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A Rubric-Based Assessment of Information Literacy in Graduate Course Term Papers

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Abstract

The Materials Processing course at Northeastern University enrolls both Master's level students with a concentration in Materials and undergraduates who select the course as an elective for their combined BS/MS degree. For the term project, students work in teams to research and write a journal-quality review article detailing the state of the art for a particular process. This study aimed to assess students' information literacy (IL) skills as demonstrated in this term project to identify IL skills with which graduate and upper-level undergraduate students may need more support. A secondary goal was to examine any differences in information between the undergraduate and graduate students, many of whom speak English as a second language.

A customized version of the VALUE rubric for Information Literacy was used to assess a sample of 25 term projects from two semesters spanning 2021-2022. A Mechanical Engineering faculty member rated half the criteria that required more subject matter expertise. An Engineering Librarian rated the other half of the criteria which are more research oriented. This method resulted in substantial time savings and increased expertise in overall ratings.

Results indicate the students in aggregate were most skilled in choosing sources related to the research question and selecting those sources based on multiple criteria. Students were least skilled in the proper citation of sources and in communicating and synthesizing literature information into a coherent argument. Two outcomes that were strongly related to high report grades were being able to properly paraphrase literature information as well as properly synthesize it into an argument. These last two outcomes were particularly weak for teams consisting solely or primarily of graduate students. It is recommended that undergraduate students receive reinforcement of library research skills, while graduate students require additional instruction in paraphrasing, synthesis of ideas, and ethical attribution. Additional research is needed to examine the IL background of international students.

Introduction

The Materials Processing and Process Selection course (ME6500) at Northeastern University enrolls both Master's level students with a concentration in Materials and undergraduates who select the course as an elective for their combined BS/MS degree. For the term project, students work in teams to research and write a journal-quality review article detailing the state of the art for a particular process. This study aimed to assess students' information literacy (IL) skills as demonstrated in this term project to identify IL skills with which graduate and upper-level undergraduate students may need more support. A secondary goal was to examine any differences in information between the undergraduate and graduate students, many of whom speak English as a second language.

Previous IL instruction varies greatly for students in this course. Undergraduate students taking the course as an elective may have attended library workshops during previous classes at Northeastern University. There is a common course for all first years that includes a library

workshop; however, that program was not required for all sections when this cohort were freshmen, so attendance likely varies from student to student. Those who did attend would have received an introduction to commonly used research databases in engineering and would have practiced evaluating and citing sources as part of assignments for that course. Additionally, students likely received some instruction and practice for IL skills in other courses throughout the curriculum, including a writing intensive course in their major and an advanced technical writing course required for all engineering students. For graduate students who did not go to Northeastern University for their undergraduate studies, previous IL instruction is generally unknown. Most graduate students in this course are international students, so there may be significant differences depending on common practices in their various countries of origin. In the Materials Processing and Selection class, the instructor provides an overview of the existing library sources as well as other sources of refereed literature. Additionally, the students are required to read and discuss subject matter-based review papers. While the primary focus is on the subject matter, every paper is discussed by the instructor to point out the features and language that are expected in professional publications. This study aims to identify remaining gaps and opportunities for the instructor and librarian to provide additional scaffolding and support for IL skills.

Literature Review

Assessment of engineering students' information literacy (IL) skills has to date focused more on the undergraduate than graduate level [1]–[3]. Much of the research focused on the undergraduate level has focused on first-year courses and design-oriented courses such as Capstone [4]. Generally, in these types of courses, students are acting more as consumers of information (in order to learn new concepts, inform decisions, etc.), rather than as producers of information, as would be expected at the graduate level or in upper-level undergraduate, non-design focused courses. [5]

Of the research that has been done on graduate-level IL, much of it relates to information behavior and needs, rather than instruction or assessment [6]. Several studies were found that assessed the efficacy of outreach and instruction strategies specifically for graduate students, such as workshops targeted to specific needs [7], express classes [8], and embedded consultation models [9], [10]. Citation analyses of upper-level and graduate-level literature reviews, theses, and dissertations show that as students progress up the curriculum, they tend to cite increasingly more sources, and more scholarly sources [11], [12]. Other studies indicate some significant challenges with IL skills, including trends like overreliance on websites, lack of diversity in sources [13], [14], inaccurate citations [11], [13], [15], lack of experience with patent searching [16], and lack of deep engagement with the primary literature [17]. In 2022, Xie & Savory found that graduate students generally did well with gathering quality sources, but many produced summaries of those sources rather than critical evaluations or syntheses of the information [15]. This finding is consistent with Carroll's broader assessment of graduate students across STEM disciplines, which calls out a lack of the information literacy skills it takes to engage meaningfully with primary research [17].

While there are valuable lessons to be learned from the existing research, there is certainly a need for more assessment of engineering students' IL skills as they move through the curriculum. One reason for the limited research may be that the complexity and contextuality of IL at the graduate level makes it much harder to measure. Methods such as surveys and tests that are commonly used in undergraduate-focused research are simply not as effective [5]. Additionally, a recent systematic review concluded that a lack of objective measures and statistical analysis made it challenging to draw conclusions about effective information literacy instruction techniques in engineering [4]. A method that can add this type of rigor to studies on this topic is rubric-based assessment. Benefits of rubric-based assessment include evaluation of students' higher order thinking skills in a more authentic context, less biased and more consistent rating of projects, and more granular analysis of skills [18]. To promote more research using this method, Project RAILS (Rubric Assessment of Information Literacy Skills) developed and offered guidance for implementing rubric-based assessment of IL skills, including collaboration between librarians and faculty and customizing rubrics, such as the AAC&U's Valid Assessment of Learning in Undergraduate Education (VALUE) rubric for Information Literacy [19], to fit the assignment being evaluated [20].

In sum, there is a need for more studies of engineering information literacy skills using rigorous research methods, especially at higher levels in the curriculum. The goal of this study is to add evidence in this area and guide efforts at Northeastern University to provide more effective instructional support to upper-level undergraduates and graduate students around these skills.

Method

A customized version of the VALUE rubric for Information Literacy was used to assess a sample of 25 term projects from two semesters spanning 2021-2022. This customized version of the rubric is described more fully in a previous study [21] and is included in Appendix A. There are eight criteria spanning four categories: Determine the extent of information needed; Evaluate information and its source critically; Use information effectively to accomplish a specific purpose; and Access and use information ethically and legally. Each criterion was rated on a scale of 0-5. The higher the rating, the better the skill was demonstrated. Each term project was co-researched and co-written by a team of 2-3 students. Teams were formed by the students, with some containing only graduate students, some with only undergraduates, and some with a combination of the two. The assignment prompts students to research a particular process and write a journal quality review article detailing the state of the art for that process. The prompt defines a review article, provides an example, and links to a resource that describes steps for writing a scientific review article. Also provided are guidelines for formatting, citing references, and tables and figures. A grading rubric is also provided, which includes content-based evaluation of factors like organization, description and critique of current state of the art, discussion of current debates, and recommendations for future research. An IL-related item is included for References, but the description is much higher level than the customized VALUE rubric used for the study, since it is only one of many factors on which the students' grades are based. The full assignment prompt is included in Appendix B. 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 was not required for this study.

The initial VALUE rubric for this project had previously been customized from AACU's original version for a prior study. Several cycles of norming were done at that time to ensure interrater reliability between the faculty member and librarian who would be scoring projects [21]. The previously customized rubric was applied to the ME 5600 term projects. A Mechanical Engineering faculty member rated half the criteria that required more subject matter expertise. An Engineering Librarian rated the other half of the criteria which are more research-oriented (Table 1). This method resulted in substantial time savings and increased expertise in overall ratings. Additionally, similarity reports from the Turnitin™ plagiarism checker were used to speed up scoring for the outcome "Paraphrases, summarizes, or quotes from sources appropriately."

Table 1: Rubric criteria rated by each researcher.

Outcomes	**Rated By**
Recognizes key concepts that require research	Mechanical Engineering Faculty Member
Provides evidence for ideas that are not common knowledge	Mechanical Engineering Faculty Member
Types of sources selected relate to the information need	Mechanical Engineering Faculty Member
Chooses a variety of sources appropriate to the research question	Engineering Librarian
Selects sources after considering multiple criteria	Engineering Librarian
Communicates, organizes, and synthesizes information to achieve a specific purpose	Mechanical Engineering Faculty Member
Cites sources accurately	Engineering Librarian
Paraphrases, summarizes, or quotes from sources appropriately	Engineering Librarian

As initial ratings were discussed, it became clear that the scoring criteria for one outcome needed to be further customized to fit the requirements for this assignment: "Chooses a variety of sources appropriate to the research question." Since the goal of this assignment was to write a review article, the variety of source types was less important than the appropriateness of those source types to the review article genre. In other words, the primary goal was to include a variety of refereed sources, like journal articles and conference papers, rather than including many different types of sources. The rubric scoring criteria were revised to reflect this emphasis, and all scores for that outcome were updated to reflect the updated rubric (see Appendix A).

The final ratings were then combined into a total rubric score. Course scores for each report, as a percentage of the total possible score, and the percentage of graduate students on each team were

computed as well in order to compare the final data from the two semesters in the sample. Two-sample t-tests assuming unequal variances were used to look for statistical differences between outcomes for the Summer 2021 and Summer 2022 data. As no significant differences were identified, average scores for each rubric outcome were determined to compare how well each skill was demonstrated by the combined set of students. Then, Pearson's product-moment correlation analysis was used to determine relationships between various factors for the combined dataset. Correlations with $R \geq 0.70$ were considered strong positive correlations, and moderate correlations are those where $0.30 < R < 0.70$. $R < 0.29$ is considered a weak to non-existent correlation.

To identify possible differences between the skills of undergraduate vs graduate students, the average scores of groups with fewer than 50% graduate students were compared with groups that consisted of more than 50% graduate students. To further explore the skills of graduate students compared to undergraduate students, the report results were divided into three groups: only undergraduates, mixed groups, and only graduate students. Single-factor ANOVA was used to determine statistically significant differences between the three groups for each outcome ($\alpha = 0.05$).

Finally, similarity scores from the Turnitin™ plagiarism checker software were obtained for each report. Similarity scores were not available for all reports, due to errors with the software. Also, some scores seemed artificially high or low. One group had a 2% similarity score, but they included no sources and only received a grade of 54%. They did not plagiarize, but neither did they accomplish the task. Another group had a similarity score of 100% due to the similarity to their own rough draft. Similarity to the students' own work was disregarded in the analysis. The data from Turnitin™ was used as a major input to determine whether students were correctly paraphrasing information from the literature. However, due to the incompleteness of the Turnitin™ data, it was not used in the correlation analysis.

Results

Table 2 shows the demographics of the students in each term the course was offered, along with the average total rubric score and average report grade. The highest possible rubric score was 40, which could be achieved with a perfect 5 on each of the eight criteria. Previous work by the authors studied senior undergraduate reports and found an average rubric score of 26.78 [21]. An average score greater than or equal to this value would be expected for the graduate level. As Table 2 shows, the rubric total averages for each term did exceed the benchmark, but not by a large margin. The initial analysis observed differences between the two terms examined. The 2022 term had higher averages on several individual rubric items, total rubric score, report percentage (grade for final report), and the percentage of graduate students on each team. The summer 2021 offering had 14 graduate students of whom 4 were from India, 7 were from China, 1 from the Middle East, and 2 from the U.S. In 2022 there were 8 graduate students, with 4 from

India, 1 from the Middle East, and 3 from the U.S. Thus, in both terms international graduate students made up most of the graduate student population of the course.

Table 2: Characteristics of the two terms studied.

Term	**Total Students**	**Graduate Students**	**Undergraduate Students**	**# of Teams**	**Average Rubric Total**	**Average Report Grade (%)**
Summer 2021	39	14	25	16	27.88	87.11
Summer 2022	21	8	13	9	29.22	90.42

Pearson's product-moment correlation analysis

Two-sample t-tests assuming unequal variances were used to look for statistical differences between outcomes for the Summer 2021 and Summer 2022 data. As shown in Table 3, although the average value of the scores for various outcomes was different between terms, the differences were not statistically significant as in all cases P was greater than the level of significance (L.O.S) (α=0.05). Based on this result, the data for both terms were combined for all future analyses. The averages for the combined data set are also included in Table 3. Based on the averages it appears that students are most proficient at choosing sources that meet their information needs and least proficient at communicating and synthesizing the information found into a coherent argument.

Table 3: Comparison of outcomes from Summer 2021 and Summer 2022

Outcomes	Average (2021)	Average (2022)	P value (α=0.05)	Combined Average
Recognizes key concepts that require research	3.31	3.63	0.39	3.40
Provides evidence for ideas that are not common knowledge	3.38	3.44	0.87	3.40
Types of sources selected relate to the information need	3.94	4.11	0.68	4.00
Chooses a variety of sources appropriate to the research question	3.25	3.67	0.27	3.40
Selects sources after considering multiple criteria	3.88	4.11	0.57	3.96
Communicates, organizes, and synthesizes information to achieve a specific purpose	3.06	3.44	0.46	3.20
Cites sources accurately	3.38	3.22	0.71	3.32
Paraphrases, summarizes, or quotes from sources appropriately	3.69	3.67	0.97	3.68
Total rubric score	26.38	29.22	0.22	28.36
Report percentage	87.11	90.42	0.43	88.30
% graduate students on team	36.38	48.00	0.49	40.56

After combining the data for the two terms, Pearson's product-moment correlation analysis was used to determine relationships between various factors. Correlations with $R \geq 0.70$ were considered strong positive correlations (Table 4). The total rubric score had strong correlations with all but two of the rubric items. Correlations between the total rubric score and the rubric items are to be expected, however, it was interesting to see that not all the correlations were considered strong. Two of the strongest correlations are related to the ability to communicate, organize, and synthesize information to achieve a specific purpose. These abilities were strongly correlated with recognizing key concepts that required information from the literature and with providing evidence for those concepts that are not common knowledge. The ability to synthesize data to make an argument proved to be a differentiating factor between certain subgroups, as explained below.

Table 4: Strong positive correlations for combined data

Factor 1	Factor 2	R	P value (α=0.05)
Communicates, organizes, and synthesizes information to achieve a specific purpose	Recognizes key concepts that require research	0.82	<0.001
Total rubric score	Selects sources after considering multiple criteria	0.82	0.004
Total rubric score	Types of sources selected relate to the information need	0.80	0.003
Communicates, organizes, and synthesizes information to achieve a specific purpose	Provides evidence for ideas that are not common knowledge	0.78	<0.001
Total rubric score	Recognizes key concepts that require research	0.78	0.02
Total rubric score	Paraphrases, summarizes, or quotes from sources appropriately	0.75	<0.001
Total rubric score	Chooses a variety of sources appropriate to the research question	0.75	0.001
Total rubric score	Communicates, organizes, and synthesizes information to achieve a specific purpose	0.73	<0.001
Report Percentage	Cites sources accurately	0.70	<0.001

Moderate correlations are those where $0.30 < R < 0.70$. Statistically significant moderate correlations between various factors are shown in Table 5. The two rubric items that did not correlate strongly with the total rubric score were the ability to cite sources accurately ($R = 0.66$) and provide evidence for concepts that are not common knowledge ($R = 0.55$). These two factors seem to be the least important contributors to the final rubric score. Several factors were positively correlated with the report percentage grade, including the ability to synthesize information for a particular purpose, paraphrase appropriately, and provide evidence for concepts that are not common knowledge. Skills in paraphrasing appropriately are moderately correlated with six other factors. Skills in synthesizing information are moderately correlated with three other factors and with paraphrasing skills. Paraphrasing and synthesizing skills surface repeatedly as key abilities related to positive outcomes. The ability to accurately cite sources was correlated with three other factors. This skill is taught in undergraduate writing classes, but it is unclear whether international graduate students are exposed to proper citation during their undergraduate studies. Additional moderate correlations seem to underscore the link between

being able to discern what information needed to be backed up with evidence from the literature and having the ability to navigate scholarly resources. For example, there is a positive correlation between recognizing key concepts that required evidence from the literature and choosing sources based on multiple criteria. All rubric items were positively correlated with at least one other factor.

Table 5: Moderate yet statistically significant correlations between factors.

Factor 1	Factor 2	R	P value (α=0.05)
Total rubric score	Cites sources accurately	0.66	<0.001
Report percentage	Communicates, organizes, and synthesizes information to achieve a specific purpose	0.65	0.05
Paraphrases, summarizes, or quotes from sources appropriately	Cites sources accurately	0.57	0.001
Total rubric score	Provides evidence for ideas that are not common knowledge.	0.55	0.002
Paraphrases, summarizes, or quotes from sources appropriately	Selects sources after considering multiple criteria	0.54	<0.001
Report percentage	Paraphrases, summarizes, or quotes from sources appropriately	0.52	<0.001
Paraphrases, summarizes, or quotes from sources appropriately	Types of sources selected relate to the information need	0.51	<0.001
Selects sources after considering multiple criteria	Recognizes key concepts that require research	0.50	0.03
Paraphrases, summarizes, or quotes from sources appropriately	Chooses a variety of sources appropriate to the research question	0.49	<0.001
Cites sources accurately	Types of sources selected relate to the information need	0.49	0.001
Paraphrases, summarizes, or quotes from sources appropriately	Communicates, organizes, and synthesizes information to achieve a specific purpose	0.48	0.02
Chooses a variety of sources appropriate to the research question	Recognizes key concepts that require research	0.48	0.05
Report percentage	Provides evidence for ideas that are not common knowledge.	0.42	0.002
Communicates, organizes, and synthesizes information to achieve a specific purpose	Types of sources selected relate to the information need	0.35	0.01

Comparison of groups with and without graduate students

There was one weak but significant negative correlation ($R = -0.28$, $P = 0.005$) between the percentage of graduate students on a team and the ability to paraphrase, summarize, or quote from sources appropriately. This falls in line with the difference in average Turnitin™ scores for groups with and without graduate students. The average Turnitin™ score of 51% for teams with graduate students was statistically and significantly larger than the average score of 33% for teams without graduate students ($\alpha = 0.1$). The Turnitin™ scores are acknowledged to be imperfect, and one team was missing a similarity score entirely. Although the difference is only significant at a L.O.S. of 0.1, this is still suggestive of a lack of knowledge of how to properly discuss information from literature sources among a group of largely international graduate students.

The average scores of groups with fewer than 50% graduate students were compared with groups that consisted of more than 50% graduate students, as shown in Table 6. Only one of the differences was close to statistically significant: Groups with fewer graduate students had a larger average score on the item "communicates, organizes, and synthesizes information to achieve a specific purpose" ($P = 0.05$, $\alpha = 0.05$). Although this difference is barely significant at $\alpha = 0.05$, it was significant at $\alpha = 0.1$. The reports were scored as much as possible based on content, rather than English language proficiency. It is conceded that some very poorly written reports may have been difficult to judge. Nevertheless, graduate students tended to have more difficulty supporting their arguments with information from the literature. While the organization of information was not part of the rubric, it was observed that the logical organization of information was also a weak point.

Table 6: Average outcome scores for groups with fewer than/greater than 50% graduate students. The shading highlights the larger of the two averages.

Outcomes	Average for groups with <50% graduate students	Average for groups with >50% graduate students
Recognizes key concepts that require research	3.5	3.3
Provides evidence for ideas that are not common knowledge	3.7	3.0
Types of sources selected relate to the information need	3.8	4.3
Chooses a variety of sources appropriate to the research question	3.1	3.3
Selects sources after considering multiple criteria	3.8	4.2
Communicates, organizes, and synthesizes information to achieve a specific purpose	3.6	2.3
Cites sources accurately	3.4	3.3
Paraphrases, summarizes, or quotes from sources appropriately	4.0	3.3
Total	28.9	27.7
Report percentage	89.7	86.5

Although most of the differences in Table 6 are not statistically significant, there do seem to be some patterns that support the instructor's observations. Groups consisting primarily of graduate students had higher averages in skills relating to finding and selecting a variety of sources based on multiple criteria that were related to the information needed. However, groups consisting primarily of undergraduate students had higher averages in every other measure. Some of these skills may be more dependent on proficient English, such as communicating and synthesizing information and paraphrasing appropriately. Out of all the undergraduates in the combined data set only 4 were international students and they had all gone through the Northeastern University writing program.

To further explore the skills of graduate students compared to undergraduate students the report results were divided into three groups: only undergraduates, mixed groups, and only graduate students. Single-factor ANOVA was used to determine statistically significant differences between the three groups for each outcome ($\alpha = 0.05$). Only the report grade percentage showed any significant differences between the three groups, with $P = 0.04$. A t-test revealed that there was a highly significant difference between the report grades for groups with only graduate students and mixed groups containing both graduate and undergraduate students ($P < 0.001$). As

shown in Table 7, mixed groups had an average of 46% graduate students, which means more than half of the mixed groups were predominately undergraduates. Although only the report grade percentages were statistically different, in all cases mixed groups had the highest average score. It appears that mixed groups allow students to compensate for each other's weaknesses.

Table 7: Average scores for different groups of students

Outcome	**Average: Only Graduate Students**	**Average: Only Undergraduate Students**	**Average: Mixed group**
Recognizes key concepts that require research / supporting information	3.12	3.30	3.67
Provides evidence for information and ideas that are not common knowledge.	3.00	3.50	3.56
Types of info (sources) selected relate to concepts / meet the information need	4.17	3.70	4.22
Chooses a variety of information sources appropriate to the scope and discipline of the research question	3.50	2.90	3.89
Selects sources after considering multiple criteria, such as relevance to the research question, currency, authority, audience, and bias or point of view	4.00	3.60	4.30
Communicates, organizes, and synthesizes information from sources to achieve a specific purpose	2.50	3.20	3.67
Cites sources accurately	2.83	3.20	3.78
Paraphrases, summarizes, or quotes from sources appropriately	2.83	3.90	4.00
Total	26.00	27.30	31.11
Report percentage	80.63	86.88	95.00
% grad students on team	100.00	0.00	46.00

Discussion

Viewed as an overall group, the students studied were most skilled at selecting sources that met the information needs, selecting sources based on multiple criteria, and paraphrasing or summarizing properly from the literature. The group was equally proficient at recognizing key concepts and uncommon knowledge, both of which require literature evidence, as well as choosing a variety of appropriate sources. The two weakest skills were the ability to cite sources accurately and the ability to synthesize information from the sources to form a coherent argument. Two of the top skills related to selecting sources seem to require knowledge of search

strategies, which could be reinforced with video tutorials provided by the library and subject librarians. The ability to paraphrase seems to depend not only on English proficiency but also on understanding why and how to paraphrase. The report grade was highly influenced by the ability to paraphrase, synthesize information for a purpose, recognize and provide evidence for uncommon terms, and cite sources correctly. Given that only one of these abilities is in the top three skills, this could guide the information provided in future programming.

The disparities between the skills of undergraduate and graduate students warrant a closer look as well. Although not studied for this paper, anecdotal evidence from the instructor indicates that graduate students also have a lower average score on the exams. The exams are take-home exams that require research and properly cited information from the literature as part of the answers. On both the term projects and reports, graduate students are known to copy long direct quotes, sometimes unattributed, or gather information from several sources but then fail to clearly synthesize the information. The result is often a collage of facts related to a topic that is presented in an unclear and disorganized way. This may be occurring due to a lack of confidence in their English writing ability, leading them to copy and paste information to avoid grammar difficulties, and/or lack of deep reading and meaningful engagement with the literature. It should also be acknowledged that the rubric used in this study was created by educators at U.S.-based colleges and universities [22], and both researchers in this study have primarily learned and taught in U.S.-based institutions. There may simply be differences in previous IL instruction and practice opportunities in the education systems in international students' countries of origin. That said, the results demonstrate a clear need for more support and practice with the mechanics of citation, as well as the ethics of attributing credit for the information being cited. On the other hand, the graduate students did seem to excel at finding a variety of sources that met the information need, and generally selecting high-quality, refereed sources, suggesting a higher level of comfort with accessing and selecting scholarly literature than was seen with the undergraduates. This is consistent with previous findings showing that graduate students did well with gathering quality sources but not as well with evaluating or synthesizing that research in a meaningful way [15], [17].

By the time they are eligible to take this course, most undergraduate students from Northeastern University have had 1-2 writing intensive laboratory classes, a first-year module on how to use library sources, and a class in technical writing in the discipline. Additionally, some of the students have already taken Capstone Design, which requires them to write a rather lengthy report and use literature information to guide their design. The undergraduate students are also overwhelmingly domestic students, which suggests relative consistency between IL instruction and practice they may have received in U.S.-based K12 schools and the practices and expectations at a U.S.-based university. The repeated instruction and practice afforded by this background would seem to explain their relative skill at paraphrasing and synthesizing information from the literature as well as accurately following the standards for citation. Their

weakness seems to be in locating scholarly sources, rather than using Google as their main source of information. This is also consistent with previous research which showed a tendency to cite more scholarly sources the higher one goes in the curriculum [11], [12].

A positive finding was that students working in groups with both graduate and undergraduate students had significantly higher report grades than groups with only graduate students. It is acknowledged that there is no way to know who was performing which tasks while writing the report. However, evidence suggests that pairing graduate and undergraduate students together allows them to compensate for each other's weaknesses.

Recommendations

Based on these results, it is recommended that additional IL instructional support and practice be focused on different skills for graduates and undergraduates. While all students demonstrate the need for more practice with synthesizing and communicating information, undergraduate IL instruction should also emphasize skills related to identifying and selecting a variety of refereed, scholarly sources. For graduate students, emphasis should be less on selecting sources and more on how the information in those sources is used, from higher-level skills like synthesizing and analyzing, to the basics of citation and paraphrasing. While these additional supports will hopefully result in more students having a well-rounded set of IL skills, the strategy of pairing graduate and undergraduate students together on research and writing projects should be continued as a way for students with complementary skills to learn from one another and produce higher quality work. Additionally, more work is required to determine the effect of English language learners on these outcomes. The international student population is expected to continue increasing at Northeastern University, and as such, a better understanding of how language learning intersects with IL skills may help faculty and librarians shape more effective instruction and practice opportunities. A more in-depth understanding of secondary and postsecondary IL instruction and expectations in students' cultures of origin may also help with designing learning experiences that can bridge existing gaps.

Conclusion

Group term projects from a graduate class were evaluated to examine IL skills using a previously developed and modified rubric. This study reinforced the utility of evaluating IL by splitting the evaluation between a subject matter expert and a research librarian. Undergraduate students were found to require additional instruction in finding high-quality refereed sources that supported their ideas. Graduate students require additional practice and instruction with proper paraphrasing of literature information, proper attribution of sources, and synthesizing information from multiple sources into a coherent argument. Groups consisting of both graduate and undergraduate students tended to achieve higher grades on the assignment, which may

indicate that the team members are compensating for each other's weaknesses. Further work is required to investigate the IL background of international students so that previous instruction and current instruction can be brought into alignment.

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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 assumption s 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 source types (articles, conference papers, + other), and all appropriate to the assignment type (I.e., refereed)	References a variety of source types (articles, conference papers) and most are appropriate to the assignment type (I.e., refereed)	References a variety of source types, but some are not appropriate to the assignment type (I.e. refereed) OR a limited variety but most are appropriate	Reference a limited variety of sources, and some are not appropriate to the assignment type (I.e. refereed)	References only one type of source, and/or more not appropriate to the assignment type (I.e., refereed)	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	Sources and evidence are not provided

						are not recognized)	
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

Appendix B: Term Project Assignment Details

ME5600 Term Project

This class includes a term-long project that is worth 20% of your grade. The goal of this project is to research a particular process and write a journal quality review article detailing the state of the art for that particular process. According to The University of Texas at Austin:[1]

"*Review articles are an attempt by one or more writers to sum up the current state of the research on a particular topic. Ideally, the writer searches for everything relevant to the topic, and then sorts it all out into a coherent view of the "state of the art" as it now stands. Review Articles will teach you about:*

- *The main people working in a field*
- *Recent major advances and discoveries*
- *Significant gaps in the research*
- *Current debates*
- *Ideas of where research might go next*

Review Articles are virtual gold mines if you want to find out what the key articles are for a given topic. If you read and thoroughly digest a good review article, you should be able to "talk the talk" about a given topic. Unlike research articles, review articles are good places to get a basic idea about a topic."

An example of a review article discussing paper based batteries can be found here: http://www.sciencedirect.com/science/article/pii/S0956566313007859. It is hoped that the review article you create will be something that you can put in your professional portfolio and/or actually submit for publication. An article that outlines steps to write a scientific review article can be found here, for further information: http://www.ascb.org/tips-for-writing-a-scientific-review-article/

Students will be working in teams of 2 or 3. You may choose your own partners. Partners are expected to share the work equally. In the case of someone not pulling their weight, I will consider lowering the grade of the underperforming group member, so please be diligent.

Project Proposal: Due September 16, by midnight.

The proposal should be no more than two pages, typed. In it I expect you to outline:

- The names of the students who are working together
- The process you plan to study
- Why you think this will be interesting to study
- A list of at least three sources of information you have consulted so far. NO WIKIPEDIA ARTICLES!

Written Report: Rough Draft Due November 8. Final Report Due December 6.

A required rough draft of the report is due on **November 8.** This rough draft will be returned to you with

comments on how to improve organization and provide feedback on what needs improvement.

Oral Presentations: December 2 & 6

Each student team will give a 15 minute (max) presentation on their project, with at least 10 minutes for Q&A. This project will be presented synchronously in class during the last week of class and recorded. Presentation order will be scheduled later in the term. Each student will be assigned to provide feedback for 3 other presentations.

Report Formatting Requirements

In order to produce a publication quality article, this paper will follow the Journal of Materials (JOM) manuscript preparation guidelines. I have reproduced them here, but you can also find them at **http://www.tms.org/pubs/journals/jom/authorStyleGuide.aspx**

TITLE PAGE ELEMENTS

Title Page

The title page should include:

- The name(s) of the author(s)
- A concise and informative title
- The affiliation(s) and address(es) of the author(s)
- The e-mail address of the corresponding author

Abstract

Please provide an abstract of 150 to 250 words. The abstract should not contain any undefined abbreviations or unspecified references.

TEXT

Text Formatting

- Manuscripts should be submitted in Word.
- Use a normal, plain font (e.g., 10-point Times Roman) for text.
- Use italics for emphasis.
- Use the automatic page numbering function to number the pages.
- Do not use field functions.
- Use tab stops or other commands for indents, not the space bar.
- Use the table function, not spreadsheets, to make tables.
- Use the equation editor or MathType for equations. Note: If you use Word 2007, do not create the equations with the default equation editor. Instead, use the Microsoft equation editor or MathType instead.

Headings

Please use no more than three levels of displayed headings.

Abbreviations

Abbreviations should be defined at first mention and used consistently after that occurrence. If the abbreviation occurs first in the abstract, it should be defined both there and at first mention in the text.

Footnotes

- Footnotes can be used to give additional information. This may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and should never include the bibliographic details of a reference They should also not contain any figures or tables.
- Footnotes to the text are numbered consecutively. Footnotes to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.
- Always use footnotes instead of endnotes.

Acknowledgements

Acknowledgments of people, grants, funds, etc. should be placed in a separate section before the reference list. The names of funding organizations should be written in full.

REFERENCES

Citation

Reference citations in the text should be identified by numbers in square brackets. Some examples:

- Negotiation research spans many disciplines [3].
- This result was later contradicted by Becker and Seligman [5].
- This effect has been widely studied [1-3, 7].

Styling of References

- A journal reference should be readily available on subscription and included in most library collections. Use journal abbreviations as given in the current listing of Chemical Abstracts Service at this link. Article titles are not to be included. List all authors' names—Do not use et al.
    - Form: Author: italicized journal title, year, ser., vol., pp. Example: R.M. Horn and Robert O. Ritchie,: Metall. Trans. A, 1978, vol. 9A, pp. 1039-53.
- References to books should include the italicized book title, and pages within the book:
    - Form: Author: Book title, edition, publisher name, publisher location, date, pages.
    - Example: George E. Dieter,: Mechanical Metallurgy, 2 nd ed. (McGraw-Hill Book Co., New York, NY, 1976), pp. 160-65.

- Book chapters or sections within a book:
    - Example: D.M. Abrams, in Conductive Polymers, ed. R.S. Seymour and A. Smith (Springer, New York, 1973), p. 307.
- A “private communication” or “unpublished research” may be referenced when required to give proper credit. The citation must include the affiliation and location of the person involved, as well as the year. Papers presented at meetings, but not published, fall under this category.
    - Example: J.J. Doe, AAA Company, Washington, DC, unpublished research, 2004.
- References to internal reports and other publications of limited availability (not available by subscription) are not desirable. However, they will be permitted when the use results in a saving of page space or is required for proper recognition. In these matters, the author’s judgment must be supported by the review committee and editor. The report should be available on request and include the source from which a copy may be obtained.
    - Example: J.J. Doe, Report No. 738, AAA Company, Washington, DC, January 2004.
- Article by DOI
    - Example: M.K. Slifka, J.L. Whitton, J. Mol. Med. (2000) doi:10.1007/s001090000086.
- Online document:
    - Example: J. Cartwright, “Big Stars Have Weather Too” (IOP Publishing PhysicsWeb, 2007), http://physicsweb.org/articles/news/11/6/16/1. Accessed 26 June 2007.
- “In Press” references must include the name of the journal. Balance of reference should be supplied when available. This may be done on the proofs.
- References such as “submitted for publication” and “to be published” are not acceptable. If the item is still undergoing review, use same format as “unpublished research” above.
- References must be numbered throughout the manuscript and presented in consecutive numerical order on the reference page.
- No other references will be published.

TABLES AND FIGURES

- All tables and figures are to be numbered using Arabic numerals.
- Tables and figures should always be cited in text in consecutive numerical order.
- For each table, please supply a table caption (title) explaining the components of the table. The caption goes ABOVE the table.
- For each figure, please supply of figure captions (title) explaining what the figure presents. The caption goes BELOW the figure.
- Identify any previously published material by giving the original source in the form of a reference at the end of the table/figure caption.
- Footnotes to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data) and included beneath the table body.

SCIENTIFIC STYLE

Please always use internationally accepted signs and symbols for units, SI units.

Grading Scheme: The table below shows how the project will be graded. **NOTE: The different rubric items are NOT required headings. Information should be integrated into a coherent whole. Use headings that clearly introduce the information in the section.**

Item	Points	Description
Written Presentation		
Improvement from rough draft	5	Did you make changes or suggested improvements from the draft?
Grammar, figures and tables	10	Did you use the correct fonts and required elements? Were the figures and tables clearly referenced and useful? Did you use third person, clearly written technical English?
Organization	10	Was the information presented in a logical, organized order? Could I clearly follow where you were going?
Key researchers in the field.	10	Did you introduce the main people working in a field? Did you compare and contrast their work? Did you provide the main goals of their research
Current state of the art	10	Did you discuss recent major advances and discoveries?
Critique of the current state of the art	10	Did you find and discuss significant gaps in the research? Were there no gaps, but areas where there was less work to be found?
Discussion of current debates	10	What are the current controversies in this field? What are the concepts that people seem to disagree on? What are the key alternate ways this process can be studied?
Recommendations for future research	10	Did you provide ideas for where research might go next? Are your ideas reasonable and supported by the literature?
References	5	Did you use proper footnotes/endnotes throughout? Were your sources of good quality? Did you provide all the necessary bibliographical information in the proper format?
Oral presentation		
Organization of ideas	5	Was there a logical progression in the ideas presented? Was it easy to follow?
Quality of content	5	Did you provide sufficient background? Was there a clear discussion of where the research could go in the future? Was

		there enough detail to follow without being bogged down in minute details?
Effectiveness of visual aids	5	Were the slides clear and readable? Did they help tell the story, or did they distract?
Public speaking (volume, speed, eye contact, etc.)	5	Could you be heard and understood? Did you block the screen? Did you look at the audience?
Total	100	