Capstone Design CONFERENCE 2026
JUNE 1–3, 2026 ▶ COLLEGE STATION, TX

Guiding Background Research in Engineering Capstone Design through Information Literacy

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A dedicated class module with a guided exercise in Information Literacy was developed for a two-semester Industrial Engineering (IE) Capstone sequence. It was used to introduce students to tools and techniques for background research in the middle of the first Capstone term. The exercise was based on a Design Information Audit developed at Purdue University and was customized to meet the unique needs of IE Capstone. The module contents and exercise evolved over five years from a simple introduction to research methods into a guided set of activities focused on each capstone team's individual research needs. Students reported they learned a lot from the session, it was helpful to their projects' success, and they were confident they had the knowledge they needed to complete their background research after the exercise. An assessment of the students' success in acquiring and applying knowledge from outside the classroom made by alumni juries at the end of the second term of capstone showed a modest improvement over the period studied.

Keywords: Background Research; Information Literacy; Exercise; Assessment

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Introduction

The undergraduate program in the Mechanical and Industrial Engineering Department at Northeastern University requires a 2-semester Capstone sequence. The Industrial Engineering (IE) cohort offers Capstone 1 in the Summer 1 and Fall terms. In Capstone 1, students are matched with faculty advisors and capstone problems, define their solution approaches, and conduct necessary background research and other preliminary and planning work. The bulk of the work is carried out in Capstone 2, which all students take in Spring.

In Capstone 1 the student teams are expected to do a thorough background search and literature review. They are expected to understand the context and scope of their problem; find relevant existing solutions, best practices, and ongoing research; and educate themselves in the techniques, technologies, and tools that they need to form their own solutions. Each project has its own mix of needs, so it is impossible to define a rigid template for this work.

Five years ago, the students in IE Capstone were only given a brief introduction to the concept of background research. General expectations were set, and students were provided with a list of resources, including the availability of library resources and the engineering librarians. It was observed that students generally did not take advantage of these assets.

In the Fall term of 2021, the engineering librarian (J. Bolognese) offered to work with the Capstone leadership to improve this situation. She was invited to deliver a class module on techniques and available resources expressly related to Capstone research. This module evolved over the following few years into an active session with an exercise that launched the students' background research. It was customized to each project's individual needs, and included active mentoring and feedback by the librarian and the course leaders. In this paper, we define the basis of the module and its activities, trace the evolution of the class session, and present evidence that the method is helpful, interesting to the students, and effective.

Background

Gathering and using information, i.e. information literacy (IL), is an integral part of the engineering design process.[1] Capstone design projects are the key point in the undergraduate engineering curriculum in which students practice and develop these skills in context.[2] The limited research on application of IL skills in engineering design courses shows that students could use more support with these skills.[2-8] To address this opportunity, a team of engineering faculty and engineering librarians at Purdue University collaboratively developed and tested the Information-Rich Engineering Design (I-RED) model as a framework for intentionally integrating information into the engineering design process.[3,9] One of the tools they use is the Design Information Audit.[9] This has been a useful starting point for developing additional IL support for IE students in their first Capstone semester at Northeastern University.

Development

Based on the framework in Fosmire's Design Information Audit worksheet (Figure 1), capstone professors and the engineering librarian collaborated to create a customized template for background research for IE Capstone Project**s,** referred to hereafter as "the guide."

The professors' subject matter expertise provided critical input on what's most important in industrial engineering projects, including types of information, sources, and tips. Language was reviewed and edited to be consistent with the vocabulary of industrial engineers, and project examples from previous semesters helped the librarian generate relevant resources and examples.

This guide is the centerpiece of an in-class activity ("the exercise") designed to help students translate the overarching—and at times overwhelming—task of background research into a concrete, actionable plan.

Like the audit worksheet, the guide is organized around types of information typically included in background research for an engineering design project. These types (partially) replace the original left column of the audit sheets: **Domain Information**, **Stakeholder Needs**, **Existing Solutions/Current State of the Art**, **Materials/Components/Tools**, **Regulations and Standards**, and **Intellectual Property**. For each type of information, students are provided with questions to consider, which function as brainstorming prompts for their projects. The librarian gives a brief introduction to a type of information, illustrates with an industrial engineering project example (co-developed with the IE faculty), then gives students time to use those prompts to brainstorm for their projects – what do they already know, and what do they need to learn more about?

After brainstorming each type of information, teams share their ideas and prioritize a list of 3-5 research questions to start with for their project.

Once research questions have been identified, students are then introduced to the final element of the guide, Sources & Tips, intended to provide students a starting point for where and how to efficiently find specialized types of information. The librarian also provides context on why students can't just Google it or ask AI (i.e. the benefits of using specialized sources), tips for avoiding common research pitfalls, and an introduction to citation managers to help keep their research organized.

Over time, we've collaboratively iterated on the guide, the lesson plan, and the exercise based on both quantitative and anecdotal feedback from students and faculty. The engineering librarian is also consistently adding and updating sources and search tips as the landscape changes and she develops further expertise. Iterations are summarized in Figure 2.

In parallel, the engineering librarian has worked with capstone faculty in other disciplines (Mechanical Engineering and Bioengineering) to customize the guide and lesson plan for their respective fields and course

	Information Already Known	Evidence (i.e. Sources)	Additional Information Needed	Proposed Sources of Needed Information
Stakeholder Needs				
Foundational Information				
Best Practices				
Materials/Components				
Regulations and Standards				
Intellectual Property				

Figure 1. Design information audit. (after Fosmire, Ref. 9)

	AY 2020-21	AY 2021-22	AY 2022-23	AY 2023-24	AY 2024-25	AY 2025-26
Reference to Engineering Librarian	x	x	x	x	x	x
Engineering Librarian presentation		x	x	x	x	x
Guide to Background Research		x	x	x	x	x
Research planning activity		x	x	x	x	x
Search examples using teams' projects		x	x	x	x	x
Links to search tip tutorials				x	x	x
Team planning and tracking template					x	x
Team search time in-class						x
Guide to Background Research 2.0						x

Figure 2. Continuous improvement of capstone background research activity

contexts. Learnings from those variations and significant feedback from many students has informed subsequent iterations. Notably, (1) students do better with more structure around the research process, and (2) students see the value of tracking and sharing their research among team members. There were also indications that students found the Sources & Tips a bit overwhelming.

Current Guide

In response to student feedback, the faculty/librarian team created an updated guide with further structure around the research process. The guide was implemented as an Excel workbook with three spreadsheet tabs:

1. ***Brainstorm*** introduces the framework: types of information, the questions to consider (brainstorm prompts), and an IE-specific example to help inspire ideas. This is the template for the in-class brainstorming activity. Figure 3 shows the first row of this sheet. There is one row for each of the information types listed previously.
2. ***Plan & Track*** is where teams prioritize their research questions, divide the work, and track and share their findings. This is a blank worksheet, with column headings **Prioritized Research Question**, **Where to Search**, and **What was found: Source, Quality, and Key Takeaways**. This is intended to be a frequently-updated document for tracking research progress.
3. ***Search*** is guidance on where and how to find specialized types of information. It is broken down by types of information, where to search, tips, and tutorials, with the intent of making it easier to find what's needed. This is now a robust resource, full of references and links to on-line tutorials. Figure. 4 shows the first row of this sheet.

Customized versions were used in all three engineering disciplines starting Summer 2025. Initial feedback has been very positive, and anecdotal reports indicate that use of the guide has increased.

The full 2025 version of the IE Guide can be found at bit.ly/Guide-IE-2025. You are free to use it, although the links to Northeastern-specific resources may not work in your environment.

Evidence of Effectiveness

IE Capstone at Northeastern is driven by data-based continuous improvement. Quantitative data on student performance, student self-assessments, and feedback on class effectiveness are collected. Qualitative data (e.g. comments and text feedback) are also collected. To evaluate the success of the research guidance, student self-assessments of research skills were collected before and after the module. Students were also asked at the end of Capstone 1 how much they learned from various class sessions and activities, and if this knowledge was helpful. At the end of Capstone 1, and in the middle of and at the end of Capstone 2, the background research in class reports were graded. The report grading rubric captures both the completeness of the background research and the appropriateness of the references.[10] Finally, at the end of Capstone 2, alumni juries rate the students' ability to learn and apply new knowledge.

Figure 5 presents data from 24 individual students in the 2025 Capstone 1 cohort. They indicate their ability to conduct background research on a Likert scale from 1 (no clue) to 5 (complete mastery), before and then after participating in the research session. Highly significant ($p < 0.001$) differences are seen between the reported "before" versus "after" assessment.

Type of Information	Questions to consider	Brainstorm: what info do you already have? What do you need to learn/research?	Example: Recent capstone project on bike sharing
Domain Info	What are the elements of this domain? What concepts do we need to understand? What is the current terminology/vocabulary/ good keywords to search? What are the basic principles involved in understanding and solving the problem?		Bike sharing business Forecasting models Machine learning Behavioral elements of alternative transport

Figure 3. Example Row of Brainstorming Sheet

Type of Information	Types of Sources	Where to look	Tips	Tutorials
Domain Info	Your advisor			
	Textbook/ebooks/ reference materials	Scholar OneSearch (the library catalog)	Use the e-book filter. Books provide overviews/intro material on topics, and are a great (citable) source for general reference info. The library catalog will search across e-book databases like Knovel (used heavily by engineers in industry) and other reliable sources for this type of info.	How to find an e-book
	Review articles	Web of Science, Scopus, Google Scholar have filters for review articles.	Review articles are an excellent gateway to a new topic because they synthesize research from many sources into one article. Read it well and use the bibliography to find related sources.	How to find a review article
	GenAI tools	Tools that provide sources: Scopus AI, Scite, Perplexity, Elicit, Copilot, Gemini, Claude	GenAI (or Wikipedia) can be a good starting point for ideas, but are not authoritative enough to use at face value (or cite). Make sure you find the original source of the info they provide, and check your facts!	How do we know when to cite evidence?

Figure 4. Example Row of Search Resources Sheet

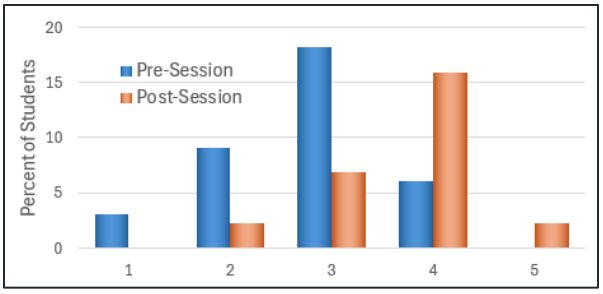

Figure 5. Student self-assessment of research capability before / after session (1 = no clue, 5 = complete mastery)

The student assessments of how much they learned and how helpful it was for their project were uniformly positive as soon as the exercise was introduced. The research module was rated in the top third of elements of the Capstone course across most semesters, with a majority of students giving it a high satisfaction rating. There was no clear trend over time in this data.

Student grades on the report writing rubrics also do not show a significant trend over time. Anecdotally, this may be at least partly due to raised expectations from the faculty based on strong student performance on the in-class research exercise.

The scores given for "*Learning and using new knowledge*" by alumni juries evaluating the students' final presentations at the end of Capstone 2 show improvement after the introduction of the exercise. The improvement is small (5%) but consistent.

Qualitatively, students have noted less frustration in starting the background research section, feeling like they have a better handle on the current state of conditions for their Capstone topic, and less difficulty overcoming inertia when composing this aspect of the first report.

From a faculty support perspective, students have shown more initiative in this area, the research has been richer and more diverse, and the ideation for solution options appears to have a wider lens when more advanced research is conducted at the outset.

Future work will evaluate the open-ended responses collected after the sessions and will specifically outline the lessons learned and tools acquired by the students.

Summary

A class module with an exercise in information literacy, using a guide in the form of an Excel workbook, was developed by a team of capstone leaders and an engineering librarian. It was iteratively improved over five years. It has been successfully used to launch engineering capstone students' background research efforts in several departments at Northeastern University.

The specific module used by the IE cohort is described in this paper. The full guide used in the module may be downloaded for your evaluation and possible use.

The structured IL module significantly improved students' perceived research capabilities and confidence. Students reported highly significant improvements in their ability to conduct background research and rated the module highly for satisfaction and usefulness. Alumni juries evaluating final capstone presentations showed a modest but consistent 5% improvement in scores for "learning and using new knowledge" after the introduction of the module. Qualitatively, students experienced less frustration starting their research, demonstrated more initiative, conducted more diverse research, and generated solution ideas with a wider lens, while faculty observed that students had a better handle on the current state of their capstone topics and overcame inertia more easily when composing their background research sections. Future work will evaluate learning themes from the IL modules.

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