ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022
Paper ID #36587

Assessing Information Literacy in Capstone Design Projects: Where are students still struggling?

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Abstract

Mechanical Engineering students at Northeastern University are introduced to research skills and information literacy at several points during the undergraduate curriculum, including a recently introduced first-year engineering workshop and a required technical writing in the discipline course. There are also two writing intensive courses that require background research to inform lab reports and research presentations. When students reach Capstone Design, project reports show vastly different levels of proficiency in information literacy skills. The goal of this study was to assess which information literacy skills were poorly learned and retained by the students, in order to inform potential adjustments in the earlier curriculum. Additional support in Capstone Design may also be developed based on these results.

A sample of 26 reports from a Capstone 1 class conducted in Summer 2021 were rated using a customized version of the VALUE rubric for Information Literacy (IL). Results show that students were most proficient in paraphrasing from sources, selecting high quality sources, choosing a variety of information sources, and citing sources accurately. They struggled more with higher order, more contextually dependent skills like determining the extent of information needed and synthesizing information from multiple sources to achieve a specific purpose, such as justifying a course of action. Additionally, project type was observed to have more of an impact on IL rubric scores than students' previous participation in IL workshops or writing intensive courses. Results suggest that more practice with higher order skills in context of the engineering design process at additional points during the curriculum may be necessary to enable students to retain these skills. Additional recommendations based on the analysis include making IL requirements in the Capstone grading rubric more explicit and granular, and combining engineering subject matter experts and engineering librarians to collectively score students' work. This may be a path to enabling more rubric-based assessments of IL in the engineering discipline.

Background

Mechanical Engineering students at Northeastern University are introduced to research skills and information literacy (IL) at several points during the undergraduate curriculum. For the majority of engineering students IL instruction starts in the first year, in which most faculty require an engineering-specific library workshop as part of the First Year Engineering (FYE) curriculum. The FYE library workshops were introduced as a small pilot in 2018, and the program has grown to serve a projected 76% of FYE students in the 2021-2022 academic year. Students also take a required writing in the technical professions course, which addresses a common set of learning outcomes that are aligned with ACRL's Framework for Information Literacy for Higher

Education [1]. The course is taught by a variety of faculty as part of the university's Writing Program. There are also two writing intensive courses that require background research to inform lab reports and research presentations. In sum, students are exposed to research and IL-related practice at several points in the Mechanical Engineering curriculum, albeit with some variability. For example, not all FYE students attend the library workshop, and despite a common set of learning outcomes for the technical writing course, different faculty take different approaches to designing their courses. Also, students may not take the technical writing course until late in their academic career due to scheduling reasons.

When students reach Capstone Design, where they are expected to apply their research skills to a design project, reports show vastly different levels of proficiency in IL skills. This observation prompted the Mechanical Engineering Capstone instructor to experiment with the AAC&U's Valid Assessment of Learning in Undergraduate Education (VALUE) rubric for Information Literacy [2] as a method for assessing students' Capstone reports. The Capstone instructor soon connected with the university's Engineering Librarian to partner on a more rigorous study, with the goal of pinpointing the most common skills gaps. Additional supports in Capstone Design and other potential changes in the curriculum may be developed based on these results.

Literature Review

Measuring the effectiveness of IL instructional strategies in undergraduate Engineering courses has often relied on self-reported data. Phillips et al's systematic review concludes that more rigorous design and analysis would allow educators to draw more concrete conclusions about best practices for IL instruction in engineering [3]. Among the more rigorous studies that have been done, performance-based assessment methods have been used by research teams to assess undergraduate engineers' assignments, using methods such as citation analysis [4]–[9] and the Information Seeking, Evaluation, Application, and Documentation (InfoSEAD) protocol, which is a model for more comprehensive assessment of higher order thinking skills [10]. Another such method that has been on the rise is rubric-based assessment. Among other benefits, this assessment method offers a way to evaluate a more authentic demonstration of students' higher order thinking skills, facilitates consistent scoring of projects with less bias, and provides granular analysis of specific skills to inform future changes to instructional strategies [11]. Guidelines have been published to guide rubric-based assessment of IL skills that include strategies such as building collaborative relationships between faculty and librarians, choosing an assignment in which students must demonstrate the skills being assessed, and customizing a rubric, such as the VALUE rubric for Information Literacy, specifically to the chosen assignment [12]. The VALUE rubric for Information Literacy is designed to assess students' IL skills regardless of discipline [2], and several such studies from beyond engineering were useful in informing this project [13]–[15].

In engineering, several studies using rubric-based assessment methods have been published that evaluate IL in performance-based assessments at different points in the undergraduate curriculum, particularly for design project assignments [8], [16]–[18]. This method is particularly suited for assessing IL curricular outcomes at the Capstone level. Capstone projects have been described as "the turning point" in the Engineering curriculum, where students are meant to demonstrate all the skills they've learned in context of the design process, including IL [19]. There is a growing body of work that demonstrates the importance of IL as part of developing design expertise [20]–[22], as well as instructional methods for integrating IL instruction and practice into the context of the design process for undergraduates [23]. However, relatively few studies have assessed the IL outcomes of Capstone students using rubrics. Of the existing studies that use this method, the most challenging IL skills identified are limited ability to define information needs and getting beyond using search engines for quick fact-finding to identify quality, in-depth research [17]. Students also had trouble with differentiating between different types of sources, lack of assessment of quality reference material, lack of familiarity with how to find and use technical papers, few references, and improper use of citations and what information needs to be cited [16], "usage of references across paper", "consistency of citation style across paper", lack of overall time spent on information gathering, and challenges with evaluating web resources [18].

In studies of upper-level undergraduate engineering students that use other methods, similar challenges were found. For example, faculty at Worcester Polytechnic Institute cited students' lack of diversity of sources and perspectives on a single topic, lack of familiarity with the range of sources available, challenges with coming up with keywords, overuse of websites, and lack of recognition of what type of sources they were looking at on the web and thus incorrect citations [7]. At West Virginia University, researchers noted challenges with Mechanical Engineering Capstone students' overreliance on Google searches, and lack of evaluation of the resources found there. After additional instruction, they found improvements on IL topics such as intellectual property, database use, and reliability of sources [24]. At Purdue University, many upper-level students reported no prior experience with patent searching, prior to the instructional intervention introduced and assessed there [25]. This study aims to contribute to this evidence base, as well as inform specific adjustments to the curriculum at Northeastern University in order to improve IL outcomes.

Method

Twenty-six final Capstone 1 reports from the 2021 Summer 1 semester were scored using a customized version of AAC&U's VALUE rubric for Information Literacy. This sample represents a current, complete class of Mechanical Engineering Capstone 1 students. Each project team consists of four or five students working together to complete the Capstone project, including the required research and report writing. Provided the reports and other data were gathered as part of regular class activities, and no student identifying information was connected to any of the results, IRB approval is not required for this study.

The VALUE rubric was used to begin scoring papers, but it rapidly became clear that the generic rubric was not specific enough to the Capstone assignment to be applied accurately. Based on findings from previous studies on rubric-based assessment, a customized version of the VALUE rubric and other sources was designed to more closely align with the Capstone assignment [12], [13], [16], [17]. The customizations included specifying scoring criteria based on the expected outcomes of the assignment, as well as eliminating certain elements that were not included.

Even more important was clarifying intent and chosen language for scoring criteria. There were two scorers, one Mechanical Engineering faculty member and one Engineering Librarian, whose interpretations of the initial rubric were sometimes quite different. In order to tailor the rubric and ensure a common understanding (and thus consistent ratings), thirteen example reports were rated during two rounds of norming prior to scoring the selected sample [12]. During each round of norming, both raters scored the reports independently on all criteria, then met to compare the results, discuss discrepancies, and iterate on the rubric accordingly. Between the initial customizations to match the assignment, and revisions as a result of norming discussions, the final rubric used was the result of five iterations (see Appendix A). In the final round of norming, the raters achieved 75% agreement on all scores, and 96% adjusted agreement (i.e., scores were adjacent, or within one point on a six-point scale).

Due to the raters' complementary backgrounds – the faculty member's in engineering and the engineering librarian's in information literacy – the raters also tried an alternate method of scoring where each scorer was responsible for half the criteria that aligned more closely with their subject matter expertise. The Mechanical Engineering faculty member rated the categories 'Determining the Extent of Information Needed' and 'Using Information Effectively to Accomplish a Specific Purpose', since they are more content-oriented, and the Engineering Librarian rated 'Evaluating Information and its Source Critically' and 'Access and Use Information Ethically and Legally' since they are more search and citation-oriented. This method enabled both raters to narrow their focus as they worked through the reports, and thus move much more quickly. Since the raters had already established interrater reliability, and the range of total rubric scores was consistent with the previous method, this shared rubric method was used to score the twenty-six papers in the sample.

After the ratings were complete a Pearson's product moment correlation analysis was used to determine the relationships between individual rubric items and the total rubric score as well as the final report grade. Correlations were considered strong if $R \geq 0.70$, moderate if $R \geq 0.30$, and $R < 0.29$ considered a weak to non-existent correlation [26]. Correlations were also sought between rubric items and the fraction of students on each team who were selected by the instructor, rather than the students themselves, as this has previously been shown to influence course outcomes [27]. Additionally, comparisons were made between the outcomes of groups that had taken the FYE library workshop and had not taken the FYE library workshop. Also, groups with members that had not yet taken a highly writing intensive lab course before Capstone design were compared to other groups to determine any effect this might have on outcomes. Finally, scores for each rubric item were averaged and standard deviation calculated to determine which skills students performed the best on, which skills they struggled with the most, and which skills had the widest range of results. For the skills on which they struggled most, sample reports were reviewed to identify specific skills that might be addressed with additional instruction and support.

Results

The average scores of the individual rubric items are given in Table 1. At first glance, students were most proficient in properly quoting from and paraphrasing information from sources. Another strength was the ability to select high quality sources after considering multiple criteria. The results indicated that an area of relative weakness was the ability to effectively combine and synthesize data from multiple sources to achieve a purpose such as justifying a course of action. Results varied widely when it came to students' ability to find sources that met their information needs. As other researchers have noted, Wikipedia and vendor websites were used as references for concepts that should have been backed up by textbooks or other refereed sources. Results also varied widely for students' ability to paraphrase, summarize or quote from sources appropriately, indicating a wide skills gap between those who generally paraphrase well and those who do not.

Table 1: Rubric item average scores

Item #	Rubric item	Average	Standard Deviation
1	Recognizes key concepts that require research / supporting information	3.24	1.11
2	Provides evidence for information and ideas that are not common knowledge.	3.30	0.82
3	Types of info (sources) selected relate to concepts / meet the information need	3.22	1.35
4	Chooses a variety of information sources appropriate to the scope and discipline of the research question	3.48	1.12
5	Selects sources after considering multiple criteria, such as relevance to the research question, currency, authority, audience, and bias or point of view	3.76	0.90

6	Communicates, organizes, and synthesizes information from sources to achieve a specific purpose	2.48	1.27
7	Cites sources accurately	3.35	0.98
8	Paraphrases, summarizes, or quotes from sources appropriately	3.96	1.33
9	Total Rubric Score (Max = 40)	26.78	6.43
10	Report grade (Max = 100)	79.92	10.49

Table 2 below shows the results from the Pearson's correlation analysis between rubric items where there was a highly significant and strong correlation between items. As expected, the total rubric score (Item #9) was strongly correlated with most rubric items. Two notable exceptions were the item stating that team members chose a variety of information sources (Item #4), and the ability to paraphrase information appropriately (Item #8). These items did not have a strong correlation with the total rubric score. Two other notable correlations were seen that did not relate to the total rubric score. One such pairing was between the information achieving the desired purpose (Item #6) and students recognizing evidence that was not common knowledge (Item #2). Also, the ability of students to select sources considering multiple criteria (Item #5) was strongly correlated with the ability of those sources to meet the needs of the work (Item #3).

Table 2: Strong positive correlations between rubric items

Correlating factors	Pearson's R	P value ($\alpha = 0.05$)
Total rubric score / Sources meet need	0.81	$P < 0.001$
Total rubric score / Cites sources accurately	0.80	$P < 0.001$
Total rubric score / Recognizes key concepts	0.78	$P < 0.001$
Total rubric score / Achieves purpose	0.77	$P < 0.001$
Total rubric score / Evidence not common knowledge	0.72	$P < 0.001$
Achieves purpose / Evidence not common knowledge	0.71	$P < 0.001$
Total rubric score / Selected sources using multiple criteria	0.71	$P < 0.001$
Selected sources using multiple criteria / Sources meet need	0.70	$P < 0.001$

Table 3 shows moderately strong yet statistically significant correlations between rubric items. Several factors were seen to be correlated with a number of others. For example, 'recognizing key concepts' is correlated with six other items, as is the ability to cite sources accurately. These skills would appear to be complementary, as recognizing the need for literature evidence and finding it would leave the students with the relatively easy skill of using the correct citation. The ability to choose sources that meet the information need is associated with five other items, while the ability to paraphrase appropriately and synthesize information to achieve a purpose were each correlated with four other items. Paraphrasing and synthesizing information also seem to be complementary skills. Students who attempt to build arguments from direct quotes often fail to fully connect the ideas in those quotes to each other and to the project. Interestingly, the report grade from the Capstone class itself was correlated with only two items: synthesizing source material to achieve a desired purpose and the total rubric score. These two correlations were barely significant. This result underlines the disconnect between the report grading and the assessment of IL for this class.

Table 3: Moderate positive correlations between rubric items

Correlating factors	Pearson's R	P value ($\alpha = 0.05$)
Evidence not common knowledge / recognizes key concepts	0.66	$P < 0.001$
Cites sources accurately / recognizes key concepts	0.65	$P < 0.001$
Achieves purpose / recognizes key concepts	0.61	$P = 0.001$
Cites sources accurately / sources meet need	0.60	$P = 0.001$
Total rubric score / variety of information	0.60	$P = 0.001$
Total rubric score / paraphrases appropriately	0.60	$P = 0.001$
Cites sources accurately / selected sources based on multiple criteria	0.59	$P = 0.001$
Achieves purpose / sources meet need	0.58	$P = 0.002$
Paraphrases appropriately / cites sources accurately	0.56	$P = 0.003$
Cites sources accurately / evidence not common knowledge	0.54	$P = 0.005$
Sources meet need / evidence not common knowledge	0.51	$P = 0.008$
Selected sources using multiple criteria / variety of information	0.50	$P = 0.009$
Sources meet need / recognizes key concepts	0.49	$P = 0.01$
Cites sources accurately / achieves purpose	0.49	$P = 0.01$
Paraphrases appropriately / report grade	0.47	$P = 0.02$
Variety of information / Sources meet need	0.46	$P = 0.03$
Report grade / achieves purpose	0.46	$P = 0.03$
Paraphrases appropriately / recognizes key concepts	0.42	$P = 0.04$
Selected sources using multiple criteria / recognizes key concepts	0.41	$P = 0.05$
Report grade / Total rubric score	0.41	$P = 0.05$

Two-tailed t- tests were used to compare various groups of students to determine if there were significant differences between them. The Capstone groups were divided into those in which at least one member had taken the First Year Engineering (FYE) library workshop and those with no members who had taken the workshop. No significant differences were found, however there were only 11 students out of a class of 124 who had taken the FYE workshop. With only one or two of these students on a team, there did not seem to be enough critical mass to effect any major changes.

T-tests were also used to compare teams that had and had not taken a junior level lab course in Measurements and Analysis prior to Capstone. This course is writing intensive and emphasizes the need for scholarly research when planning experiments. There were no significant differences found between the groups, with one exception. Groups that had team members who had not yet taken the lab course fared better than those who had in terms of choosing sources to meet the information need ($P = 0.02$). This result currently has no explanation, although project topic may be a factor.

Capstone design projects can have a wide variety of topics, however they tend to fall into certain categories. The reports in this work were divided into five categories: research, accessibility, education, consumer, and competition. The average score of various rubric items was examined to determine if there were any patterns to the best and worst average scores based on project type. This information is detailed in Table 4. While this dataset is limited, a few patterns emerge. Education based projects, such as developing a tool for an aerodynamics course, scored highest in seven categories including total rubric score, paraphrases appropriately, achieves purpose, selects using multiple criteria, sources meeting needs, and recognizing key concepts. The single competition-based project, which involved building a dynamometer for the university's SAE Formula team, had the best score in report grade and paraphrases appropriately. This same category was, however, the worst in seven rubric items. Although there was only one report in this category, competition-based projects happen nearly every semester and as observed by the Mechanical Engineering Capstone instructor, the weaknesses are common to many of these projects. Accessibility projects, which included building a golf swing apparatus for a paraplegic client, were best in paraphrasing. The consumer projects, which involved developing new products that could potentially reach a consumer market, were the best only in paraphrasing appropriately and had the lowest average in the overall report grade. Finally, research projects, such as building an exhalation simulator, were the best in choosing a variety of information sources and paraphrasing appropriately, and worst in terms of report grade. Given the limited nature of this dataset, more data would be needed to validate these observations; however, these observed differences may be useful in understanding how the characteristics of different project types may impact students' IL needs.

Table 4: Average highest and lowest scoring items, separated by project type

Project Type	**Number of Projects**	**Example Project**	**High scoring items**	**Low scoring items**
Accessibility	4	Golf Swing for Paraplegic Client	Paraphrases appropriately	Recognizes evidence not common knowledge, Cites sources accurately
Competition	1	eFormula Dynamometer	Paraphrases appropriately, Report grade	Recognizes key concepts, Sources meet need, Variety of information sources, Selects sources with multiple criteria, Achieves purpose, Cites sources accurately, Total rubric score
Consumer	9	Mechanical Leaf Blower	Paraphrases appropriately	Achieves purpose
Education	4	Flexible Airfoil for Wind Tunnel	Recognizes key concepts, Recognizes evidence not common knowledge, Sources met need, Selects sources with multiple criteria, Achieves purpose, Cites sources accurately, Total rubric score	Paraphrases appropriately
Research	8	Exhalation Simulator	Variety of information sources, Paraphrases appropriately	Report grade

Discussion

The top four rubric items in terms of average scores are the ability to properly paraphrase from sources, the ability to select sources considering multiple criteria, the ability to choose a variety of information sources, and the ability to cite sources accurately. This makes sense as information-focused skills such as searching for literature, identifying sources based on quality and relevance, and proper citation using standard engineering styles are covered in all the writing intensive classes taken prior to Capstone. For example, the FYE library workshop introduces students to applicable library resources where they can find high quality sources. In the lab intensive course that is taken during sophomore year, the focus is on writing skills and writing conventions for technical writing. Junior level courses such as advanced writing in the disciplines and a writing intensive lab course have relatively more emphasis on using information from the literature to support an argument, predict outcomes and validate experimental approaches. However, it’s not until the Capstone design course that students are asked to apply this wide range of skills in context of the design process. Every group, for their very different projects, must be able to identify information that is common knowledge to an audience of engineers versus what requires explanation and evidence, as well as synthesize information from multiple sources to justify design decisions. While there is intentional scaffolding throughout the curriculum to build students’ information literacy and writing skills, there is little opportunity to practice these highly contextual skills prior to Capstone. These results indicate that more explicit practice with determining the extent of information needed and using information in context of various engineering design projects is required for students to master these skills.

Correlation analysis showed, as expected, that most of the individual items did correlate highly with the total rubric score. The most highly correlated items have to do with finding sources to meet current information needs and citing those sources accurately. As mentioned, these are skills which are reinforced repeatedly through many courses. The two rubric items that did not strongly correlate to the total report score included using a variety of information source types and being able to properly paraphrase. These two scores illustrate shortcomings in both information literacy and technical writing ability. One skill that correlated moderately with many other skills was the ability to recognize key concepts that require research and supporting evidence. This finding indicates that if one can recognize key concepts that need to be explained and supported by the literature, one can also likely find sources that will achieve that purpose and be able to cite them accurately.

The correlation analysis also shows very clearly the disconnect between assessing design reports for information literacy versus assessing for ability to convey design. The rubric for report grades focuses on students' ability to present and explain their work, to justify their design decisions, and to convey information concisely in proper technical English. There are two items in the report grade rubric that contain information literacy items, but the requirements are not as granular or as explicit as in the customized VALUE rubric used for this study. Thus, the IL rubric items do not specifically correlate with the report grade itself.

The number of prior IL-related courses taken by students before Capstone was expected to have some effect on the outcomes. However, there was no significant difference between teams that had members who had and had not taken the FYE workshop. Additionally, there was no statistical difference between the teams that had taken the junior level lab course and those who had not yet taken it. One likely reason is that very few students in this sample had taken the FYE workshop, since it was piloted after most of the current Capstone students had finished their first year. Additionally, there were no teams without at least one student that had taken the junior level lab course. The nature of group work in Capstone may cloud these results, especially since there were more students who did not have these additional IL practice opportunities than those who did.

Another factor expected to affect results was that different types of projects require finding, using and citing different types of sources. For example, students working on consumer-based projects often struggled with choosing quality sources, perhaps because this type of project required that they do extensive patent searches to prove that there was no infringement. Patents, although mentioned in the advanced writing in the discipline course, are not extensively discussed in the curriculum. As a result, it seems that students were generally able to cite patents correctly, but not necessarily use them to achieve the purpose of justifying the need for the project.

Another type of project, education-based projects, had the highest averages in seven rubric items. This may be because these projects require a thorough discussion and explanation of the educational concepts they are meant to support, to both justify the need for the project and explain the reason for design choices. However, students working on this type of project often chose sources that did not best meet information needs, and paraphrased things poorly. For example, they tended to use Wikipedia or other websites, rather than using other more authoritative reference sources, such as textbooks. This reflects a larger observed trend that background research for information such as general scientific principles is often lacking, both in terms of inconsistent recognition of the need for evidence and lack of quality of sources selected to provide such evidence. For several types of projects, especially those developing consumer products, it is often easier to find what seems like appropriate information on the web versus finding it in textbooks and other scholarly sources. Across project categories, this issue seemed to lead to lower scores on items such as choosing information sources that meet an information need, and citing sources in website format, regardless of actual source type. For example, students generally struggled with citing images from the web properly, sometimes citing them in website format, sometimes providing only URLs, and sometimes not providing a citation at all.

Another type of project for Capstone students is competition-based projects, such as for the SAE Formula, miniBaja, or HyperLoop competitions. Although there was only one competition group this term, their report reflected previously shown patterns for competition projects, as observed by the Mechanical Engineering professor. The report grade for this project was very high, which is expected as these groups must produce multiple reports for their competitions (so they get a lot of chances to revise). However, when writing for the Capstone design audience, they often fail to provide enough background information for a reader not familiar with the competition. They are also often not as good at recognizing information that is not common knowledge, since most of their writing and presentation is to other teams that are very familiar with the background and subject matter of the competition.

Information literacy skills that reflect the ability to search and retrieve information effectively, including finding sources that meet the information need, choosing a variety of source types, and selecting sources based on multiple evaluation criteria, are necessary in most of the courses that require research and writing. However, these were not necessarily the skills with the highest averages. This could be because teaching the ability to search and retrieve information is easier to control and emphasize in a class solely dedicated to writing, as opposed to the Capstone design class that has many competing outcomes. There was also little evidence of students' thought process when evaluating sources, so scores for that rubric item are dependent on judging the quality of sources themselves.

Recommendations

Based on the results from this study, several recommendations can be made, both for Northeastern University and for other similar programs. Regarding methods, this study has demonstrated the ability to combine engineering subject matter experts and engineering librarians to collectively score student work. This both speeds up the scoring and allows each rater to apply their own expertise to the rubric items that are most relevant to them, and may be a path to enabling more rubric-based assessments of IL in the engineering discipline.

Regarding IL skills, students scored higher in categories where they get more consistent practice throughout the curriculum, such as citing sources (Item #7) and paraphrasing properly (Item #8). Students scored lower in categories that require higher order thinking skills and are more contextual such as determining the extent of information needed (Item #1) and using information effectively to accomplish a specific purpose (Item #6) – suggesting that more intentional practice is needed for those skills, particularly in the context of engineering design projects. Additionally, more scaffolded instruction and practice of weaker skills should be incorporated into the writing intensive courses in the curriculum. This could be combined with ongoing efforts to insert more design experiences into the curriculum, as these additional design experiences would be excellent opportunities to practice these skills in context.

Additional instructional support, potentially in the form of brief video tutorials on topics that students are commonly missing, could be helpful to students in several classes, without requiring additional instruction time. Potential topics include examples of what is / is not common knowledge and which concepts require evidence, and how this can depend on the audience; guidance to access reliable sources for background information such as the Knovel digital library [28] and textbooks; how to properly cite images and other less common types of sources; how to quickly and effectively evaluate web-based sources; and using patent information to support design ideas.

In order to assess the cumulative effect of IL and writing instruction, the Capstone report grading rubric should be revised to include more explicit and granular IL-related items. In this way students will more clearly understand what is expected of them, and IL skills can be a more integrated part of the overall score.

These recommendations, while based on data from one specific program, could be tailored to the needs of other universities. Video tutorials could be refined and shared between universities to promote collaboration between engineering writing instructors and engineering librarians. The collaborative rubric scoring could also be effective at bringing both engineering instructors and engineering librarians out of their individual silos. In the future, as more students who have taken the FYE workshop at Northeastern University make it to Capstone, it will be helpful to measure IL abilities again using the adapted rubric to track any improvements. This work is merely the beginning of what will hopefully be an iterative process to continually improve the information literacy skills of undergraduate students.

Conclusion

This study demonstrated that information literacy can be assessed by two evaluators, an engineering librarian and a subject matter expert, with each evaluator focusing on their realm of expertise. This arrangement was used to assess the information literacy skills demonstrated in a selection of capstone design reports. Collectively, students were most skilled in paraphrasing, summarizing, and quoting from sources appropriately and least skilled in communicating, organizing, and synthesizing information from sources to achieve a specific purpose. This is understandable given that writing courses earlier in the curriculum focus much more on the mechanical skills of citing references and avoiding plagiarism, while students get less practice in using information to bolster their arguments in context of design projects. These findings can inform changes in the information literacy instruction provided to engineering students to address these shortcomings in the future.

References

[1] American Library Association, "Framework for Information Literacy for Higher Education," Feb. 09, 2015. http://www.ala.org/acrl/standards/ilframework (accessed Dec. 20, 2021).

[2] Association of American Colleges & Universities, "Information Literacy VALUE Rubric," 2009. https://www.aacu.org/value/rubrics/information-literacy (accessed Jan. 03, 2022).

[3] M. Phillips, A. van Epps, N. Johnson, and D. Zwicky, "Effective Engineering Information Literacy Instruction: A Systematic Literature Review," *The Journal of academic librarianship*, vol. 44, no. 6, pp. 705–711, 2018, doi: 10.1016/j.acalib.2018.10.006.

[4] A. J. Carroll, J. D. Borycz, and J. Vernon, "Works in Progress: Integrating information literacy into a multi-disciplinary first-year engineering program," *ASEE Annual Conference and Exposition, Conference Proceedings*, vol. 2020-June, 2020, doi: 10.18260/1-2--35655.

[5] D. Denick, J. Bhatt, and B. Layton, "Citation analysis of Engineering Design reports for information literacy assessment," *ASEE Annual Conference and Exposition, Conference Proceedings*, 2010, doi: 10.18260/1-2--16508.

[6] E. Gadd, A. Baldwin, and M. Norris, "The citation behaviour of Civil Engineering students," *Journal of Information Literacy*, vol. 4, no. 2, 2010, doi: 10.11645/4.2.1483.

[7] L. R. Hanlan and E. M. Riley, "Information use by undergraduate STEM teams engaged in global project-based learning," *ASEE Annual Conference and Exposition, Conference Proceedings*, vol. 122nd ASEE, no. 122nd ASEE Annual Conference and Exposition: Making Value for Society, 2015, doi: 10.18260/p.24300.

[8] R. E. H. Wertz, M. C. Ross, M. Fosmire, M. E. Cardella, and S. Purzer, "Do students gather information to inform design decisions? Assessment with an authentic design task in first-year engineering," *ASEE Annual Conference and Exposition, Conference Proceedings*, 2011, doi: 10.18260/1-2--17789.

[9] S. Purzer, M. Fosmire, A. S. van Epps, R. E. H. Wertz, and K. A. Douglas, "Information literacy skill development and assessment in engineering," *ASEE Annual Conference and Exposition, Conference Proceedings*, 2014, doi: 10.18260/1-2--20640.

[10] R. Wertz, M. Fosmire, S. Purzer, and M. E. Cardella, "InfoSEAD protocol and sample memo," *Purdue University Research Repository*. Mar. 2013. doi: doi:/10.4231/D3WW7702P.

[11] M. Oakleaf, "Dangers and opportunities: A conceptual map of information literacy assessment approaches," *Portal*, vol. 8, no. 3, pp. 233–253, 2008, doi: 10.1353/pla.0.0011.

[12] J. Belanger *et al.*, "Project RAILS: Lessons Learned about Rubric Assessment of Information Literacy Skills," *Portal: Libraries and the Academy*, vol. 15, no. 4, pp. 623–644, 2015.

[13] W. Holliday *et al.*, "An information literacy snapshot: Authentic assessment across the curriculum," *College and Research Libraries*, vol. 76, no. 2, pp. 170–187, 2015, doi: 10.5860/crl.76.2.170.

[14] M. Sara Lowe, C. Booth, S. Stone, and N. Tagge, "Impacting information literacy learning in first-year seminars: A rubric-based evaluation," *Portal: Libraries and the Academy*, vol. 15, no. 3, pp. 489–512, 2015, doi: 10.1353/pla.2015.0030.

[15] S. Lohmann, K. R. Diller, and S. F. Phelps, "Learning Outcomes, Portfolios, and Rubrics, Oh My! Authentic Assessment of an Information Literacy Program," *Libraries and the Academy*, vol. Vol. 19, no. 1, p. No. 3 (2019), pp. 429–460., 2019.

[16] W. W. Tsai and A. Janssen, "Reinforcing information fluency: Instruction collaboration in senior capstone laboratory course," *ASEE Annual Conference and Exposition, Conference Proceedings*, vol. 2018-June, 2018, doi: 10.18260/1-2--30930.

[17] M. Phillips, S. Lucchesi, J. Sams, and P. J. van Susante, "Using direct information literacy assessment to improve mechanical engineering student learning - A report on rubric analysis of student research assignments," *ASEE Annual Conference and Exposition, Conference Proceedings*, vol. 122nd ASEE, no. 122nd ASEE Annual Conference and Exposition: Making Value for Society, 2015, doi: 10.18260/p.24999.

[18] P. Ekwaro-Osire, Stephen; Afuh, Innocent; Orono, "Information Gathering Activities in Engineering Design," *American Society for Engineering Education*, 2008.

[19] K. Mercer, K. D. Weaver, and A. J. Stables-Kennedy, "Understanding undergraduate engineering student information access and needs: Results from a scoping review," *ASEE Annual Conference and Exposition, Conference Proceedings*, 2019, doi: 10.18260/1-2--33485.

[20] C. J. Atman, R. S. Adams, M. E. Cardella, J. Turns, S. Mosborg, and J. Saleem, "Engineering Design Processes: A Comparison of Students and Expert Practitioners," *Journal of engineering education*, vol. 96, no. 4, pp. 359–379, 2007, doi: 10.1002/j.2168-9830.2007.tb00945.x.

[21] M. Fosmire, "Information literacy and engineering design: Developing an integrated conceptual model," *IFLA Journal*, vol. 38, no. 1, pp. 47–52, Mar. 2012, doi: 10.1177/0340035211435071.

[22] M. Fosmire, "Making Informed Decisions: The Role of Information Literacy in Ethical and Effective Engineering Design," *Theory into Practice*, vol. 56, no. 4, pp. 308–317, Oct. 2017, doi: 10.1080/00405841.2017.1350495.

[23] Michael. Fosmire and David. Radcliffe, *Integrating Information into the Engineering Design Process*. 2019. doi: 10.2307/j.ctt6wq25v.

[24] F. Zabihian, M. L. Strife, and M. G. Armour-Gemmen, "Integration of information literacy skills to mechanical engineering capstone projects," *ASEE Annual Conference and Exposition, Conference Proceedings*, vol. 122nd ASEE, no. 122nd ASEE Annual Conference and Exposition: Making Value for Society, 2015, doi: 10.18260/p.24335.

[25] M. Phillips and D. Zwicky, "Information Literacy in Engineering Technology Education: A Case Study," *Journal of Engineering Technology*, vol. 35, no. 2, pp. 48–57, 2018.

[26] J. L. Devore, N. R. Farnum, and J. A. Doi, *Applied Statistics for Engineers and Scientists*. Cengage Learning, 2013.

[27] B. M. Smyser and K. Jaeger-Helton, "How Did We End up Together? Evaluating Success Levels of Student-formed vs. Instructor-formed Capstone Teams How Did We End up Together? Evaluating Capstone Project Success as a Function of Team and Project Formation Methods and Other Contributing Factors," 2015. doi: 10.18260/p.24189.

[28] Elsevier. "Knovel." URL: https://www-elsevier-com.ezproxy.neu.edu/solutions/knovel-engineering-information (accessed Feb 2, 2022).

Appendix A: Tailored VALUE Rubric

This rubric was created using the Association of American Colleges and Universities (AAC&U) Critical Thinking VALUE Rubric. Retrieved from https://www.aacu.org/value-rubrics

Category	Criteria						
	Score:	5	4	3	2	1	0
Determine the Extent of Information Needed	Recognizes key concepts that require research / supporting information	Recognizes ALL key concepts that require research / supporting information	Recognizes MOST key concepts that require research / supporting information	Recognizes SOME key concepts that require research / supporting information (e.g. some are missing, or too broad/narrow)	Recognizes FEW key concepts that require research / supporting information (most are missing or poorly scoped)	Recognizes only one or two key concepts that require research/ supporting information (all are poorly scoped)	Does not identify concepts that require research / supporting information
	Provides evidence for information and ideas that are not common knowledge.	Evidence is provided for all information and ideas that are not common knowledge	Evidence is provided for most information and ideas that are not common knowledge	Evidence is provided for some information and ideas that are not common knowledge	Evidence is NOT provided for most information and ideas that are not common knowledge	Evidence is provided for only one or two ideas that are not common knowledge. Sources poorly utilized.	Writing from assumptions about common knowledge or own experience. Sources not utilized.
	Types of info (sources) selected relate to concepts / meet the information need	All sources directly relate to key concepts and specifically meet the information need	Most sources relate to key concepts and address the information need, and/or not as directly	Most sources partially relate to key concepts / partially address the information need	Most sources are loosely related to key concepts / do not meet the information need	Most sources do not relate to key concepts / do not meet the information need.	Sources are not provided
Evaluate Information and its Source Critically	Chooses a variety of information sources appropriate to the scope and discipline of the research question	References a wide variety of sources appropriate to the topic	References a variety of sources appropriate to the topic	References a few types of sources appropriate to the topic, but variety is lacking	References a few types of sources, but some are are not appropriate to the topic	References only one type of source (e.g. websites) appropriate to the topic	References are not provided
	Selects sources after considering multiple criteria, such as relevance to the research question, currency, authority, audience, and bias or point of view	ALL sources and evidence are relevant, current, authoritative, audience appropriate, and unbiased (and if not, limitations are recognized)	MOST sources and evidence are relevant, current, authoritative, audience appropriate, and unbiased (and if not, most limitations are recognized)	SOME sources and evidence are relevant, current, authoritative, audience appropriate, and unbiased (and if not, some limitations are recognized)	FEW sources and evidence are relevant, current, authoritative, audience appropriate, and unbiased (and if not, few limitations are recognized)	Sources or evidence are provided, but NONE are relevant, current, authoritative, audience appropriate, and unbiased (and limitations are not recognized)	Sources and evidence are not provided

Use Information Effectively to Accomplish a Specific Purpose	Communicates, organizes, and synthesizes information from sources to achieve a specific purpose	Communicates, organizes and synthesizes information from multiple sources to fully and clearly achieve a specific purpose	Communicates, organizes and synthesizes information from multiple sources. Intended purpose is achieved.	Communicates information from sources, but not fully synthesized / integrated or clearly communicated. Intended purpose partially achieved.	Communicates information from sources, but tends to rely heavily on one source, or use of sources is inconsistent. Intended purpose partially achieved.	Communicates some information from sources, but information is fragmented and/or used inappropriately so that the intended purpose is not achieved	Communicates little or no information from sources
Access and Use Information Ethically and Legally	Cites sources accurately	All in-text citations and reference list citations are accurate	Most in-text citations and reference list citations are accurate	Some in-text citations and reference list citations are accurate	Few in-text citations and reference list citations are accurate	No in-text citations and reference list citations are accurate	Sources are not cited
	Paraphrases, summarizes, or quotes from sources appropriately	Consistently and effectively paraphrases, summarizes or quotes from sources	Mostly paraphrases, summarizes or quotes from sources effectively	Mostly paraphrases, summarizes, or quotes from sources effectively, but not consistently	Sometimes struggles to paraphrase, summarize or quote from sources effectively	Overreliance on quotations	No attribution