

## **BOARD #144: Electronic-Resources for Engineering Formation (e-REF): An Open Educational Platform for Student and Professional Engineers**

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# **WIP: Electronic-Resources for Engineering Formation (e-REF): An Open Educational Platform for Student and Professional Engineers**

## **Abstract**

This Work in Progress Evidence-Based Practice paper aims to present the electronic Resources for Engineering Formation (e-REF).

Engineering is grounded in the principles of science and mathematics, yet the ability to communicate effectively through writing remains equally vital for its advancement. In today's engineering practice, professionals must be proficient not only in technical skills but also in retrieving and evaluating reliable sources of information such as journal articles, patents, books, and industry standards. These competencies are critical in addressing engineering problems and ensure solutions are built upon accurate, peer-reviewed, and reliable information. Additionally, the importance of creating structured formats for collecting and analyzing data—such as spreadsheets and experimental outlines—remains a challenge for many students as they transition into the professional environment.

While Open Educational Resources (OER) have demonstrated significant potential to enhance engineering education, the adoption of these resources remains limited, despite the growing awareness among educators. Many instructors lack familiarity with the breadth of existing resources and are unsure how to contribute effectively to the OER ecosystem. OER provides the opportunity to improve educational quality, promote knowledge sharing, and enable the reuse and adaptation of materials across institutions. However, there are still challenges to overcome, particularly in terms of fragmented efforts, the limited availability of resources for upper-division courses, and the need for better discoverability and interoperability.

The Engineering First-Year Program serves approximately 2,000 students who are exploring 18 different majors within the College of Engineering. These students are introduced to foundational knowledge in their majors, alongside key policies and strategies for navigating their academic and professional paths. To support these students as they engage with complex engineering problems and documentation, we have developed the electronic Resources for Engineering Formation (e-REF).

e-REF is an innovative educational strategy designed to provide students with continuous access to a reliable and comprehensive repository of information. This resource emphasizes key areas such as note-taking and document management in engineering, including patents, standards, and journal articles. Furthermore, e-REF covers essential skills like conducting comprehensive literature reviews, managing citations, utilizing artificial intelligence (AI) in research, and understanding the available programming languages and tools relevant to engineering practice. e-REF provides tutorials and information to develop detailed data summaries using spreadsheet software and its integration with advanced programming tools.

To evaluate the effectiveness of e-REF, we will implement two survey instruments—pre-course and post-course—to gauge the students' familiarity with these topics before and after using the resource. Approximately 500 students enrolled in the “Introduction to Engineering and Problem Solving” course will participate in the study. The students will be divided into two groups: Group A will have access to

e-REF as a continuous resource throughout the semester, while Group B will receive similar instruction but rely solely on materials provided through the learning management system. The surveys will assess the students' knowledge of engineering documentation, literature review techniques, data management, and programming tools, as well as their interest in applying these skills to their career development.

Ultimately, e-REF aims to provide students and engineering populations at large, with a long-term resource that reinforces key engineering concepts and supports their academic journey. In the future, we plan to enhance e-REF by integrating AI-driven learning models, enabling personalized learning experiences that can adapt to individual needs and further align with the learning outcomes of the resource.

## **Introduction**

Effective communication through scientific writing is essential for integrating engineering principles into applied scenarios. While scientific and mathematical concepts form the core of modern engineering curricula, literary and documentation are often overlooked [1]. Many engineering students struggle with locating and evaluating credible information, using spreadsheet software for data analysis, and comprehending specialized engineering documentation [2-5]. These skills are foundational for students to propose and troubleshoot engineering solutions effectively [2], [3], [6]. Creating avenues for personalized and concept retentive learning—rather than mere information dissemination—can help students and professionals hone these critical skills. [7].

Open Educational Resources (OERs) are teaching, learning, or research materials released into the public domain or under open licenses, permitting free use, adaptation and distribution [8]. OERs enhance the accessibility of academic content, foster innovation and collaboration, and promote greater equity in education [9]. Although progress has been made in adopting OERs in engineering education, widespread integration remains limited [10]. Platforms such as OpenStax and LibreText exemplify the potential of OERs in higher education [11] [12], while initiatives like Open SUNY, Open Textbook Library, and BCcampus demonstrate institutional commitment to expanding open-access resources [13]-[15]. Nonetheless, challenges remain, including insufficient resources for advanced engineering topics, limited discoverability, and fragmented adoption efforts [10].

We have created e-REF, a platform serving as both a precursor and a bridge to the larger OER ecosystem, to address this need. The primary goal of this platform is to integrate reliable, targeted resources into engineering coursework and professional practice. By doing so, we seek to fill existing OER gaps in engineering education.

e-REF is an innovative, comprehensive toolkit covering essential aspects of engineering documentation and analysis, including technical writing, note taking, data visualization, programming, and responsible AI use. Currently hosted on a North Carolina State University server, e-REF is transitioning to open access to ensure lasting availability and to enable community members to access resources through a simple URL or learning management system (LMS). Its foundation draws on curated materials from NC State University Libraries resources and specialized digital repositories, aligning with the spirit of OER principles.

Developed in alignment with the 2030 Agenda for Sustainable Development's fourth goal, e-REF addresses critical needs in engineering education such as accessibility to equitable and quality education, promoting lifelong learning opportunities, and reducing educational inequalities within and between countries [16], [17], [18]. It is designed as a flexible OER, suitable for learners at various stages—from first-year undergraduates to graduate students and industry professionals. By focusing on common engineering skills, e-REF aims to enrich technical writing and data literacy competencies that students can apply throughout their academic and professional careers. Ultimately, this project advances OER integration by providing a centralized, accessible resource, thereby helping to diversify and strengthen the educational landscape for engineering students [16].

This paper presents the current progress of e-REF and outlines our plans for its current implementation and evaluation. We describe its learning outcomes, structure, and preliminary assessment strategies designed to measure its effectiveness in teaching literature review skills, engineering documentation, and data visualization techniques.

## **Project Approach and Experimental Methods**

### *e-REF: Learning Outcomes*

In the first-year engineering program at NC State University, we provide a project-based course emphasizing teamwork, task management, and problem-solving. Students learn project management principles, engineering design, computer-aided design, data analysis, and prototype development and presentation. The overarching learning outcomes of this course include the ability to:

- Conduct comprehensive literature reviews to effectively address specific engineering problems.
- Identify different types of engineering documents and apply them in relevant engineering situations.
- Explain and apply the engineering design cycle and stages to come up with solution prototypes for problems in the engineering field.
- Recognize the value of team collaboration and contribute effectively to group engineering projects.
- Interpret and present technical data obtained from software-based platforms in both written and oral formats.
- Design and implement a team-based solution to address current engineering challenges on campus, utilizing project management principles.
- Create professional documents and profiles that align with industry standards for career development.
- Recognize various engineering majors and their respective applications to plan for career development.

We designed e-REF to specifically reinforce students' mastery of these outcomes. Tailored to first-year engineering needs and adaptable to broader contexts. In this way, the learning outcomes for e-REF are listed as follows:

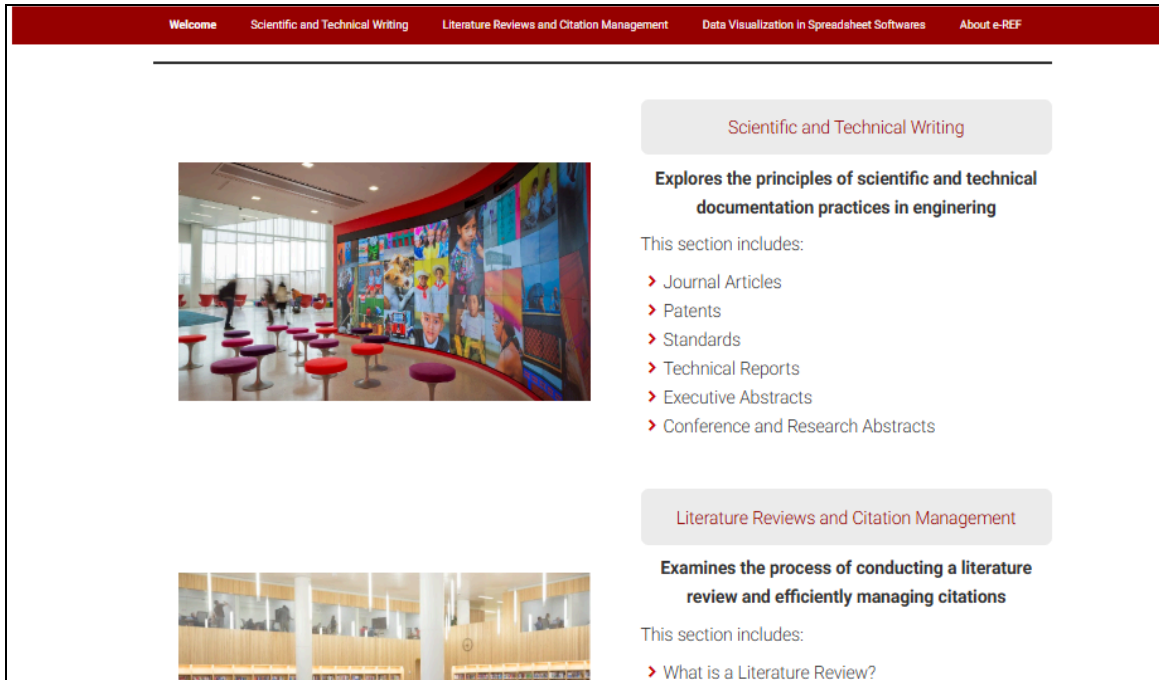
1. Retrieve engineering related documents (journal articles, books, patents, standards) from reliable databases.
2. Explain the importance of reliable sources, and the impact of citations.
3. Provide comprehensive and structured literature reviews to address engineering problems.
4. Develop detailed graphics and data summaries in spreadsheet softwares.
5. Assemble structured spreadsheets to present results, data analysis, and evidence materials for engineering problems.
6. Discuss different types of files employed in engineering and their management.
7. Appraise different coding softwares available for engineering and science.
8. Evaluate the proper use of AI resources in engineering research

By aligning these outcomes with the existing first-year course objectives, we ensure that students consistently encounter and practice the concepts embedded in e-REF.

#### *e-REF: Platform Structure*

The e-REF platform features a user-friendly design, allowing learners to quickly locate relevant information. Upon landing on the homepage, users see a set of broad categories. Selecting any category reveals a concise overview of the skills covered, followed by a set of subcategories for deeper exploration (Figure 1). Each subcategory is divided into succinct topics that include:

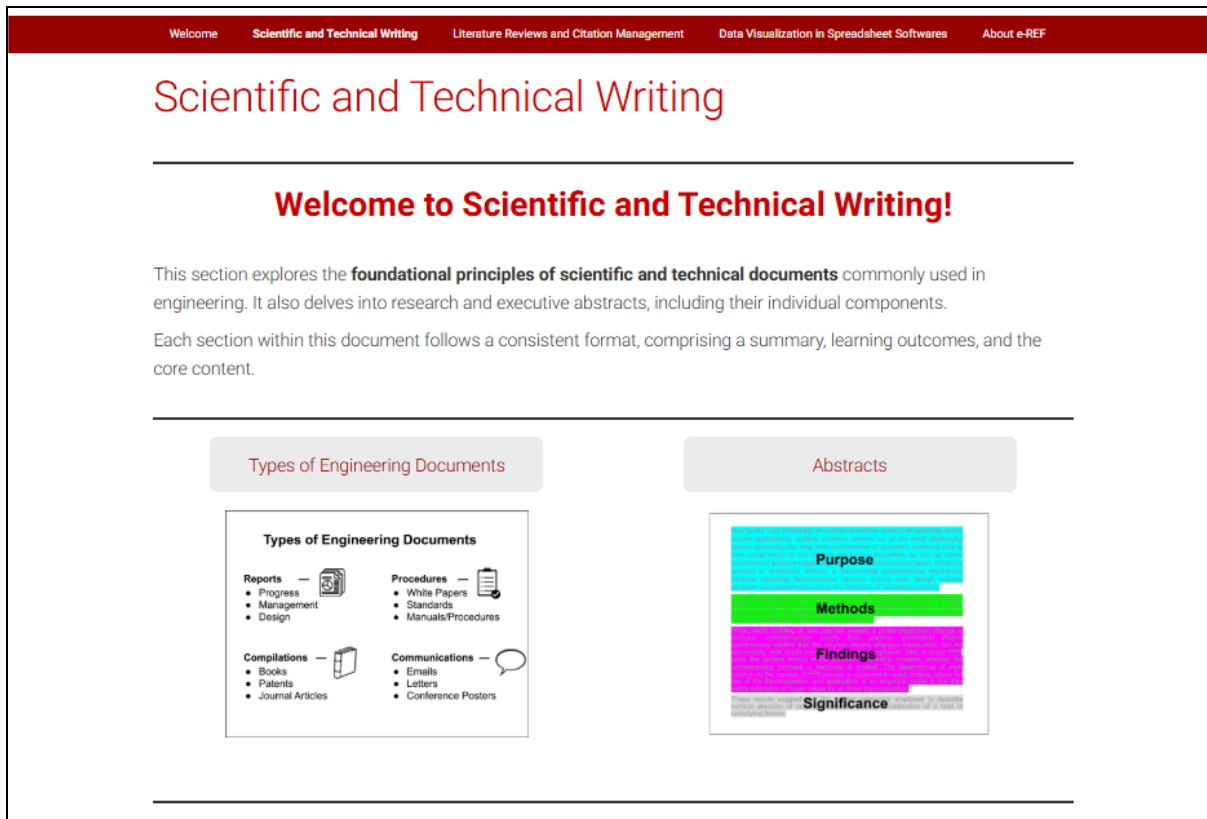
- Summary: A broad overview of the topic.
- Learning Outcomes: The specific objectives for the topic.
- Content: Curated educational resources, including videos, infographics, images, and links to primary information repositories.



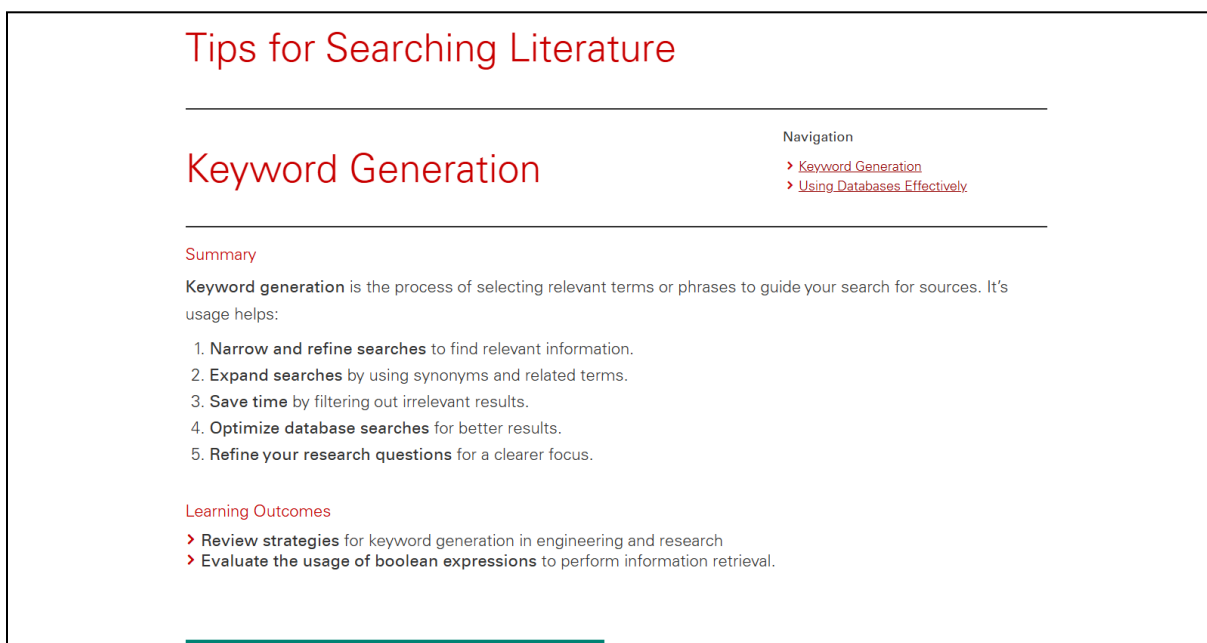
**Figure 1. e-REF's landing page interface. This page provides a list of categories available for exploration within the platform.**

Currently, e-REF emphasizes three main categories:

1. **Scientific and Technical Writing**  
Comprises two subcategories: *Types of Engineering Documents* (journal articles, patents, standards, and technical reports) and *Abstracts* (executive, conference, and research). Key themes include structural conventions, the writing process, and best practices for specialized material. (Figure 2)
2. **Literature Reviews and Citation Management**  
Organized into three subcategories: *Literature Reviews*, *Tips for Searching Literature* (keyword generation, Boolean operators, database utilization), and *Citation Management* (styles, plagiarism, and tools such as Zotero, EndNote, and RefWorks). (Figure 3)
3. **Data Visualization in Spreadsheet Software**  
Covers *Spreadsheet Software for Engineering*, *Datasets and Their Manipulation in Spreadsheet Software*, and *Visualizing Data Effectively*. These subcategories guide users through data import, cleaning, analysis, and effective visualization techniques, including an introduction to color usage and chart types.



**Figure 2. Landing page for the Scientific and Technical Writing section. The content for the various sections, along with the learning outcomes and summaries, can be accessed by clicking on the thumbnails.**



**Figure 3. Summary and Learning Outcomes for the Keyword Generation section**

To address emerging skills, we are developing additional sections:

- Types of Files, Coding Languages, and Their Management: Basic computing concepts, file management practices, and overview of popular programming languages.
- AI and the Engineering Writing Process: Foundational knowledge of AI, with an emphasis on ethical considerations and best practices when employing AI tools in research and writing.

Collectively, these sections serve as a focused gateway to specialized resources, bridging existing OER materials and refining them for engineering education needs. As engineering education continues to evolve, new categories will be introduced to broaden both the scope and depth of this open-access resource.

### *Study Methodology*

We plan to evaluate the impact of e-REF on four sections of a first-year engineering course at North Carolina State University. Approximately 56 students enroll in each section, which integrates a semester-long team project culminating in a final presentation. Literature reviews and engineering documentation play a central role in these projects.

Group A (two sections): Will receive dedicated e-REF-based instruction on literature reviews and data analysis through the LMS.

Group B (two sections): Will receive equivalent content through traditional lectures without e-REF resources.

To measure e-REF's effectiveness, we will administer two surveys—one before the course start and one after. The surveys will assess students' understanding of citation practices, literature review methodologies, and engineering documentation. Group A will receive an additional survey soliciting feedback on e-REF content quality and usability. Data collection will take place during the Spring 2025 and 2026 semesters. Students in both groups will be quasi-experimental participants, assigned to a section without knowing whether they will use e-REF.

### **Preliminary Outcomes**

As of January 2025, the electronic Resources for Engineering Formation (e-REF) platform is operational. It has been piloted in the current semester under IRB protocol #27636, and preliminary surveys have been collected. By year's end, e-REF will be publicly available under a Creative Commons license, transitioning to a new university server that will host ongoing updates and user-driven revisions. In its role as an emerging OER, e-REF aims to support engineering formation by offering a centralized, structured gateway to critical professional skills. We hope that this WIP can foster further collaborations and implementations throughout our engineering education community.

e-REF is designed with the intention for expansion and scalability. Since the content aligns with foundational engineering competencies, institutions can integrate it into their engineering curricula. Furthermore, e-REF follows Open Educational Resource (OER) principles. Institutions with limited access to proprietary educational materials can benefit from its freely available and



high quality content, thereby promoting equity in education and lifelong learning opportunities. With integration into various engineering curricula, students will be better equipped to conduct research, navigate technical documentation, and perform data analysis.

For updated information, additional questions, or interest in using e-REF please contact:

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