Integrating Information into the Engineering Design Process

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PART III

Ensuring That Students Develop Information Literacy Skills
Learning Objectives

So that you can actively promote the effective development of information literacy skills in student design teams, upon reading this chapter should be able to

- Explain common student challenges in information literacy
- Use assessments of information literacy for diagnostic purposes
- Use the InfoSEAD rubric for ongoing formative assessment and to provide feedback
- Implement scaffolding activities appropriate to students’ information literacy skill levels and remove these scaffolds when appropriate
INTRODUCTION

The previous chapters in this handbook outline the place of information literacy within engineering design. This chapter complements the other chapters by showing how instructors can lay a foundation for students so that their first exposure to using information in an engineering context is not when they are engaged in a fully autonomous design project. In this chapter methods are described for assessing information literacy and provide examples that help gradually build student knowledge and skills as early as the first year of the engineering curriculum.

This chapter starts with a review of common challenges faced by undergraduate engineering students. Understanding these challenges is necessary in guiding the development of targeted instruction. We also emphasize the need for ongoing assessment and feedback, which are integral to scaffolding student learning. The strategies we discuss are designed to support student learning while gradually reducing the instructor support as students become more competent and independent.

COMMON CHALLENGES FOR STUDENTS

Obtaining an accurate measure of students’ skill and ability levels is a longstanding problem within education. Methods of quickly obtaining measures of student learning are, by nature, likely to focus too heavily on shallow conceptual understanding or students’ perceptions of learning, rather than their actual learning (Wiersma & Jurs, 1990). There are, however, often disparities between students’ perceived and actual skill levels. For example, despite the complexity of the behaviors and skills necessary for information literacy, novice engineering students often perceive their information literacy skills to be higher than their actual skills (Holliday & Li, 2004; Ross, Fosmire, Wertz, Cardella, & Purzer, 2011).

Students, however, are able to identify specific skills that they find challenging. For example, they find creating a plan of action and locating information efficiently to be their key challenges (Head & Eisenberg, 2009). These challenges are associated with information-seeking behavior. In addition, our observations of students’ actual performance show common errors in the following areas:

- Selection of inappropriate, untrustworthy resources (evaluating)
- Incorrect calculations and incorrect representation of scientific facts and information (applying)
- Misuse of information through exaggeration of information or misrepresentation of data (applying)
- Inconsistent documentation of information sources and citation errors (documenting)

These errors are associated with four areas of information literacy that we summarize in a framework called the InfoSEAD model: information seeking, evaluating, applying, and documenting. The information literacy behaviors of seeking and evaluating information as well as documenting and applying resources are essential during design projects. Students’ common errors and weaknesses in key aspects of information literacy influence the quality of their arguments. In addition, documentation and citation errors are concerning in other ways as well. First, inappropriate or inconsistent citations point to haphazard collection of resources and impact the face quality of student reports and similar documents. Second, the use of ex-
ternal information without appropriate citation is a violation of academic and professional integrity and can have significant consequences and even legal complications.

Educators are faced with the need to address these student challenges in a context where students feel confident about their skills. Ongoing classroom assessments and feedback are needed to identify skill areas that need the most improvement along with carefully developed scaffolding activities that can help correct student perceptions while building their knowledge and skills.

THE INFOSEAD MODEL

Information literacy can be seen as a skill emerging from a combination of self-directed learning and reflective judgment (Wertz, Purzer, Fosmire, & Cardella, in press). This means that an information-literate individual should not only be able to plan and pursue information searches but also have the skills necessary to evaluate the accuracy of information and the quality of information sources (ACRL, 2000). We organized this knowledge and these skills in a four-dimensional framework called InfoSEAD (Wertz, Purzer, et al., 2013), summarized in Figure 15.1. We present this model to the students in our first-year engineering course as an intuitive mnemonic way to internalize the core tenets of information literacy. Breaking down the Association of College and Research Libraries (ACRL) standards into language more convenient for students removes the jargon barrier that some information literacy instruction can pose to incoming students.

SEEKING: Where Do I Find Information?

The InfoSEAD model starts with seeking activity, which refers to the search for information from a variety of information sources. The

![Figure 15.1: Four facets of information literacy in the InfoSEAD model.](image-url)
search for information has to begin with a well-formed research question. Once students know what they are looking for, they then need to search in appropriate places to fill that information need. Examples of variety in information seeking are resources such as monographs, periodicals, and websites. The sources or authors of information can be internal or external to the organization. Some, such as conversations with peers, may also be more informal than the others but may play a critical role in the process.

**EVALUATING: What Is High-Quality Information?**

Once information sources are found and pieces of information identified, these need to be evaluated. Evaluation skills include the ability to critically evaluate the arguments made by the authors and identify the trustworthiness of the sources and references the arguments are based upon. These decisions can be made on the basis of the information source or the content of the material. The intended audience, such as popular or scholarly, can be an indicator of quality. Popular sources, though they are written for the general public and provide nonscientific or nontechnical information, can be appropriate in situations such as when the perceptions of users are sought. So, the evaluation of the quality of information depends on the context or situation.

**APPLYING: How Well Does the Information Support My Argument?**

Once information is evaluated and selected, it needs to be applied to the given situation and used to support design decisions. Information might be of high quality, but it also needs to be relevant to the situation under consideration. Students also need to be open to changing their decisions or perspectives based on new information, rather than disregarding information that doesn’t fit their hypothesis or misrepresenting the information contained in a document just to further their argument.

**DOCUMENTING: Where Does My Information Come From?**

The documentation of information sources is critical in several ways. First, documentation allows readers to judge the quality of information sources and hence the decisions made. Second, documentation acknowledges the sources cited and makes the document useful for those who may build on the information provided. Missing elements in a citation or reference make it difficult to link the information thread to the original source. Documentation errors can be as simple as citing and referencing errors or more substantial such as incorrect interpretation of information. Through in-text references arguments can be supported.

**SCAFFOLDING STUDENTS’ INFORMATION LITERACY SKILLS**

In educational research, scaffolding is a metaphor used to describe temporary support provided to learners. Such support allows students to accomplish tasks that they are not able to accomplish otherwise (van de Pol, Volman, & Beishuizen, 2010). There are three critical characteristics of effective scaffolding: ongoing diagnosis, calibrated support, and fading. Scaffolding starts with a diagnostic assessment of student knowledge and skills. This diagnosis leads to the development of contingent or calibrated support appropriate for the needs of the learners. This support is then gradually reduced (i.e.,
as the learners become more competent in the task. Figure 15.2 demonstrates a scaffolding process involving two scaffolding activities that starts with a diagnostic assessment and gradually transfers responsibilities from the instructor to the students.

**Diagnostic Assessment**

Because effective scaffolding requires differentiated support, the process starts by assessing student learning and skills associated with a given task. Our recommendation is to start with an easy to administer and easy to score instrument for initial diagnosis. The Critical Engineering Literacy Test (CELT) is an instrument developed for this purpose (Wertz, Saragih, et al., 2013). CELT is a multiple choice instrument and hence easy to administer and score. It starts with a text and a series of questions about this text. The full instrument is available upon request from the authors.

While CELT is administered once in our scaffolding process, ongoing assessments occur frequently through other formal or informal means to allow calibration of scaffolding.

Another form of scaffolding includes clarification of expectations. An evaluation rubric, shown in Table 15.1, provides characteristics of good quality outcomes and allows students to
TABLE 15.1 InfoSEAD Assessment Rubric

<table>
<thead>
<tr>
<th>Seek</th>
<th>Evaluate</th>
<th>Apply</th>
<th>Document</th>
<th>Subject-matter context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source quantity</td>
<td>Source quality</td>
<td>Argument</td>
<td>Citations</td>
<td>References</td>
</tr>
</tbody>
</table>

- **Seek**: Source quantity
  - Developing: Citations were fewer than the required quantity
  - Emerging: Citations met the required quantity
  - Proficient: Citations exceeded the required quantity

- **Evaluate**: Source quality
  - Few sources are appropriate*
  - Most sources are appropriate*
  - All sources are appropriate*

- **Apply**: Argument
  - Argument is disorganized with inconsistent use of evidence for support
  - Argument is understandable and somewhat supported with evidence
  - Argument is well structured and clearly supported with evidence

- **Document**: Citations
  - Few citations are complete
  - Most citations are complete
  - All citations are complete and consistently formatted

- **References**: Few citations, tables, charts, and/or figures are referenced in text
  - Most citations, tables, charts, and/or figures are referenced in text
  - All citations, tables, charts, and/or figures are referenced in text

- **Subject-matter context**: Subject literacy
  - Mostly incorrect use of terminology, scientific data, and units (several errors or misrepresentations)
  - Mostly correct use of terminology, scientific data, and units (a few minor errors)
  - Correct use of terminology, scientific data, and units

*Appropriate sources may include scholarly journals, technical reports, textbooks, and handbooks. Web resources such as government reports and product reviews may be acceptable but should be used only after careful assessment of the intended audience and purpose.

engage in self-evaluation as they develop their report. This InfoSEAD rubric can further be operationalized and familiarized to the students by having students evaluate the example report in Figure 15.3.

**Calibrated Support**

The results from CELT or a similar assessment should guide the development of calibrated instruction. Such instruction can take many forms ranging from modeling to questioning strategies. To scaffold student knowledge and skills in information seeking and documentation, we provide a model report for students to analyze.

**Coffeemaker Activity: Scaffolding by Modeling and Discussing a Written Example**

This example report (Figure 15.3) models appropriate information documentation evidenced by in-text citations and a list of references and information seeking modeling the use of high-quality references, including peer-
Part I: Read the following narrative.

**Evaluating the Design of a Coffeemaker**

The objective of this report is to evaluate energy consumption associated with coffee making. Our analysis has shown that current coffeemaker machines are energy efficient and that the major energy cost occurs during the production of coffee. According to the U.S. Department of Energy, the power requirements for coffeemakers range from 900 to 1200 watts. We conducted an experiment using a wattage measuring device, Kill-A-Watt, to test the power consumption of a Black & Decker coffeemaker. Our results showed that when the machine was turned on and the brewing cycle was started, the meter recorded a power consumption of 1 kilowatt hour (kWh). Assuming that the machine is used for one hour every day in a household and that electricity costs 10 cents per kWh, the cost of this machine's energy use would be 10 cents a day, or about 365 kWh annually. Assuming that all 115 million households in the U.S. (Day, 1996) use coffeemakers, the annual energy consumption for making coffee in the U.S. would be 42 x 10^9 kWh.

According to a research study conducted by Heller and Keoleian (2000), 10 percent of the energy used annually in the U.S. is consumed for producing food (based on data for 1994). Figure 1 shows the energy needed to produce a can of corn where the total energy input is 2.6 kWh. If all U.S. households consume one can of corn daily, the total energy need would be 111 x 10^9 kWh. Because we were not able to find data specifically for coffee production, we will assume that the energy needed for the production of coffee will be no less than the production of corn. The energy required to operate our individual coffeemaker (approximately 42 x 10^9 kWh) is significantly less than the energy used to process coffee (approximately 111 x 10^9 kWh per year). Therefore, we will focus on reducing the energy costs involved in producing coffee. Our boundary of analysis includes the production, processing, and packing of coffee beans and their transportation to and distribution in the mainland.

**FIGURE 1** Energy input needed to produce a 455 g can of corn. (Modified from Pimentel & Pimentel, 1996.)

References


Part II: Answer the following questions after reading the sample text.

<table>
<thead>
<tr>
<th>InfoSEAD category</th>
<th>Reflection questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeking</td>
<td>What three keywords might the authors of this report have used to find trustworthy information on this topic?</td>
</tr>
<tr>
<td>Evaluation</td>
<td>What aspects of this report help it make a strong argument?</td>
</tr>
<tr>
<td>Application</td>
<td>Give examples of how the authors apply information sources appropriately and inappropriately to their argument?</td>
</tr>
<tr>
<td>Documenting</td>
<td>How well have the authors documented their resources? What information still needs to be documented?</td>
</tr>
</tbody>
</table>

**FIGURE 15.3** Coffeemaker scaffolding activity.
Mythbusters of Information

In this assignment, your task is to research a common belief and write an argument on. Please note that you will not conduct an experiment (or blow up stuff, as done in the popular Discovery Channel show MythBusters) to test the problem. Rather, you will conduct a literature search (e.g., search information using the library resources) to justify your arguments.

- You should cite at least four trustworthy external sources.
- Use in-text citations to support your arguments. In other words, show how your external information sources support your statements.
- Use correct terminology, scientific information, etc.
- Provide a clear and coherent argument.
- All citations should be in APA format.

Select one from the following statements/common beliefs:
- The carbon footprint of electrical cars is smaller than that of a comparable conventional gasoline-powered vehicle.
- Frozen vegetables are less nutritious than fresh vegetables.
- Cell phones that are left on could cause an airplane to crash.
- A person sitting in a car will not be hurt if the car is struck by lightning.

Suggested outline/structure
- First paragraph: What is the issue (claim)?
- Second paragraph: What are the reasons? What is the evidence and reasoning?
- Third paragraph: What are the counter arguments? Rebuttal?
- Fourth paragraph: What are the conclusions?
- References

<table>
<thead>
<tr>
<th>FIGURE 15.4 Mythbuster scaffolding activity.</th>
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</table>

reviewed journal articles and textbooks. The instructor can further expand expectations for evaluating and applying by describing or speculating on the underlying decisions that led to the brief report on coffeemakers.

The example in Figure 15.3 is presented to the students along with a list of reflection questions that highlight key aspects of the report. The report models expected behaviors in referencing and in-text citation.

Mythbuster Activity: Scaffolding by Application and Feedback

The mythbuster activity (Figure 15.4) is structured as a team or a pair activity that can be done in the classroom, assuming students have access to the Internet to conduct their research. After students complete their report, they can be provided with feedback through instructor evaluation, peer evaluation, or self-evaluation using the InfoSEAD rubric.

Fading Support, Transferring Responsibilities

While the sample report on coffee making is a highly instructor-led activity, effective scaffolding requires the transfer of responsibilities from the instructor to the student over time in response to learning growth. The mythbuster assignment is an example of fading scaffolding that allows instructors to transfer responsibilities to the students so that they can engage in information evaluation and application. The scaffolding in this case is the InfoSEAD rubric that students are asked to follow as they conduct their research.

The scaffolding of information literacy is further removed as students engage in their design projects. Now they can take ownership and responsibility as they seek information from trustworthy resources, evaluate the quality and appropriateness of this information, apply this information to their design
project, and correctly document their information sources. Prior to a capstone design project, instructors should reinforce the InfoSEAD approach throughout the engineering curriculum through the incorporation of mini-research papers, feasibility studies, and similar projects. Student mastery and internalization of the InfoSEAD (or similar) approach to information literacy will foster the increasingly independent, self-regulated learning that students will need to become effective lifelong learners throughout their post-graduate career.

SUMMARY

In this chapter we provided examples of ongoing assessment tools and sample scaffolding activities that can help correct students’ perceived beliefs about information literacy. These activities also support further development of students’ information literacy skills. We also provided tools for the assessment of information literacy and hands-on application of these tools.

The scaffolding activities discussed in this chapter allow increasing levels of student competence and confidence in their information literacy skills. Lifelong learning can be achieved with necessary information literacy skills, as well as motivation and self-regulation. Hence, it is important to provide students with support that will lead to increased control over their learning.

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REFERENCES


