resources to conduct.

The potential of this approach has not yet been fully explored. A logical next step for such a course is to assign a mid-course annotated bibliography assignment to allow instructors to examine another student reflection on their practice after the library intervention and teaching. This could continue with another reflection in the final project to track the evolution of each student's research approach and compare it to the actual use of resources. Final developments could more closely assess which sources have been assessed for credibility in final projects, and how much they represent the students' cited evidence. More broadly, ethics approval could allow institutions to track students' evaluation and use of credible sources in future courses or even throughout their programs in order to assess the long-term effects of such teaching on engineering practice.

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