Using a faceted taxonomy to investigate student selection of information sources in an engineering lab course

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Abstract

Do the type of sources used by students in their lab reports relate to their comprehension of theory? The objective of this research project is to investigate the connections between student selection of information sources and the comprehension of theory in an engineering lab course. The results will provide instructors with a tool that provides multiple aspects and qualities to examine when assessing the information sources students use in an engineering lab course.

This study examined the types of information sources that students cited in their lab reports by four facets that include format, author, editorial process, and publication purpose and compared them with a disciplinary evaluation of their technical reports. Classification of these facets was based on a taxonomy created for English composition courses. The taxonomy was modified to include information formats specific to the engineering discipline. The information sources were extracted from student lab reports over three years, and each citation was classified by the four facets. In addition, the reports themselves were evaluated for the demonstration of their understanding of the theory. Each student cohort was then divided into one of three performance categories (top, middle, and bottom third) based on the evaluation. The frequency of usage and the most frequent combinations of subfacet attributes were identified. The differences in the distribution of subfacet attributes were examined for relationships between the sources and performance. Although causation cannot be established, the data set could lay the groundwork in identifying the types of sources most commonly used by engineering students and those that are associated with the higher-performing students.

Background

Engineering librarians are concerned with the quality of sources students use in their assignments [1]–[4]. However, the changing nature of the information landscape and the expansion of information sources available to undergraduate students has made it more difficult to use one-size-fits-all recommendations or conclusions. This challenge has led academic librarians, in general, to move away from prescriptive standards to a more flexible framework for the development of information literacy instruction [5]. Recently, the approach of using a faceted taxonomy to examine information sources used by students has been piloted by two studies.

Leeder, Markey, and Yakel [6] sought to create a standardized assessment tool that was flexible enough to include online sources that students use. They found fault with the criteria used by previous citation analyses: currency, relevance, the correctness of citation format, quality, and scholarliness. Instead, they developed a faceted taxonomy that included the information format, the literary content, the author identity, the editorial process, and the publication purpose. They also assigned ranked scores to each facet. They used the taxonomy to assess the impact of an online game by using the taxonomy on a student research assignment completed by both a test and control group. They found the faceted taxonomy was useful for categorizing the sources used for the assignment, understanding the assignment was geared toward online sources and had no requirement to use scholarly sources. For this pilot study, 30 bibliographies were scored.

Rosenzweig, Thill, and Lambert [7] adapted the same faceted taxonomy to assess research papers in an English writing course. Their goal was to better understand the sources selected by students and how they determined authority. They chose to use only the facets for author identity, editorial process, and publication purpose. They did not use the numerical scores used by Leeder, Markey, and Yakel [6] instead taking a more descriptive approach. They scored 60 student papers with a total of 692 citations. They found that 75 percent of the citations were represented by 14 subfacet attribute combinations. They compared these 14 subfacet combinations to student variables such as GPA, student age, and paper grade. They found no significant patterns or correlations.

It has been well recognized that engineers use information sources differently than other disciplines [8]–[10]. This faceted taxonomy left out some information formats that are key to engineering. With small modifications, the faceted taxonomies developed by Leeder, Markey, and Yakel [6] and Rosenzweig, Thill, and Lambert [7] can be used to better capture the types of information sources used by contemporary engineering students in their assignments. This modified taxonomy will help engineering librarians and engineering faculty to have a greater understanding of the types of information sources that engineering students are using.

Purpose

The objective of this research project was to identify and categorize commonly cited information sources and then to further investigate the connections between source selection and student comprehension of the theory in the context of an engineering lab report. In particular, do the better performing students rely more on sources written for academic audiences when compared to lower-achieving students? This project built on the two previous uses of a faceted taxonomy and used a bigger dataset. The resulting taxonomy for engineering will provide instructors and librarians with a tool to examine multiple aspects and qualities when assessing the information sources students use in an engineering lab course. A secondary objective was to explore the impact of the assignments on the types of information sources used. Using the taxonomy provided a mechanism to quantify the impact of the assignment on the findings from the students' literature searches.

Design/Method

This project was conducted at California State University, Maritime Academy in the Fall of 2019. Data were gathered from student lab reports completed in the required Thermal/Fluids Laboratory course taken by Mechanical Engineering majors in their Fall Semester of Senior year. An Institutional Review Board (IRB) application was approved by the California State University, Maritime Academy IRB committee. Over three years, all students taking the course were invited to participate. This resulted in 106 of 112 students giving consent: Fall 2017 (32 students), Fall 2018 (42 students), and Fall 2019 (32 students). The course consisted of three major laboratory experiments. The lab report topics were convection, airfoil, and truck drag. As the semester progressed, the latter two topics were not based on knowledge from prerequisite courses. Students were provided additional information literacy instruction to help with their searches. The supplemental instruction was also a part of an effort to improve students' information literacy skills in this program. Each experiment included theory presentations

halfway through and a final technical report at the conclusion. The work presented will examine the 318 final technical reports submitted by students during the three year period.

A faceted taxonomy was developed based on previous studies [6], [7] and was modified to include information formats specific to the engineering discipline (Appendix A). In Facet 1: Information Format, five subfacets were removed (policy statement, directory, news story, institutional repository, and digital repository). Five subfacets were added (dissertation/thesis, manual/user guide, presentation, website, and unknown) and the monograph subfacet was split into two to create a separate subfacet for textbooks. Facet 2: Literary Content was eliminated because it had little relevance to engineering literature. In Facet 3: Author Identity, unknown authorship was split into two subfacets (unknown and anonymous) to distinguish between instances where the authorship was intentionally anonymous versus instances where there was too little information to determine authorship. No modificatons were made to Facet 4: Editorial Process or Facet 5: Publicaton Purpose

The authors reviewed the 318 lab reports and extracted 1,665 citations. Fifteen citations were excluded because they were for images used in the lab report. The authors coded each citation according to the faceted taxonomy (Appendix A). To ensure consistent coding, a random sample of 83 unique citations were pulled, including repeats which accounted for 622 citations. The coding of the facets amongst the same and similar information sources was compared. This comparison led to the modification of codes for 23 of the 622 citations or 3.7%.

The authors, one of which was the instructor for the course during the three year period, also evaluated the theory section of each report for completeness, accuracy, as well as clarity and depth using a rubric (Appendix B). For each year and topic, the reports were divided into three groupings based on the rubric assessment scores: top, middle, and bottom third. The division into thirds was done by the population, meaning that the scores that define each group may have varied from year to year or report to report. Each group consisted of approximately 35 students over the three year period. Using two performance groups would have created a larger sample size but would have diluted the variations, while using four performance groups would have reduced the confidence in the results due to the small sample size.

Results

The results of the facet analysis are presented by two underlying themes. First, the data were related to student performance to examine the connections between the source types and performance. Second, the data were related to the report topics to examine the connections between the source types and the nature of the assignments.

Findings by Student Performance

Figure 1 shows the breakdown by Facet 1: Information Format for each of the performance groups, and Table 1 provides detailed numbers for the top five subfacets by percentage. The most frequently used subfacet was websites (1W) representing 24.8%, 25.9%, and 27.4% of sources used for the top, middle, and bottom third performance groups, respectively. It was interesting to note the similar percentages in this subfacet, suggesting a similar preference for website usage among all three groups. Of the next four subfacets, there was slight variation when

comparing by student performance group. Textbook usage (1T) represented 24.2%, 24.0%, and 24.7% of sources used for the top, middle, and bottom third performance groups, respectively. The top third had slightly higher usage of blogs (1A) and reports (1R). The top five subfacets was rounded out by works from scholarly journals, which ranged from 5.3% to 8.0%. These small variations, such as the increased usage of reports and scholarly journal articles by the top third performance group, were expected. However, the increased usage of blogs by the top third performance group was interesting to note, as was the increased usage of material from public sharing sites by the bottom third performance group.

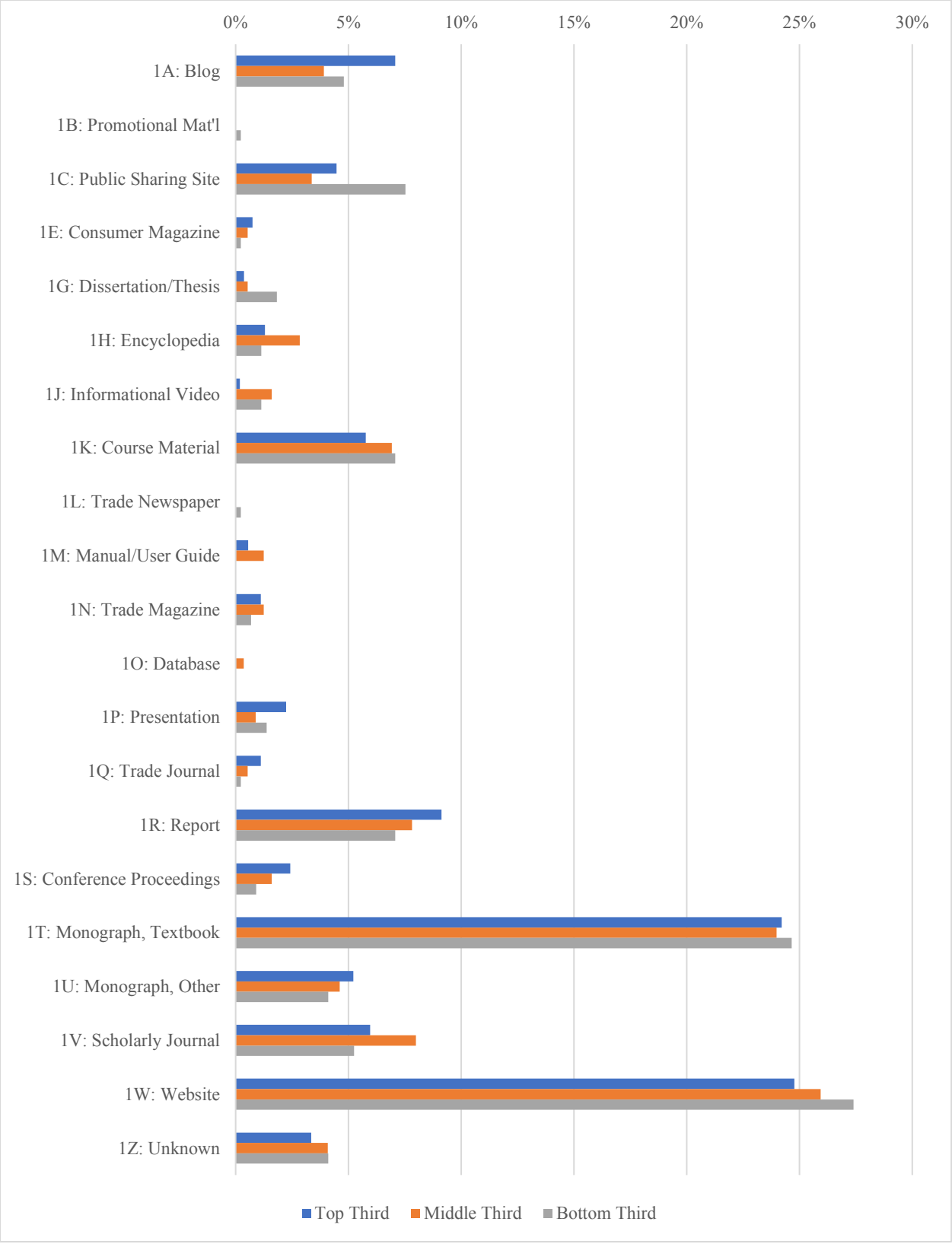

Figure 1. Breakdown of Facet 1: Information Format by student performance categories.

Table 1. Detailed percentages of total citations for the five most frequent information formats in Figure 1 by student performance categories.

Facet 1: Information Format	Top Third	Middle Third	Bottom Third
1W: Websites	24.8%	25.9%	27.4%
1T: Textbooks	24.2%	24.0%	24.7%
1R: Reports	9.1%	7.8%	7.1%
1A: Blogs	7.1%	3.9%	4.8%
1V: Scholarly Journal	6.0%	8.0%	5.3%

When examining the data for Facet 3: Author Identity (Figure 2), it became difficult to distinguish variations amongst the three groups. Approximately half of all of the sources used by all students were authored by academic professionals (3F), constituting 50.8%, 50.3%, and 47.5% from the top, middle, and bottom third performance groups, respectively. Recall that in the previous facet, approximately 25% of sources were categorized as textbooks. These percentages for 3F indicate that the roughly half were written by academic professionals but were not textbooks. For all three performance groups (top, middle and bottom), corporate authorship (3C), representing 18.1%, 18.7%, and 20.3%, respectively, and anonymous authors (3A), representing 16.2%, 13.9%, and 16.4%, respectively were the next largest. The results were encouraging in that the majority of the sources did come from academic professionals, and behavior amongst the three groups was relatively similar.

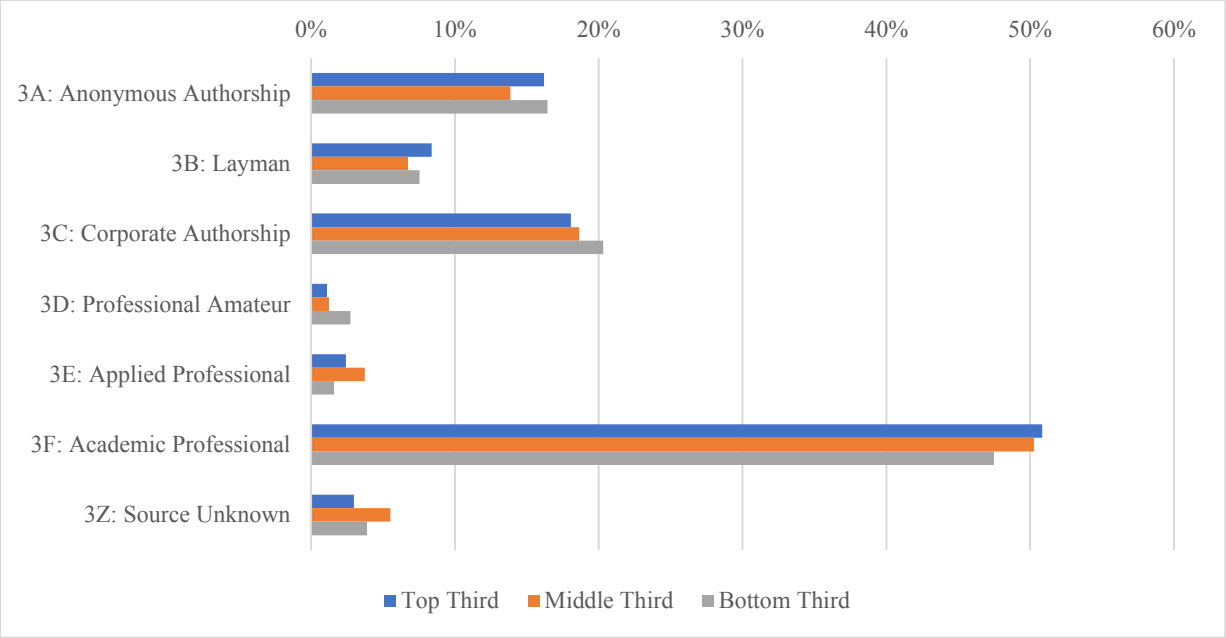

Figure 2. Breakdown of Facet 3: Author Identity by student performance categories.

Much like the previous facet, the results for Facet 4: Editorial Process showed similar findings across all student performance categories (Figure 3). The highest percentage of the sources were categorized as having a self-published editorial process (4A), at 48.0%, 47.4%, and 46.6% of sources from the top, middle, and bottom third performance groups, respectively. The fact that the highest percentage of sources were self-published was not expected. Although these sources may come from reputable origins, such as government reports, there is no indication that these sources undergo external review. Websites, corporate materials, and blogs, for example, tend to fall into this category. The next largest group consisted of sources that were professionally reviewed by an editor or editorial staff (4E), ranging from 29.7% to 31.1%. The remaining subfacets were found in less than 10% of the sources and showed variations of no more than 2%.

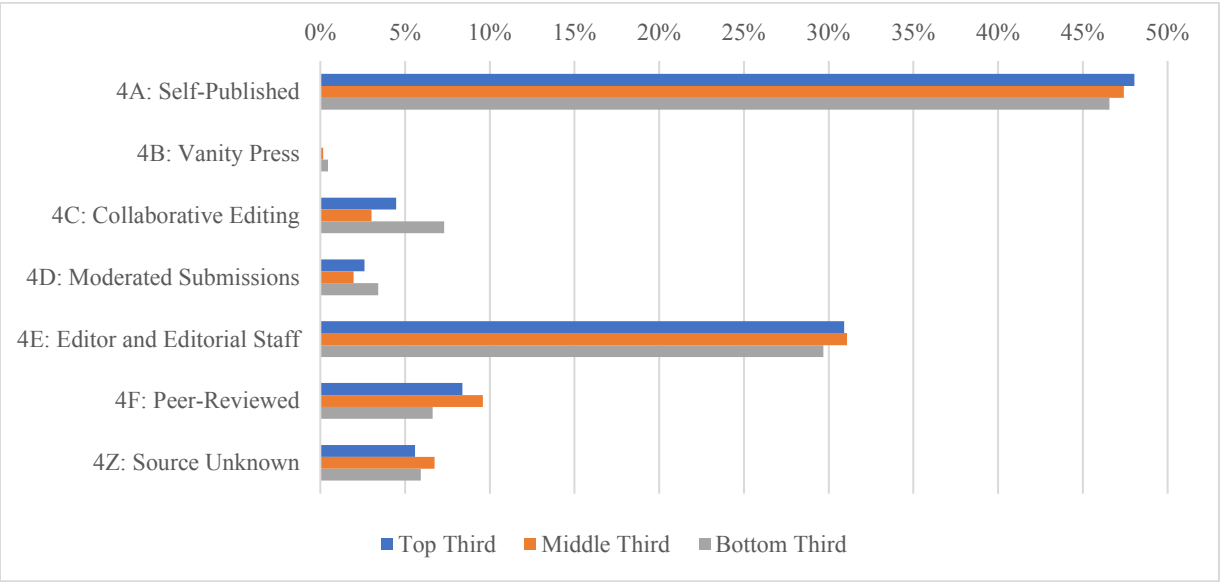

Figure 3. Breakdown of Facet 4: Editorial Process by student performance categories.

Lastly, the results showed only slight variations in Facet 5: Publication Purpose, as seen in Figure 4. Most of the sources used were intended for higher education (5F), consisting of 42.8%, 44.3%, and 39.5% of the sources from the top, middle, and bottom third performance groups, respectively. This was followed by similar usage of publications for commercial purposes (5B) at 16.4%, 17.1%, and 18.0% and government purposes (5E) at 16.4%, 15.%, and 18.0% for the top, middle, and bottom third performance groups, respectively. There was a slightly elevated usage of publications written for personal reasons (5A) by the top third at 15.5% as compared to the bottom third at 12.8%. Overall though, it appeared that publication purpose across the student performance categories was similar.

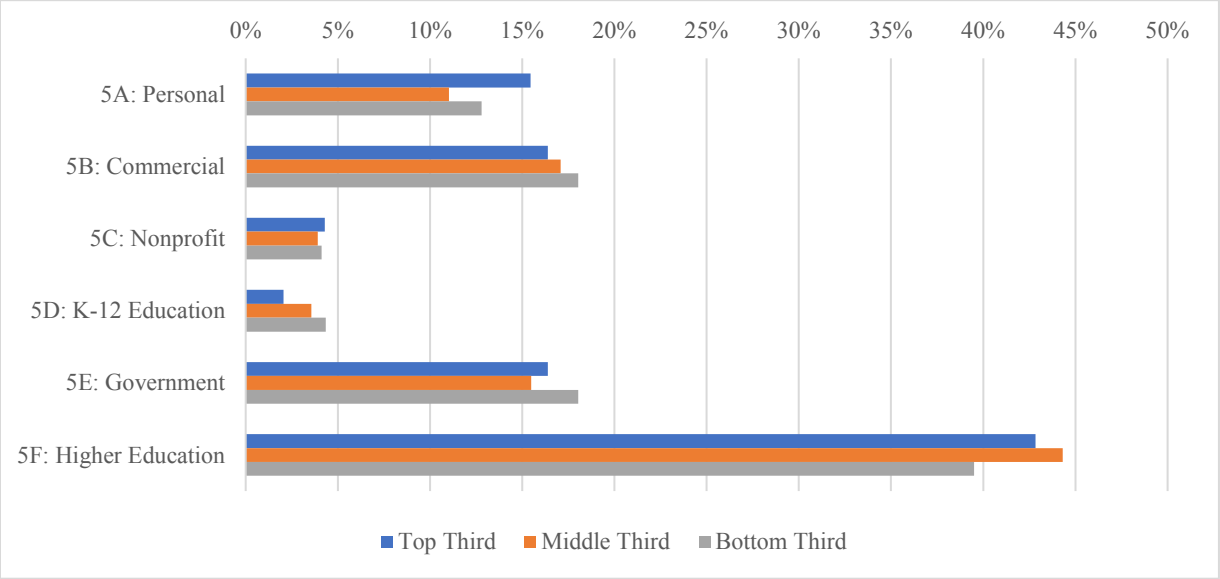

Figure 4. Breakdown of Facet 5: Publication Purpose by student performance categories.

Overall, the results by student performance did not show considerable variation amongst the student performance groups. By looking at each facet separately, the data presented was an incomplete picture of the types of sources students were using. To address this concern, subfacet combinations were considered. The five most frequent combinations used by all students are listed in Table 2. By far, the most commonly used source was textbooks (21.4%), which links the textbook subfacet in Facet 1 with those related to peer review and academic purposes. This was followed by government reports (11.4%) and government websites (8.0%). These were followed by journal articles (5.9%) and product websites (5.9%). The results were encouraging, in that the top four source subfacet combinations were generally considered credible sources and that neither personally published sites nor collaborative editing sites were on this list. This combination of subfacets used presents a different picture than the analysis of each facet individually. For example, looking only at the editorial process in Facet 4, the high percentage of self-published sources might seem alarming until the overall combinations were examined, where some of those sources were identified as government reports and government websites.

Table 2. Top 5 most frequent subfacet combinations cited in student lab reports

Facet 1: Information Format	Facet 3: Author Identity	Facet 4: Editorial Process	Facet 5: Publication Process	Example	No. of Samples	% of Total
Monograph, Textbook (T)	Academic Professional (F)	Editor and Editorial staff (E)	Higher Education (F)	Textbooks	353	21.4%
Report (R)	Academic Professional (F)	Self-Published (A)	Government (E)	Government Reports	188	11.4%
Website (W)	Corporate Authorship (C)	Self-Published (A)	Government (E)	Government Websites	132	8.0%
Scholarly Journal (V)	Academic Professional (F)	Peer-Reviewed (F)	Higher Education (F)	Journal Articles	98	5.9%
Website (W)	Corporate Authorship (C)	Self-Published (A)	Commercial (B)	Product Websites	97	5.9%

Findings by Report

Another avenue to explore was the effect of each assignment on the sources used. The assignments and lab experiments associated with each setup were quite different. The starting experiment on convection was more reliant on concepts from a prerequisite course. A literature review for the theory section could have been completed using a prior textbook. The next lab report was on airfoils, which was a topic the students had no prior exposure to. Students were expected to conduct a literature search to understand the theory. Students could find sources that were located within the library's materials, including textbooks or old journal articles. However, there was also ample content on this topic on the internet. The final lab report on truck aerodynamics differed from the previous two because it was based primarily on research completed over the last couple of decades. As a result, the literature search directed students toward resources such as journal articles and government reports. Examing the results by report could help identify some trends not captured in the breakdown by student performance.

The breakdown of Facet 1: Information Format by report is shown in Figure 5. The most noticeable feature was the significant usage of textbooks (1T) in the convection reports (47.9%). This was consistent with the fact that this report relied on materials from a prerequisite course. The usage of websites (1W) was consistently significant, representing the second-highest usage in the convection report (21.8%) and the highest usage in the airfoil (26.4%) and truck (24.2%) reports. Usage of reports (1R) and scholarly journals (1V) rose appreciably over the semester,

increasing by 11.2% and 8.9%, respectively. In addition, small increases in the usage of blogs (1A) and public sharing sites (1C) were noted. The reduction of course materials was expected based on the limited exposure the students had to the latter two topics. This distribution illustrated the impact of the scope and nature of the assignment. The results from the airfoil and truck lab were more aligned with students carrying out a complete literature search and having fewer resources at the outset.

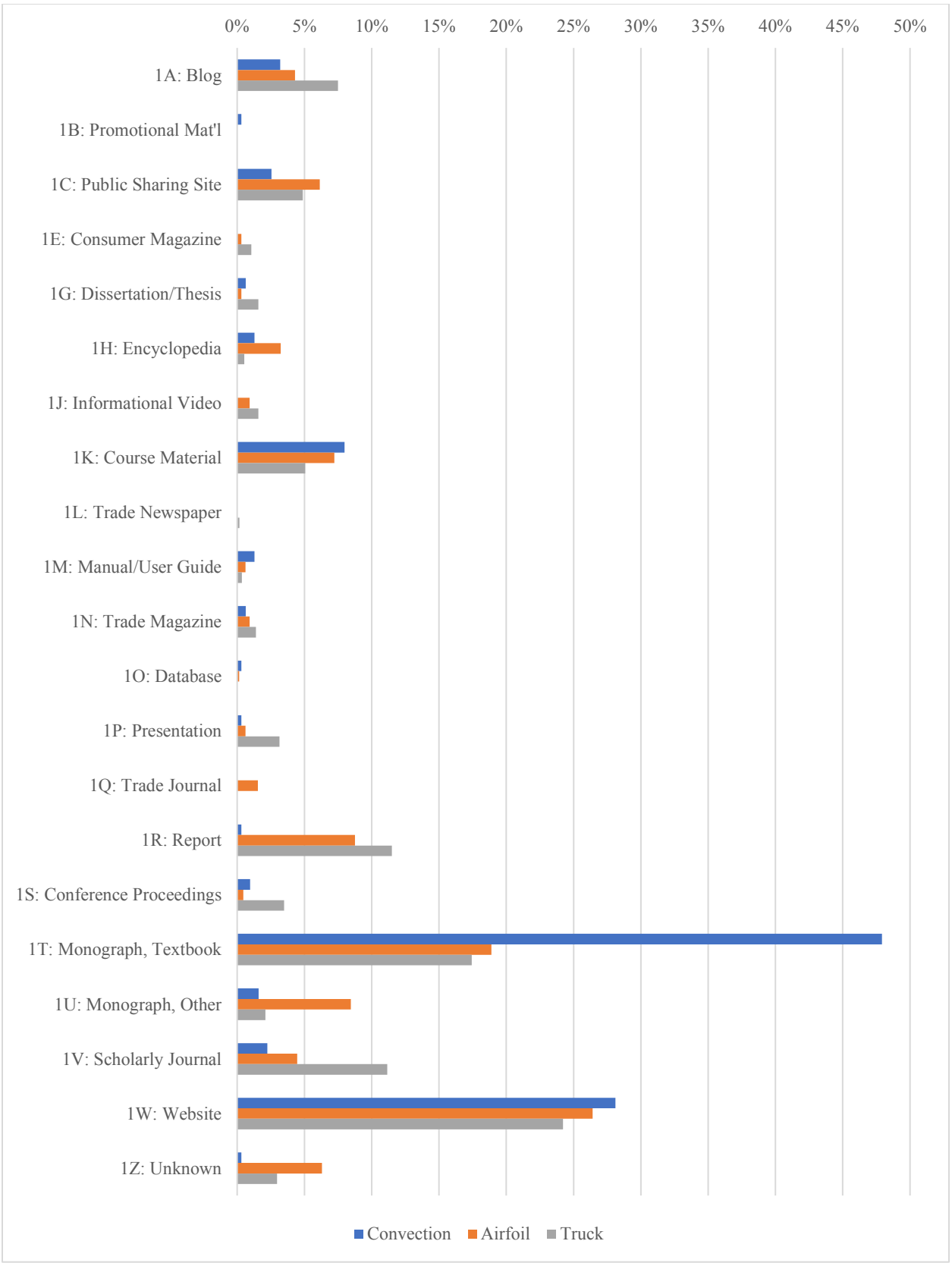

Figure 5. Breakdown of Facet 1: Information Format by report.

In examining author identity (Facet 3), there were noticeable similarities in the percentages between the convection and truck report (Figure 6). The most common author identity was academic professional (3F), although the percentage for the convection report (60.1%) exceeded the percentage for the truck (50.9%) and the airfoil (43.6%) reports. For the convection and truck lab reports, the next largest groups were corporate authorship (3C) at 21.4% and 23.2%, followed by anonymous authorship (3A) at 11.8% and 13.4% respectively. Interestingly, for the airfoil report, there was a much higher instance of anonymous authorship (18.9%) and authorship by a layman (3B) at 13.1%. In this instance, the airfoil report also saw less use of corporate authorship (14.0%). These authorship trends may have reflected the nature of the type of material available outside of academia. For example, information on websites introducing aerodynamic principles tended to come from anonymous or layman authorship. Websites covering the topics of convection and truck aerodynamics were far less common.

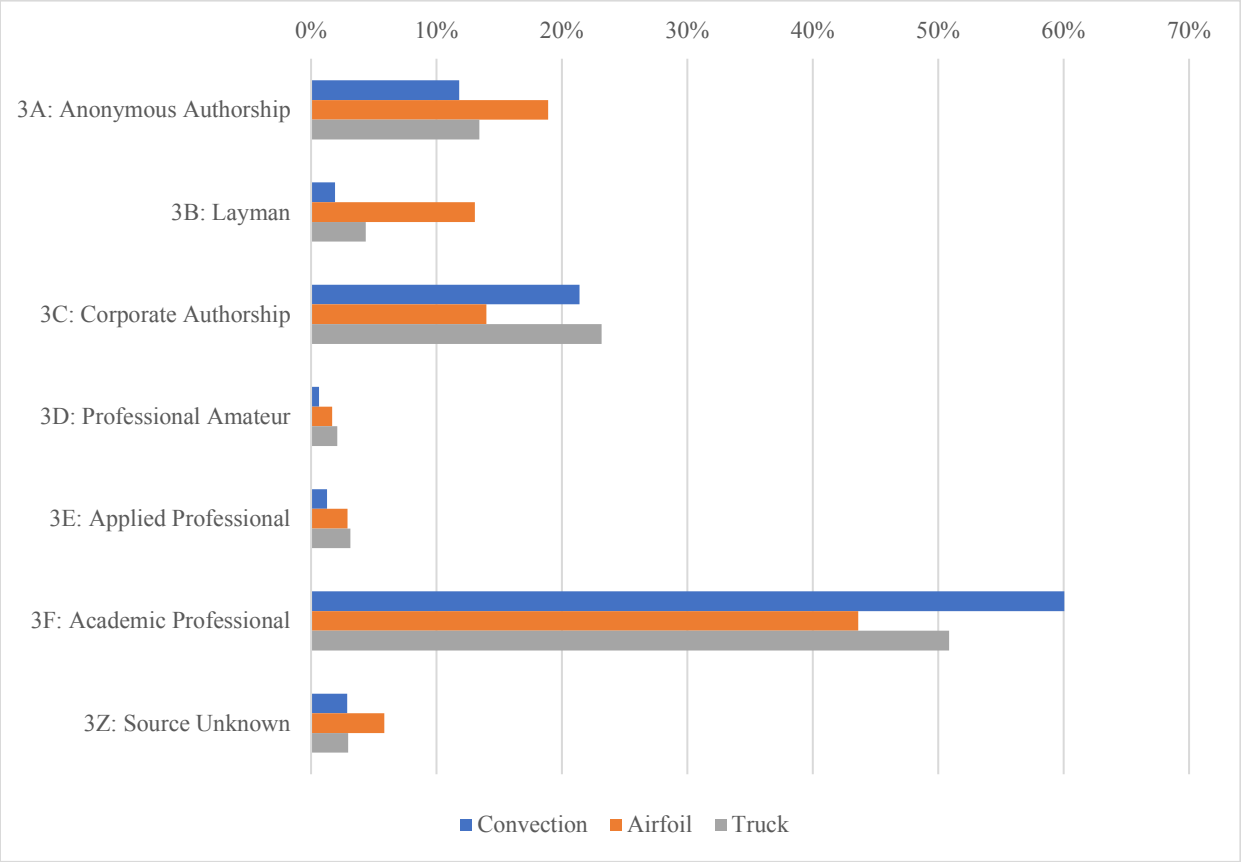

Figure 6. Breakdown of Facet 3: Author Identity by report.

The results for Facet 4: Editorial Process showed much larger variations than the previous two facets (Figure 7). The convection report saw an elevated use of sources professionally reviewed by an editor or editorial staff (4E) at 48.9% as compared to the airfoil (30.7%) and truck (20.6%) reports. In the airfoil and truck reports, 49.8% and 52.1% respectively were self-published (4A). While there was a substantial drop in sources reviewed by the editorial staff after each report, there was also a rise in the use of peer-reviewed sources (4F). For the truck report, peer-reviewed sources made up 14.8%, approaching the usage of editorial sources. This may suggest more

varied sources as the nature of the assignment changed, and students were exposed to more research tools through instruction.

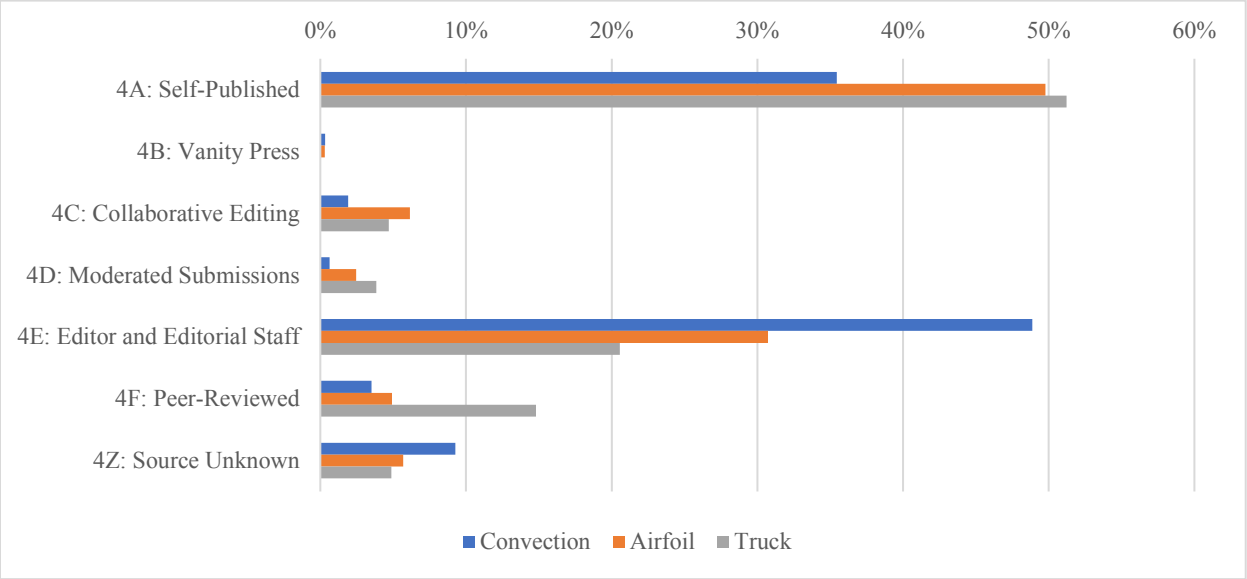

Figure 7. Breakdown of Facet 4: Editorial Process by report.

In examining the publication process (Facet 5), there was relatively uniform usage of academic materials (5F) in the convection (41.9%), airfoil (44.9%), and truck (40.0%) reports. However, the next most common publication process varied considerably by the report. For the convection report, there was much heavier usage of commercial material (5B) at 37.7%. For the airfoil report, government publications (5E) came in second at 18.9%, and personally published material (5A) came in third at 17.7%. For the truck report, government publications also came in second at 17.8%, followed closely by commercial material (5B) at 16.6%. It could be argued that Facet 5 was most strongly influenced by the nature of the assignment. The reliance on commercial material could potentially be explained by the need to explain the unique instruments in the convection lab report and the common usage of commercial aerodynamics solutions when explaining application in the truck lab report.

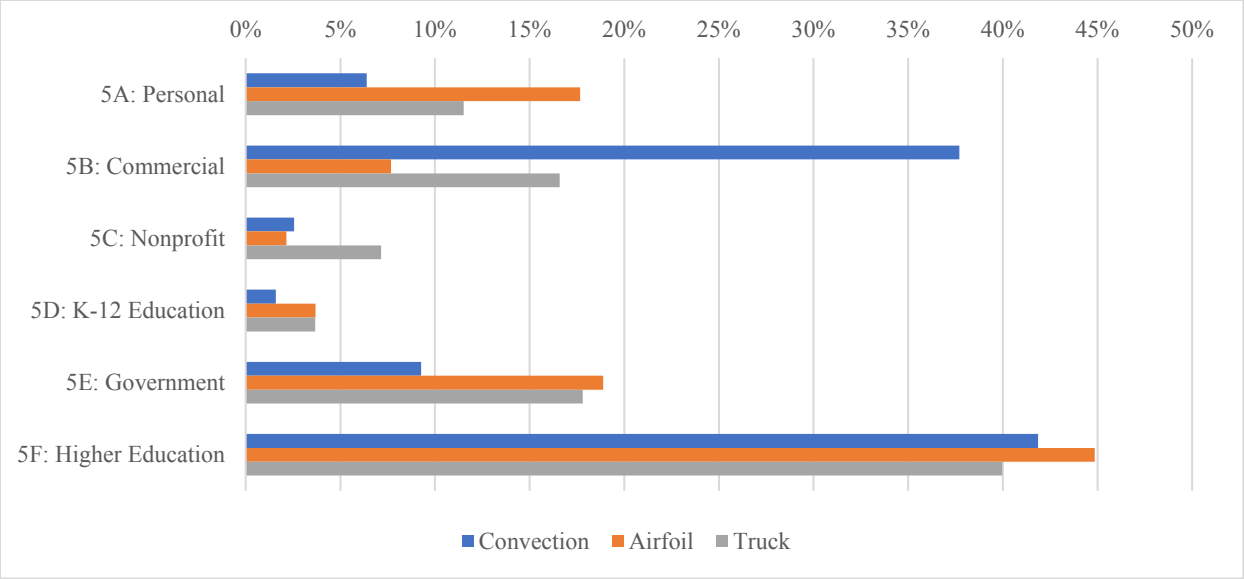

Figure 8. Breakdown of Facet 5: Publication Purpose by report.

Overall, the breakdown by report provided some insights into the impact of the nature of the assignment. Several of the trends seen in the data could be associated with specific aspects of the assignment. For example, having an assignment that built off of content covered in past courses likely yielded a much higher percentage of textbooks if they serve as a valid resource, which would raise the number of citations published for Higher Education (5F). The most noticeable difference was the use of commercial (5B) sources in the convection lab reports.

Conclusions

The top three subfacet combinations of textbooks, government reports, and government websites are all sources that are easy to access and, in most cases, are low cost or free. This reflects similar patterns to information used by professional engineers [11], [12]. The faceted taxonomy provided a way to look beyond information format and look at the authors and the editorial process used. For example, a less nuanced categorization of information sources might label all websites as low-quality information sources, but some of the websites used by students in this study have credentialed authors and some sort of editorial review process. This distinction could not have been made without the faceted taxonomy.

Our finding that there was no obvious relationship between the grade on the assignment and the types of information sources used matches the findings of Rosenzweig, Thill, and Lambert [7]. While both the previous researchers and this study had expected to find a trend that academically successful students would depend more heavily on sources written by and for academic audiences, these findings indicated that our assumptions need to be reexamined.

Comparing the types of information sources that students used as the semester progressed, provided an interesting insight into how students adapt their use of information sources to the topic or assignment. This has implications for instructors to discuss the different types of information formats that are available as they introduce new assignments. It also could be supplemented by future studies using qualitative methods to gather information directly from

students about source selection and obtain a better understanding of their thought processes. The ability to examine the role of the author and publication process also aligns with current information literacy instruction in the broader context of higher education as librarians shift away from standards to the framework [5].

This first use of the faceted taxonomy to examine engineering assignments showed the potential for further refinement of the taxonomy. This study applied the taxonomy to mechanical engineering students and used a slightly larger sample than the previous studies. This revised faceted taxonomy applied to other branches of engineering and larger populations will give engineering librarians and faculty insights into how students select information sources with the increase of freely available information sources online.

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Appendix A: Taxonomy

Facet 1: Information Format	
1A: Blog	A frequently updated website, typically run by a single person and consisting of personal observations arranged in chronological order
1B: Promotional Material	Content written for the purpose of selling a product or service
1C: Public Sharing Site	A web page designed so that its content can be edited by anyone who accesses it, using a simplified markup language (e.g., Wikipedia)
1E: Consumer Magazine	A magazine written for a general audience
1F: Consumer Newspaper	A newspaper written for a general audience
1G: Dissertation/Thesis*	An extended scholarly work, usually based upon original research, submitted for a degree or other academic qualification.
1H: Encyclopedia	A work containing entries, usually arranged in alphabetical order written for academic or professional purposes.
1J: Informational Video	Videos created to inform or educate, without a commercial purpose.
1K: Course Material	Materials created to aid students in classes in higher education
1L: Trade Newspaper	A newspaper written for an industry or profession.
1M: Manual/User Guide*	Content written about the use and operation of a specific tool, equipment, or technology
1N: Trade Magazine	A magazine written for an industry or profession
1O: Database	A structured set of data held in computer storage
1P: Presentation*	Slides or other visual material intended for presentation. May lack a detailed narrative.
1Q: Trade Journal	A journal that is not refereed, and covers business trends and industry information
1R: Report	Official record of research done with funding from a government source.
1S: Conference Proceedings	Papers published as the result of an academic conference
1T: Monograph, Textbook*	Books written for the purpose of instruction in higher education
1U: Monograph, Other*	Professional-level books not expressly written for classroom instruction (e.g. handbooks)
1V: Scholarly Journal	Publication that is referred or reviewed by experts.
1W: Website	Content originally authored for the online environment and not found otherwise in print or other publications
1Z: Unknown*	It was not possible to identify the source based on the available information in the citation.
Facet 3: Author Identity	
3A: Anonymous Authorship*	No identification is possible, or the author is explicitly identified as anonymous
3B: Layman	The author has no demonstrated expertise in the area being written about--even if they have strong opinions.
3C: Corporate Authorship	The piece has no single author. A corporation or organization takes responsibility for the content.
3D: Professional Amateur	The author has an advanced degree (e.g., MS, PhD) in a field other than the one being written about, but has demonstrated interest in the area being written about.
3E: Applied Professional	A person with relevant experience, training, or credentials relevant to the area being written about (such as a journalist with a journalism degree OR substantive professional experience).

3F: Academic Professional	The author has an advanced degree (e.g., PhD, MD, JD, MFA) in the field being written about.
3Z: Source Unknown	It was not possible to identify the source based on the available information in the citation.
Facet 4: Editorial Process	
4A: Self-Published	Material made public directly by the author (e.g., a personal blog). In cases of corporate authorship (3C), where the corporate author is also the publisher, 4A is the designation for editorial review.
4B: Vanity Press	Material the author paid to publish, generally as self-promotion.
4C: Collaborative Editing	Material that is reviewed or edited by multiple (possibly anonymous) collaborators (e.g., Wikipedia).
4D: Moderated Submissions	Contributed content that has been accepted or approved by someone other than the author but that has not undergone editorial review.
4E: Editor and Editorial Staff	Professionally reviewed and approved by editor/editorial staff.
4F: Peer-Reviewed	Professionally reviewed and approved by peer scholars.
4Z: Source Unknown	It was not possible to identify the source based on the available information in the citation.
Facet 5: Publication Purpose	
5A: Personal	Material written for personal reasons, with no visible ties to advertisers or special interest groups.
5B: Commercial	Material written for or published by a commercial organization or for the purpose of profit.
5C: Nonprofit	Material is published by a nonprofit organization.
5D: K-12 Education	Material is published for educational (K-12) purposes.
5E: Government	Material is published by the government.
5F: Higher Education	Material is published for an academic audience, regardless of whether the publisher is for-profit or non-profit. University presses, textbook publishers, and scholarly journals are all considered 5F.
5Z: Source Unknown	It was not possible to identify the source based on the available information in the citation.

* Added or modified for this study

Appendix B: Lab Report Rubric

Criteria	Level 4	Level 3	Level 2	Level 1
Theory: Completeness	Discusses all points laid out in guidelines	Discusses all but 1-2 minor points laid out in guidelines	Misses a major point laid out in guidelines	Most to all points in guidelines missed
Theory: Clarity and Depth	Explanations are concise, clear and easy to understand Depth of discussion provides reader with full understanding of concepts	Explanations are easy to understand but could be more concise Depth of discussion provides reader with sufficient understanding of concepts	Explanations too verbose or too superficial causing some confusion Depth of discussion is superficial, leaving reader with gaps in their understanding	Narrative is unclear and detracts from reader's understanding No meaningful discussion, leaving the reader with a poor understanding
Theory: Accuracy	All information presented is factually correct.	Most information presented has only a minor error.	Information presented has a handful of major errors.	Information presented is mostly inaccurate.