2018 ASEE Annual Conference & Exposition
June 24-27, 2018
Salt Palace Convention Center
Salt Lake City, UT

Paper ID #22412

Reinforcing Information Fluency: Instruction Collaboration in Senior Capstone Laboratory Course

Dr. William W. Tsai, California State University, Maritime Academy

Dr. William W. Tsai is an assistant professor in the Mechanical Engineering Department at California State University, Maritime Academy (CSUM). His research background is fluid mechanics and heat transfer and is examining research topics in laboratory education in those fields. Prior to CSUM, Dr. Tsai was a Member of the Technical Staff in the Fluid Mechanics Group at The Aerospace Corporation. Dr. Tsai earned his Ph.D., M.S., and B.S. at the University of California, Berkeley in Mechanical Engineering.

Amber Janssen MLIS, California State University, Maritime Academy

Amber Janssen is a senior assistant librarian at California State University, Maritime Academy (CSUM). Her research background is in the instruction and assessment of information fluency in undergraduate education. Prior to CSUM, Ms. Janssen was a technical editor for the Research & Development office of Tetra Tech, Inc. Ms. Janssen earned her MLIS from San Jose State University.

Reinforcing Information Fluency: Instruction Collaboration in Senior Capstone Laboratory Course

Abstract

This paper presents a study examining the effect of direct information fluency instruction in a Mechanical Engineering senior capstone laboratory course. An experiment was designed where the students examined different drag reduction techniques on heavy vehicles. This topic was selected because the students would be forced to carry out a literature search beyond their fluid mechanics textbook. The study was designed to examine a) students' attitudes toward research practices and b) whether supplemental instruction activities in information fluency would produce measurable improvements in the students' information fluency skills. A research attitudes survey given to the course corroborated past research that online tools are the preferred research tool and perceived to be easier to use than resources such as databases and the library. The class was then evenly divided into a test group and a control group. A librarian gave the test group supplemental in-class instruction that emphasized methods in searching, evaluating the quality of, and proper usage of research sources. The control group was given additional activities related to the experiment. Two quantitative methods were employed to assess the information fluency skills of the two different groups before and after the supplemental instruction. First, students completed information fluency skills assessments prior to and after the instructional activity. Second, the students' technical reports for this experiment and the one prior were scored using a rubric measuring the information fluency skills demonstrated. The data from the skills assessment showed improvement in search strategies in the test group as compared to the control group. The data from the writing assessment showed significant improvement in the quality of sources used in the test group as compared to the control group. The results support the hypothesis that the instructional activity produced measurable improvements in some of the areas of information fluency examined in this study.

Introduction

Information fluency skills that are required of engineers look different than that of other disciplines. As a profession, engineers rely on information sources, such as colleagues, that are less formal than other disciplines [1], [2]. Engineers also rely heavily on information that is not published in the traditional methods. Grey literature can be difficult to find and obtain, but the information is often valuable and not found in any other format [3]. Searching for and evaluating the relevance and credibility of grey literature is a transferable skill that will benefit students in the workplace [4], [5].

Engineering students will need to have strong information fluency skills since few engineering firms employ a librarian and employees are expected to do their own research, often on the open web [6], [7]. Engineers typically behave in line with the "law of least effort" by valuing accessibility and perceived technical quality as the top criteria for information searching [8]. So not surprisingly, practicing engineers and engineering students show a strong preference for using information sources from the web [2], [9]. One study on the quality of web sources cited by engineering students found that 75% of the high-quality sources cited were from the web, while at the same time 98% of the low-quality sources were also from the web [10]. Traditional information fluency instruction from both librarians and engineering faculty has focused on scholarly journal articles despite the likely lack of access to this information source after graduation [5]. Curl [11] suggests that bibliographic instruction for engineers should more closely match the way that they approach information: answering specific questions about a product or process and keeping abreast of developments in the field.

The greatest gains in information fluency skills seem to correlate with the influence of engineering faculty [5]. Engineering students value help from professors or lecturers over the library. Engineering students also show a strong preference for consulting their peers [1]. The assignment requirements set by faculty have the strongest influence on students' use of web searching to obtain information [12]. Kerins [1] recommends that engineering faculty and librarians collaborate to provide students with active problem-solving and research experiences.

Traditionally, senior capstone laboratory courses integrate the concepts from the first three years of engineering courses. In general, these laboratory courses focus on the ABET Engineering Student Outcome B: "the ability to design and conduct experiments, as well as to analyze and interpret data." Several experiments provide different methods of delivering the technical aspects of the course. However, an overlooked, but equally vital, part of the design of experiments is information fluency. The ability to conduct a successful literature search can be just as important as technical skills with regards to the preparation of technical reports, publications, and proposals. Often due to time constraints, students may be given little to no supplemental instruction on how to approach the literature review, instead relying only on their technical communications course. The senior capstone laboratory course is an excellent opportunity to reinforce information fluency because of the role of the literature review in the experiment process.

Institutional Setting

This study was conducted during the Fall 2017 semester at California State University, Maritime Academy. The university consists of 1,100 undergraduate students with majors related to the maritime industry. The Mechanical Engineering program has approximately 150 students. The Fluid/Thermal Laboratory is the first of two semesters of the capstone Mechanical Engineering laboratory courses. In this course, students focus on experiments in thermodynamics, fluid mechanics, and heat transfer. The course integrates the material that they learn from the theory-based courses with instrumentation and measurement systems. The course schedule rotates around three experiments, for which the students are expected to deliver a presentation and full technical report. The overall goal is to ensure that students leave the class with an understanding of the entire experimental process from literature review to analyzing results to presenting their findings. The specific goals of the course are:

- *To reinforce the fundamental knowledge of thermodynamics, fluid mechanics and heat transfer students have obtained in prior classes.*
- *To apply both analytical and "hands-on" knowledge to performing fluid and thermal measurements.*
- *To develop student's ability to design and conduct fluid and thermal measurements.*
- *To develop student's ability to interpret results of measurements.*
- *To develop student's ability to communicate test results and their interpretation.*
- *To develop students' ability to work in teams to perform experiments, analyze data, and prepare presentations.*

Interestingly, information fluency is not an explicit goal, but is an inferred requirement of being able to successfully conduct experiments.

The university's library has two faculty instruction librarians who teach information fluency in general education and upper division major courses. In the past, information fluency instruction provided by the library for the Mechanical Engineering program has been limited. Students regularly receive introductory information fluency instruction in their freshman English composition course and standards and patent searching in their junior engineering design course. Students also receive ad hoc information fluency instruction if a course has a research paper and the instructor requests information fluency instruction from the library.

Problem

A review of lab reports from the Fall 2016 semester of the Fluid/Thermal Laboratory revealed the following problems in student work:

- *Trouble differentiating between the different types of sources, including the use of non-peer-reviewed materials, such as websites;*
- *Lack of assessment of quality of reference material;*
- *Lack of familiarity with how to use technical papers;*
- *Few references when writing the theory section of their lab reports;*
- *Improper use of citations in writing; and*
- *Lack of use of library resources during the literature search.*

These findings are consistent with other observations of engineering students. A survey of sophomores at UCLA's School of Engineering and Applied Sciences, showed a lack of understanding by students of where to find different types of content and the tools available through the library, such as the catalog and periodical databases [13]. Kerins [1] found that engineering students tend to select information sources based on their accessibility and the perceived effort level required to obtain the information. This makes internet searching particularly appealing. However, in a survey of engineering students enrolled in a work experience course, 47% of the students described the task of finding technical reports as difficult [7]. In addition, undergraduate students often have erroneous perceptions about the ethical use of information found on the web and the need to include citations [12].

Literature Review

Librarians and engineering professors have tried many approaches to solve the problems previously noted in student assignments. Some notable examples have shown success in redesigning an assignment to emphasize information fluency skills in combination with instruction from a librarian. Williams, Blowers and Goldberg [14] incorporated information fluency into a thermodynamics course by revising assignments to require students to find data as part of the problem solving process. Parker [15] describes a liaising model of information fluency instruction in which a librarian participates in teaching six class sessions, assesses student assignments, and assists with assignment and curriculum development. For a group design project, Roberts and Bhatt [16] used a combination of online tutorials and a required one-on-one consultation with a librarian. In addition, students were provided with library hosted webpages about engineering research. Instructors noted general improvement in the quality of information sources. Students responded well to the presence of the library instruction with 75% of students responding that the online tutorial was helpful and 72% of students responding that the personal consultation was helpful. Leachman and Leachman [5] studied library instruction in a senior level experimental design course. They used a test and control group where the same instructor taught multiple sections. In the test group, the librarian lectured and moderated student work time while students completed an additional worksheet during one of the lab sessions. When measuring the quality of student citations used in the lab reports, the overall quality of information sources cited by the test group was higher than the control group.

Purpose

The objective of this research project was to determine if, and to what extent, integrating information fluency instruction into engineering lab sessions improved the quality of information fluency skills demonstrated in student lab reports. A pattern that was noted in the literature review was a focus on information fluency instruction in freshman engineering courses and senior design project courses. This study aimed to target a different type of course. The senior laboratory course was a potentially underrepresented learning environment in information fluency instruction. This project also aimed to collect data that could be used to build a foundation that other studies could use for comparison. The use of a test and control group in this project should provide a sound methodology that other studies can duplicate in the future.

Hypothesis

With regards to student perception, the hypothesis was that students feel more comfortable with and rely more heavily on web-based searching to find information sources for their assignments.

The second hypothesis was that instructional activities in information fluency could be devised that would improve the students' quality of sources used and ethical use of information. These hypotheses would be evaluated using data from student self-assessment surveys, student skills assessments, and rubric based assessment of writing samples.

Methods

For this study, a two-part approach was employed to address the problems identified in student work related to low quality information sources and improper referencing of sources. The first part was to redesign one of the lab assignments to require the use of grey literature instead of textbooks. The second part was to provide instruction by a librarian during regularly scheduled lab time. The following sections discuss the approach as well as the assessment methods that were employed.

Assignment

To assess the understanding of information fluency demonstrated by the students, the experiments and technical reports used for this study needed to have a significant research component. The research should consist of more than looking up the topic within the textbook. This required some modification of the course. For all the reports in this course, the students were expected to use information ethically, with the proper use of citations and references, applying the AIAA citation style. This expectation has always existed in the course although not assessed to the same level of detail as would be done in this study. This study focused on two of the three experiments in the course. One experiment (Lab A) was used as an assessment of existing information fluency skills and the other experiment (Lab B) was used to measure the influence of library instruction.

It was determined that the second of three experiments in the course could be used as Lab A. The experiment, which was used in previous semesters, was the canonical study of the relationship between lift, pressure, and angle of attack for a symmetric airfoil. This lab was relatively new from the student perspective because this was the first time they are introduced to the concepts related to lift. In preparing the technical report for this airfoil-based lab, the students had feedback from their first technical report, submitted one month earlier.

Lab B was a redesigned experiment that would better fit the measure of information fluency skills while maintaining the educational objectives of the course. In the previous year, the experiment studied drag on 3 canonical shapes in the wind tunnel: a smooth sphere, a rough sphere, and a half sphere. However, this topic was well explained in fluids textbooks and required little to no supplemental research by the students. Prior to the start of the term, the authors examined the experiment and determined what adjustments could be made to better study information fluency. It was determined that the focus of the experiment needed to explore the physics and experimental challenges related to the study of drag but would also require students to carry out a literature search to develop the theory section of their technical reports. The result was the replacement of the spheres with model trucks with different drag reduction devices implemented. The devices were designed based on research carried out over the last decade by LLNL [17]–[21], and fabricated using a 3D printer. The students were given the same review of the fluid mechanics of drag but were expected to integrate their research regarding the drag reduction devices. This research component was expected to help identify changes and trends through the literature review process.

Figure 1. Photograph of some of the different truck models used in the experiment (left) and of students testing the model (right).

Instructional Activities

The primary goal of this study was to assess the effect of additional instructional activities developed with the goal of improving students' information fluency skills. The class was divided into a test group and a control group. The test group received additional instructional activities focusing on finding information sources and the correct use of citations. The control group did not receive the instructional activity, but were instead allocated time for additional data collection and data processing during the class period. In addition, documentation regarding information fluency, in the form of a research guide and an AIAA citation style guide, were provided to both groups on the course webpage. Students in both groups were also advised to contact the engineering liaison librarian for assistance. The class consisted of 38 students distributed over 4 laboratory sections. The two sections that made up the test group consisted of a total 19 students. The remaining 2 sections and 19 students made up the control group. To prevent unfair grade advantages associated with the experiment, grades within the control and experiment groups were normalized.

The instructional activities consisted of two class visits by an instruction librarian that occurred during the truck drag experiment (Lab B). The learning outcome for the first instructional activity was:

> *Students will be familiar with appropriate information formats and sources in order to complete the theory section of their lab report.*

Students were asked to first individually brainstorm the types of information they would need to find to complete the theory section of their lab report. Students then used this list to participate in a class discussion. The class identified the top three concepts that should be researched for their lab report. Students were then split into groups and asked to search using one of three different tools. The first group was instructed to search using Google or any other search engine of their choice. The second group was instructed to search the library catalog. The third group was instructed to search grey literature databases (NASA PubSpace, National Technical Reports Library, Science.gov, and TRAIL: Technical Report Archive & Image Library). Students reported back the best information source they could find for each research topic and search tool (see Appendix A). A class discussion focused on how students found the information source, why students chose the information source, why the information source was authoritative, and which information sources seemed most likely to be helpful for their lab report.

The learning outcome for the second instructional activity was:

> *Students will be able to create correct AIAA citations in order to ethically use information in their lab reports.*

For the second instructional activity, the librarian started with a brief overview of what style guides are, why they are used, and some examples of style guides they may have already used. Students were pointed to the online location of the AIAA citation style guide and given a recent journal article using the AIAA style as an example. Students were split into groups of two or three for a citation competition. Each group was given six consecutive citation tasks. Upon completion and verification of correctness by the librarian or instructor, the group was given the next task. The first group to complete all six tasks correctly was the winner. The citation tasks were 1) create a citation for the provided book, 2) create a citation for the provided journal article, 3) create a citation for the provided technical report, 4) write a sentence about the technical report using an in-text citation at the end of the sentence, 5) write a sentence about the journal article using an in-text citation using the authors name in the sentence, and 6) write a figure caption for the provided image. Students were allowed to use any tools (print or online) that they wished to complete the tasks as long as the resulting citation was accurate and correct in format. However, during one of the lab sessions, the campus lost electricity and students completed the competition without the use of computers or online tools.

Assessment

At the beginning of the semester, all students enrolled in the course were asked to voluntarily complete a pre-survey that measured their attitudes and confidence in research skills as well as tested their knowledge of information fluency concepts. In addition, the report from Lab A was scored against an Information Fluency Rubric. The results of these two methods of data collection determined a baseline of information fluency skills demonstrated by the participants. At the end of the semester, all students enrolled in the course were asked again to voluntarily complete the second half of the original survey testing their knowledge of information fluency concepts. In addition, the report from Lab B was scored against the same Information Fluency Rubric to determine any improvement of information fluency skills by participants.

Survey

The Research Practices Survey (see Appendix B) was given to students with goals of a) measuring student experience and perception of information fluency, and b) assessing basic conceptual skills regarding information fluency. The survey was adapted from the 2016-2017 HEDS Research Practices Survey [22]. The survey was divided into two sections. The first section was designed to measure the students' experiences, research expectations in their coursework, and perception of the research and citation process. This part of the survey was administered only prior to the instructional activity. The second half of the survey consisted of multiple choice questions regarding research strategies and ethical use of information. These questions, with right and wrong answers, provide a quantitative measure of the students' skills. The second section of the survey was administered prior to the instructional activity as well as after the instructional activity during the final week of classes. In terms of the course timeline, the first survey was given just before the submission of the report for the airfoil experiment (Lab A), while the second survey was given just before the submission of the report for the truck drag experiment (Lab B).

Rubric

Previous studies have questioned the accuracy of self-reported perceptions of information fluency skills [9], [10], [23], so this study aimed to also include an assessment method that measured information fluency skills in student assignments. Evaluating student work with a rubric is a more valuable measure of student success than self-reported methods [12]. Rubrics have been adopted as an assessment tool for information fluency because they provide detailed criteria that improve the objectivity and consistency in application to student work [12], [24]. In addition, the creation of a rubric can create consensus among faculty and librarians when determining objective measures that indicate student success [12], [24]. Using rubrics to assess information fluency skills in engineering students has been used previously. Phillips, Lucchesi, Sams, and van Susante [25] used a rubric to evaluate student bibliographies in a junior-level Engineering Design Processes course. The rubric results led to revisions of librarian instruction to include more focus on search strategies instead of specific source formats. They found an increase in quality sources with the modification to instruction.

The rubric used in the assessment of the students' reports (see Appendix C) was modeled after previous studies [15], [25], as well as the AACU Information Literacy VALUE Rubric [26]. The rubric was used in scoring the quality of sources and ethical use of information in the students' reports for both Lab A and Lab B. The intent was to gather data before and after the instructional activities to provide a metric for developing correlations between the instructional activity and student performance. The scoring was completed by the librarian without knowledge of whether the student was in the test or control group.

Results and Discussion

The results from the experiment are broken up into three data sets. The first data set consists of the results of the student self-assessment survey that was given prior to the instructional activities. The goal of this data was to provide perspective of the students' experiences with the research process and their self-assessment of their capabilities, particularly regarding the process of finding sources and using them ethically in their own work. The second data set was from the assessment of student skills from the multiple-choice questions in the areas of search strategies, assessment of the quality of sources, and ethical use of information. This assessment was given both prior to and after the instructional activities to gauge overall understanding of these areas. The last data set was from the rubric-based assessment of the students' writing samples before (Lab A) and after (Lab B) the instructional activities. This data set serves as an assessment of students' abilities to implement the aforementioned strategies and practices in a laboratory report submitted for a grade.

Student Self-Assessment

The purpose of the student self-assessment data was to help gauge how much research was a part of their coursework, the methods they were using for the research process, and their assessment of their skills in the process. As a starting point, it was useful to determine how often the students have had assignments where a literature search and citations were required. Students were asked how many assignments over the last year required three or more sources. The results (Figure 2) showed that 86% of students had at least two assignments and almost half (47%) had at least five assignments due with that requirement. Over the last year, the students were enrolled in a mixture of engineering courses and elective courses, such as upper division humanities or engineering ethics. Students were also asked about the frequency at which they used the library in their research process. The results, shown in Figure 3, were divided into frequent and infrequent users. The frequent users would be considered those who used the library monthly (11%) or weekly (31%), while the infrequent users would be considered those who responded that they only use the library once or twice a year (39%) or never use the library (19%). When comparing responses to both questions, 58% of students with two or more assignments requiring three sources used the library infrequently. This suggests that the majority of students were not using the library as a part of their research process.

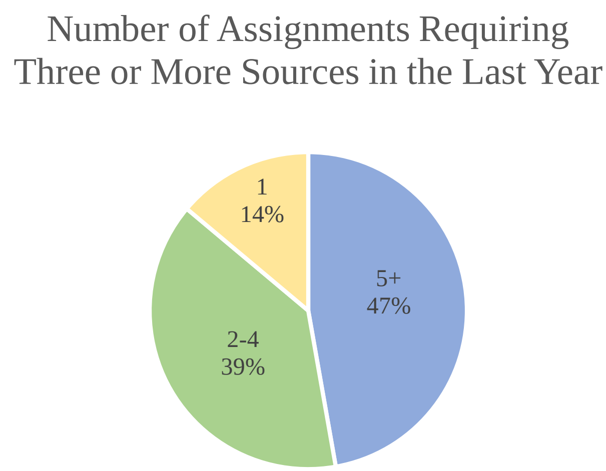

Figure 2. Percentage of students' who had research expectations of three or more sources in their coursework in 1, 2-4, or 5 or more assignments.

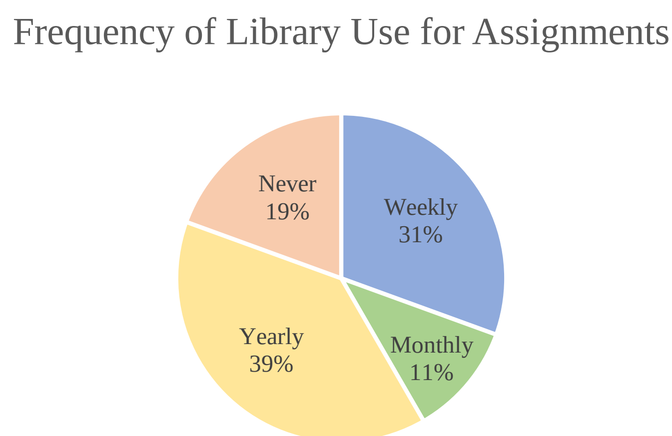

Figure 3. Percentage of students that have used the library for their assignments on a weekly, monthly, yearly or infrequent basis.

The logical follow up was to determine what sources students were using and exploring why they were not be using the library. As discussed earlier, the expected results was that much of their research centered on internet searches. The findings from the survey agreed well with the literature. For example, when the students were asked which search tools they used for their research (Table 1), the two most popular responses were web searches (86%) and Wikipedia (53%). Interestingly, only 28% of respondents used Google Scholar, which is web-based as well, but in theory should provide sources of higher quality on average. In addition, only 28% of respondents used the library catalog, which was consistent with the library usage statistics discussed earlier.

Table 1. Percentage of affirmative student responses to the question, “When you did research in the past year, which of the following search tools did you use to find sources?”

Search Tool	**% of Population**
Web Search	86%
Wikipedia	53%
Online Booksellers	42%
Library Catalog	28%
Google Scholar	28%
Online Index or Database	17%
Other	14%

The next question explored were the attitudes toward the perceived difficulty of using the library as compared to other research methods. In the survey, the students were asked to score different methods on a scale of 1-4, where 1 was very difficult and 4 was very easy. The results (Table 2) show that students, on average, considered using an internet search engine as very easy (3.75). Conversely, students considered library related activities, such as using the library catalog or locating an item in the library, as somewhat difficult, scoring 2.06 and 1.69 respectively. Of all the tasks, the most difficult was using a database, with a score of 1.28. These results quantitatively reinforced the reasoning behind the students’ preferences for internet searches. It also posed the question of how much change in library usage would occur by changing these perceptions.

The data from Table 2 also illustrated the students’ perception about the challenge involved in the search for sources, assessment of source quality, and the citation process. Regarding the search for sources, the students on average tended to find the process to be neutral with a slight tendency toward the somewhat easy. The students’ average score for the challenge of deciding the applicability of sources was 2.61 while deciding the credibility of the sources was similar at 2.67. This suggested that while the students have some concerns regarding the process of assessing sources, they still found that process to be considerably easier than the library experience. The students perceived the citation process to be somewhat easy, with scores of 3.00 for knowing how to cite and 2.94 for knowing when to cite. In the survey, the students were also asked to rate the challenge of the citation process overall as compared to the paper writing process. A breakdown of the student responses (Figure 4) shows that 44% found the citation process somewhat easy and another 20% found the process to be very easy. The self-assessments provided the student perspective on the research process, which could then be contrasted against the student skills assessment and writing sample assessment to help gauge the accuracy of that perception.

Table 2. Perception of the level of difficulty in the activities associated with the research writing process sorted from easiest to hardest.

Process	**Score**	
Using an internet search engine	3.75	Easiest
Knowing how to cite	3.00	
Knowing when to cite	2.94	
Determining the credibility and applicability of a source	2.67	
Deciding what information from sources are applicable	2.61	
Obtaining full text of online source	2.46	
Locating items in the library	2.06	
Using the library catalog	1.69	
Using a database	1.28	Hardest

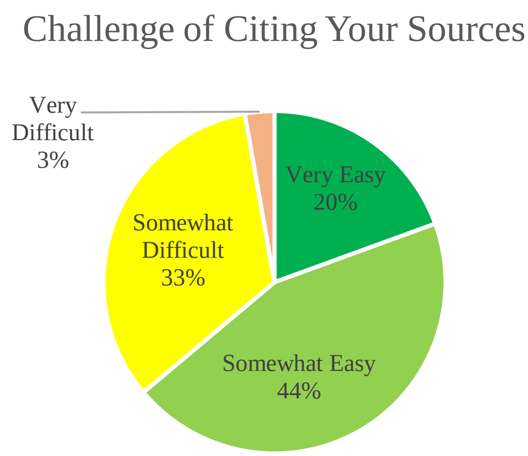

Figure 4. Percentage breakdown of students' responses to the challenge in developing their citations.

Student Skills Assessment

The student skills assessment gauged the students understanding of basic ideas associated with the literature search and ethical use of information. The multiple-choice questions were scored for correctness and aggregated into three categories: search strategies, assessing quality of sources, and ethical use of information. Table 3 shows the percentage of correct responses provided by the students in each of the groupings. The overall scores from this assessment showed agreement with the results from the students' self-assessment. The scores in the ethical use of information before the instructional activity were relatively high at 89.7% and 74.3% for the test and control group respectively. This was consistent with the students' assessment that knowing when and how to cite was a relatively easy process. The lower scores, ranging from 58.9% - 69.5%, in the categories related to the search process were consistent with the lower confidence in the search process seen in the self-assessment.

To help assess the effect of the instructional activity, it was useful to examine the changes in overall performance before (pre) and after (post) the instructional activity. The largest improvement following the instructional activities were seen in the search strategies assessment. Both groups started from approximately the same point (60.0% for the test versus 58.9% for the control), however, the test group showed a significant improvement (13.7%) as compared to the control group (3.2%). These results suggest that the instructional activities may have helped in their search mechanics. Although the activity did not explicitly address the answers to this set of questions, having guidance in their research process initially may have helped improve their search process for their lab report and ability overall.

When examining the assessment data on the quality of sources and the ethical use of information, the trends were not as strong. The first item to note was that the test group's initial performance was on average higher compared to the control group. The test group was 9.5% higher in assessing the quality of sources and 15.4% higher in the ethical use of information. Comparing the change in scores before and after the instructional activity, there was little change in performance from the test group. However, the control group saw a substantial drop in performance in both assessing quality of sources (-8.4%) and the ethical use of information (-14.4%). The researchers took a closer look at the data and the conditions of the survey to help rationalize some of these trends. The lack of change in the ethical use of information of the test group was not necessarily that surprising considering that they answered 90% of the questions correctly in the beginning. This limited the amount of improvement and suggests that most of the students in the group had a good understanding of the ethical use of information in principle. Regarding the drop in the control group's scores, one factor could have been an environmental factor outside of the experiment. The post survey was given during the final week of classes, when the students may have been additionally fatigued given the deadlines for assignments due the last week (like the lab report for this class). In addition, when this assessment was given, the students also completed other surveys and assessments for a closing activity, which the students were more interested in. These factors may have negatively impacted their performance and may contribute to the drop in the control group and lack of change in the test group. As a result, no definitive connections could be made about the instructional activity from this data set.

Table 3. Results from the assessment of student research skills before and after the instructional activities.

	Test			**Control**		
	Pre	**Post**	**Change**	**Pre**	**Post**	**Change**
Search strategies	60.0%	73.7%	*13.7%*	58.9%	62.1%	*3.2%*
Assessing quality of sources	69.5%	69.5%	*0.0%*	60.0%	51.6%	*-8.4%*
Ethical use of information	89.7%	90.2%	*0.5%*	74.3%	59.9%	*-14.4%*

Rubric-Based Assessment of Writing Samples

The final assessment method was the scoring of the students' laboratory reports for the assignment prior to and after the instructional activities. Using the rubric discussed in the Assessment section, the students were graded in two categories: quality of sources and ethical use of information. The former measured the students' ability to carry out a literature search and select sources that would be of appropriate quality for a technical report. The latter measured the ability to properly use citation and references in accordance with the AIAA standards used in the class. A rubric was used to assign scores of 0-4 with a score of 4 indicating exemplary implementation, 3 indicating proficient implementation, 2 indicating developing implementation, 1 indicating emerging implementation, and 0 indicates failure to implement.

The results for the quality of sources in the writing sample assessment (Table 4) show significant improvement in the quality of sources used in the test group as compared to the control group. Both groups initially scored between emerging and developing with scores of 1.47 for the test group and 1.29 for the control group. However, by the second laboratory report, the test group improved to the level of developing while the control group remained in between emerging and developing. The test group saw a statistically significant improvement of 0.60, $t(14)=1.87$, $p=0.041$, while the control group's change of 0.24 was not statistically significance ($t(16)=0.70$, $p=0.25$). The data appears to support the hypothesis that the instructional activities improved the students' quality of sources.

Table 4. Assessment results for the quality of sources for laboratory reports submitted before and after the instructional activity.

Quality of Sources	**Pre**	**Post**	**Change**
Test	1.47	2.07	*0.60*
Control	1.29	1.53	*0.24*

Individual changes in score from the reports before and after were examined as well. The net change in score for each student was tracked and the aggregate results for the test and control group are shown in Figure 5. The chart shows that 60% of the students in the test group showed improvement while 41% showed improvement in the control group. In fact, 27% of the test group showed substantial improvement, defined as an increase in score of 2 or more, as compared to 12% in the control group. Interestingly, both groups had roughly the same percentage (20% for the test group versus 18% for the control group) of students who had lower scores. This supports the relationship between the instruction and the improvement in the quality of sources. Recall that the test group had a dedicated exercise with a librarian that was committed to helping the students start their research process. The control group did have access to the compiled results that the test group found but were given no supplemental instruction. This may contribute to the improvement in the control group.

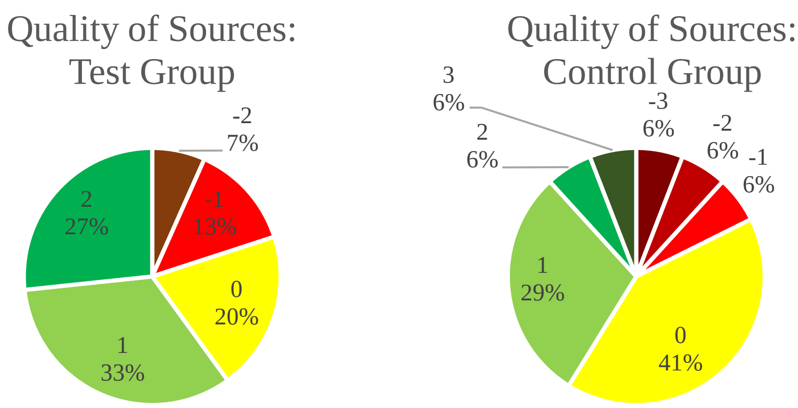

Figure 5. Change in quality of sources scores before and after the instructional activity for the test group (left) and control group (right).

The data from the ethical use of information assessment (Table 5) did not show a distinguishable trend when comparing the test and control groups. The first thing that stood out was a significant difference in the pre-activity scoring between the test and control groups. The test group scored on average between developing and proficient at 2.53, while the control group scored below developing at 1.82. Both groups improved by the second scored reports, with the test group scoring in the proficient category (3.13) and the control group scoring between the developing and proficient categories (2.47). The test group saw a mean improvement in score of 0.60 , $t(14)=4.58$, $p=0.00021$, while the control group saw a mean improvement in score of 0.65, $t(16)=3.09$, $p=0.0035$. The data show that both groups did make statistically significant improvements in their ethical use of information scores. Looking at the breakdown of individual student improvement between the two groups (Figure 6), there was a slight difference in the number of students that showed improvement at 60% for the test group compared to 47% for the control group. Given the data, it was difficult to definitively identify the specific factors responsible for this improvement. Both groups may have benefitted from the additional resources provided on the course webpage, feedback from earlier reports in the course, and sharing of information within the peer group. Further study would be required to quantify the improvement due to the instructional activities alone.

Table 5. Assessment results for the ethical use of information in laboratory reports submitted before and after the instructional activity.

Ethical Use of Information	**Pre**	**Post**	**Change**
Test	2.53	3.13	*0.60*
Control	1.82	2.47	*0.65*

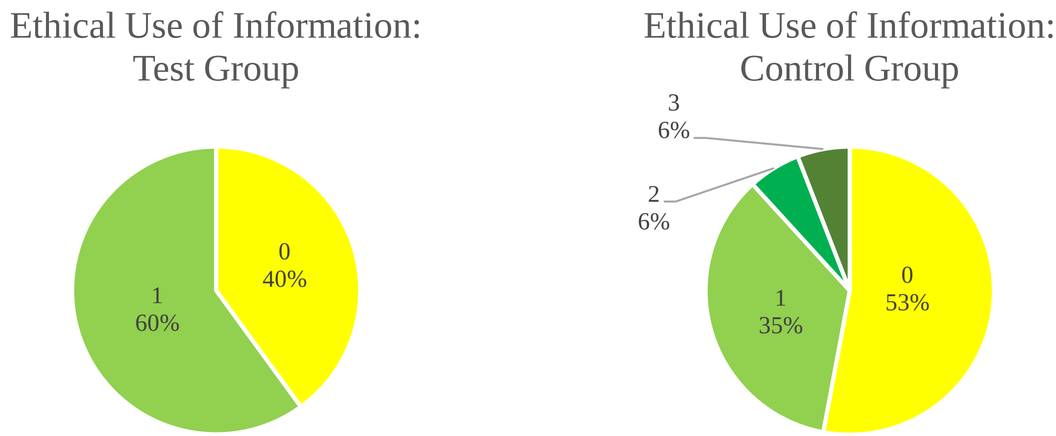

Figure 6. Net change in ethical use of information scores before and after the instructional activity for the test group (left) and control group (right).

Conclusion

The results of this study confirmed that students who received dedicated instruction from a librarian during a laboratory session demonstrate improvements in information fluency skills in their course assignments. The increases in the search strategies scores and quality of sources scores from the test group supports the addition of the library instructional activity in similar senior-level capstone laboratories. The improvements seen in both the test and control groups with regards to the ethical use of information may suggest that the promotion of assignment specific research guides created through a collaboration with the instructor and librarian could be valuable even without in-class instruction. This could work well for courses that have limited ability to adjust the curriculum, but where the students need improvement in sources or ethical use of information.

However, there are factors to be considered before attempting implementation of information fluency instruction. An initial assessment should be used to help focus the instructional activities. The disparity in the control and test group demonstrated the amount of variation within a small population. The initial assessment can identify where students' performance was sufficiently high enough that the activities in certain skills may yield little return on the instructional time invested. Another recommendation based on the study would be earlier implementation of library instruction in the term. This would allow for more time for students to hone their information fluency skills and could potentially address some of the performance "fatigue" seen in the control group in certain areas of the study.

For senior laboratory courses where there is a research component, the work presented in this paper provides quantitative evidence that would encourage dialogue and potential collaboration between engineering librarians and mechanical engineering faculty. For the course in this study, the plan for next year will be to use these instructional activities again. It also has started the discussion of where additional library collaboration earlier in the mechanical engineering program would be appropriate and beneficial. This additional exposure and training will build familiarity with information fluency skills, which may be perceived as difficult, but are essential in the professional environment.

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Appendix A: Student In-class Search Results

Topic 1: Semi-Truck Aerodynamics

Google (or other search engine) results

https://www.tc.gc.ca/media/documents/programs/AERODYNAMICS_REPORT-MAY_2012.pdf

Cal Maritime Library website results

http://www.sciencedirect.com/science/article/pii/S1877705813004621

Gray Literature and Technical Reports results

https://www.osti.gov/scitech/servlets/purl/1158764

Topic 2:| TRUCK FAIRINGS

Google (or other search engine) results

http://publications.lib.chalmers.se/records/fulltext/133659.pdf

Cal Maritime Library website results

http://www.sciencedirect.com/science/article/pii/S1877705813004621

Gray Literature Technical Reports results

Topic 3: Truck Coefficient of Drag

Google (or other search engine) results

https://www3.nd.edu/~tcorke/w.Truck_papers/DOE_slides.pdf

Cal Maritime Library website results

https://ac.els-cdn.com/S1877705813004621/1-s2.0-S1877705813004621-main.pdf?_tid=92dc9874-c5a2-11e7-bea9-00000aab0f26&acdnat=1510268949_3ee834ffc02ece8c305eb39b22808d2c

Gray Literature and Technical Reports results

https://www.nasa.gov/centers/dryden/pdf/88628main_H-2283.pdf

Appendix B: Research Practices Survey

Research Practices Survey

This survey explores the experiences and opinions of college students concerning research. Its purposes are to (1) study students' research experiences, (2) use these findings to improve the ways we help students develop their research skills, and (3) determine what changes occur in research abilities as students progress through their academic careers.

Your participation is completely voluntary, and there are no penalties if you decide not to participate or if you choose to skip any questions. All of your responses will be kept strictly confidential. Your responses may be linked to institutional records for research purposes, but at no time will your response be publicly linked with your name or with any other identifying information.

Your experience with research

The following questions ask about your library usage and experiences with research. Research refers to any project or task that requires you to investigate sources. Research can include course assignments, internship work, independent study, personal research, etc.

1. In the past year, how did you use your library? (circle all that apply)
    a. Recreation (fun reading, visiting friends, etc.)
    b. Conducting research for school assignments
    c. Doing other school work (studying, doing homework)
    d. Other
    e. I did not use a library in the past year
2. How often in the past year did you use resources from a library (in-person/print or online) for a school assignment or project?
    a. Once a week or more
    b. Once or twice a month
    c. A few times a year
    d. Never
3. In the past year, did an instructor or a librarian talk with one or more of your classes about how to use library resources, including Internet resources?
    a. Yes
    b. No

4. When you did research in the past year, which of the following search tools did you use to find sources? (circle all that apply)
    a. Library catalog (whether print or online)
    b. Online booksellers (Amazon.com, BarnesandNoble.com, etc.)
    c. Online indexes or databases (JSTOR, Academic Search Premier, ScienceDirect, etc.)
    d. Google, Yahoo Search, or other general search engines
    e. Google Scholar
    f. Wikipedia
    g. Other
    h. I did not use any search tools for research in the most recent year
5. When you did research in the past year, what types of sources (whether print, electronic, or online) did you use? (circle all that apply)
    a. Books/eBooks
    b. Encyclopedias or dictionaries
    c. Academic journals
    d. Course readings
    e. Audiovisual resources (e.g., music, videos, sheet music, artwork, graphic novels)
    f. Newspapers or magazines for the general public
    g. Other
    h. I did not use sources for research in the most recent year
6. In general, how much do you enjoy doing research?
    a. Very much
    b. Some
    c. Very little
    d. Not at all

Your course assignments

The next questions ask about your course assignments. Assignments refer to any tasks assigned by instructors. Assignments include papers, regardless of length, presentations, projects, posters, lab reports, etc.

7. How many research papers or projects have you completed in the past year that required you to include at least three sources in a Bibliography, References, or Works Cited list?
    a. Five or more
    b. Three or four
    c. One or two
    d. None

8. In the past year, how often were you required to use a specific format (APA, MLA, other) for citing sources for an assignment or project?
    a. Five or more projects
    b. 2-4 projects
    c. 1 project
    d. No projects
9. In the past year, when you were working on assignments that required citations and sources, how often did you seek help or advice from each of the following?

	Always	Often	Sometimes	Rarely	Never
Professors, teachers, or other instructors					
Librarians					
Parents or adult family members					
Friends, classmates, or siblings					
Writing labs or centers					
Online educational resources (Purdue OWL, Khan Academy, library guides, etc.)					
Software help screens					
Other					

Your Perceptions of Research

10. How challenging are the following components of research for you?

	Very easy	Somewhat easy	Somewhat difficult	Very difficult	No experience
Selecting your topic					
Using search tools to find possible sources					
Developing your main argument or thesis statement					
Using evidence from your research to support your argument effectively					
Citing your sources					
Writing the paper					

11. How challenging are the following activities for you?

	Very easy	Somewhat easy	Somewhat difficult	Very difficult	No experience
Using a library catalog (whether print or online)					
Using a database (JSTOR, Academic Search Premier, ScienceDirect, etc.)					
Using an Internet search engine					
Locating physical items in the library					
Obtaining full text of online sources					
Determining whether a source is credible and appropriate for an academic project					
Deciding what information from your sources to integrate into your project					
Knowing when you need to cite a source in text and in a bibliography					
Knowing how to cite a source in text and in a bibliography					

Your familiarity with research terms and strategies

In this portion of the questionnaire, some of the terms and concepts may be familiar to you, but others may not. Based on your knowledge of these concepts, try to select the correct answer, and feel free to use the "Don't know" response wherever appropriate.

12. You are researching renewable energy sources. What would you type into a database to yield the most RELEVANT sources for your topic?
    a. renewable OR energy
    b. renewable AND energy
    c. renewable NOT sustainable
    d. renewable INSTEAD OF climate change
    e. Don't know
13. You are searching for articles on any of the following U.S. car companies: Ford, General Motors, and Chrysler. What would you type into a database search to yield the LONGEST list of relevant sources for your topic?
    a. Ford OR General Motors OR Chrysler
    b. Ford AND General Motors AND Chrysler
    c. Ford NOT General Motors NOT Chrysler
    d. Ford OR General Motors INSTEAD OF Chrysler
    e. Don't know
14. If you type "eng*" into a database, what types of search results would you likely get?
    a. Articles that only focus on engines
    b. Articles written only by engineers
    c. All articles that contain terms such as engine, engineer, and England
    d. Articles relating only to the engineering major
    e. Don't know
15. Using a database search, you find the following article that is relevant to your lab report focusing on drag reduction:

    Yang, & Ding. (2013). Drag reduction induced by polymer in turbulent pipe flows. *Chemical Engineering Science, 102*, 200-208.

    Which of the following would most likely generate the largest list of additional relevant sources for your project?
    a. Examining the articles references
    b. Browsing this volume of *Chemical Engineering Science* for another article about drag reduction
    c. Searching for more articles by this author
    d. Locating the physical copy of the article in the library and scanning the shelves nearby
    e. Don't know

16. You have selected green technologies as your topic for a ME394 research paper. Which of the following would likely yield the most comprehensive list of scholarly articles that are relevant to this topic?
    a. Searching an electronic index or database related to the engineering (Engineering Village, ScienceDirect, etc.)
    b. Using a general Internet search like Google or Yahoo
    c. Paging through print volumes of academic journals in chemistry
    d. Searching the library catalog for sources available in the library
    e. All of the above are equally effective
    f. Don't know
17. Which of the following is TRUE of articles in scholarly journals?
    a. Only include factual information by experts
    b. Only include information not biased by author
    c. Go through a peer-review process
    d. Almost always free of charge online because scholarly
    e. Don't know
18. Which of the following statements is true of Internet search engines?
    a. They display all of the websites that are most relevant to your search topic on the first or second page of results.
    b. If they are all searched using the same terms, they will produce the same results
    c. They are generally run by not-for-profit organizations
    d. They include the option to narrow a search by domain as a means of restricting authorship
    e. Don't know
19. A *peer-reviewed* journal is best described as:
    a. A journal that publishes reviews of other journals
    b. A journal that publishes articles that have been approved by other scholars
    c. A journal that only includes articles written by peers
    d. A journal that includes references for each article it publishes
    e. Don't know
20. You are researching environmental effects of fracking. Which of the following websites likely does NOT contain biased information?
    a. Environment America (http://environmentamerica.org)
    b. Greenpeace (http://www.greenpeace.org)
    c. Investopedia (http://www.investopedia.com)
    d. Conserve Energy Future (http://www.conserve-energy-future.com)
    e. All of the above websites likely contain biased information
    f. Don't know

21. You are required to write a research paper for your American history class examining the role of radar in 20th America. An initial search turns up the following sources. Which source is LEAST likely to be appropriate to cite in your paper?
    a. Buderi, R. (1996). *The invention that changed the world: How a small group of radar pioneers won the Second World War and launched a technological revolution* (The Sloan technology series). New York: Simon & Schuster.
    b. Radar. (2008). In K. L. Lerner & B. W. Lerner (Eds.), *The Gale Encyclopedia of Science* (4th ed., Vol. 5, pp. 3582-3585). Detroit: Gale.
    c. *Harbor View: Radar Training at MIT, 1941-1945: Exhibits: Institute Archives & Special Collections: MIT. (2017).* MIT Institute Archives & Special Collections. Retrieved from http://libraries.mit.edu/archives/exhibits/radar-school/index.html
    d. Hindle, P., Mumford, R., & Lerude, G. (2017). The Infamous Pearl Harbor Radar. *Microwave Journal*, *60*(5), 26-38.
    e. Jain, P. (2017). *What is RADAR Technology*. Retrieved from https://www.engineersgarage.com/articles/what-is-radar-technology
    f. Don't know
22. I must cite the information I used in a class paper, project, or presentation IF: (Circle all that apply)
    a. I reprinted an author's exact words
    b. I read an article but didn't mention it in my paper
    c. I paraphrased the words of an author
    d. I referred to a work but did not quote from it
23. A citation is NOT required when:
    a. You are paraphrasing , rather than quoting, a source
    b. More than one source says the same thing
    c. You are stating a fact that is common knowledge
    d. All of the above
    e. Don't know

24. Indicate if each of the following statements about plagiarism is TRUE or FALSE.

	True	False	Don't know
If you paraphrase (use your own words to describe) the main idea of an article, you do not need to cite the article.			
You only need to document text sources; you do not need to document sources for graphs, tables, or charts.			
You only need to provide documentation for a book or an article when you quote it word for word.			
You can copy another author's text without using quotation marks if you cite it in the bibliography, references, or works cited list.			
A family member or friend can write parts of your paper for you as long as they use your own ideas.			

25. Do you give your consent to allow the use of your class assignments to evaluate student research skills? (Your name will be removed or redacted from your assignment before it is released to researchers).
    a. Yes
    b. No

Appendix C: Rubric

Information Fluency Rubric

	None (0)	Beginning/Emerging (1)	Developing (2)	Proficient/Competent (3)	Exemplary/Strong (4)
Quality of Sources	Unable to differentiate between relevant and irrelevant information sources. Sources are mostly from general websites. For example: Uses webpages exclusively.	Sources cited are not clearly related to the topic, and/or show very little breadth, i.e. many sources are from the same journal or web site or are from very general web sites and/or non-refereed articles. Reliability, validity, accuracy, authority, purpose, currency, and relevance are not considered. For example: Uses at least one technical report, journal article or book. Some webpages are not industry appropriate	Is able to find some relevant sources, but includes irrelevant sources in the bibliography. Rarely evaluates information for reliability, validity, accuracy, authority, purpose, currency, and relevance. Many sources are not authoritative. Sources not balanced. For example: Uses at least one technical report, journal article or book. All webpages are industry appropriate	Demonstrates the ability to distinguish between relevant and irrelevant information (based on the topic). Does not always evaluate sources for reliability, validity, accuracy, authority, purpose, currency, and relevance. Sources not always balanced. For example: Uses only technical reports, journal articles and books as sources. Uses at least one of the information types.	Able to analyze information sources based on reliability, validity, accuracy, authority, purpose, currency, and relevance as demonstrated through sources cited in the bibliography. Sources are balanced and mostly authoritative resources. Uses only technical reports, journal articles and books as sources. Uses at least two of the information types.
Access and Use Information Ethically	Does not cite sources.	Fewer than 3 references are listed or listed references are not cited in-text.	3-5 references are listed, but not all are cited in-text.	3-5 references are listed and all are cited in-text, but some or all are not in required format.	3-5 references are listed in required format and are cited properly in-text.