Assessing communication in engineering students

Collecting and analyzing quantitative and qualitative data from first-year students

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First-semester undergraduates in engineering are often surprised that becoming an excellent engineer requires learning more than technical knowledge and skills; equally important is learning to form arguments about technical information, communicate those arguments skillfully, and then reflect on the process and product.

Discussing issues related to assessing students' acquisition of communication skills and the growth of their expert-like behaviors is the focus of this paper. It begins with a very brief review of literature, continues with an equally brief identification of some critical assumptions and their implications for assessment of communication in engineering students, and concludes by suggesting quantitative and qualitative assessment strategies and one way to ensure pedagogical integrity for the assessment process. data can provide a rich picture of students' communicative competence.

Research about engineering communication

Research in rhetoric establishes a positive relationship between technical knowledge and an ability to communicate that knowledge, so students can improve their understanding of technical information if they learn to communicate that information. Research in cognitive psychology indicates that experts are often remarkably skillful in reflecting about their work, so students can develop more expert-like behavior if they learn to engage in thoughtful self-assessment.

However, this research displays gaps: No studies focus on the synergy among written, oral, and visual communication in engineering; no studies address the role of reflection about communication as part of engineering practice, few studies about communication in engineering are longitudinal or extended, and little research about communication is related to preparing students for professional engineering practice. The paucity of such research is problematic because baselines for examining the growth of engineering students come from longitudinal classroom and classroom-to-workplace ethnographies (e.g., Winsor), studies of basic writers (e.g., Sternglass), or studies that purposefully exclude engineering students (Sommers). Furthermore,

while a critical body of research exists about preparing students for professional practice, few relate specifically to engineering practice (cf. Dias et al; Freedman & Adams; Smart).

The few large-scale longitudinal studies of writing that are available each take, according to Beaufort, "one of three primary analytical frameworks as its means of both framing and analyzing the research: a linguistic frame (Faigley,1980; Haswell 1991, 2000), a social epistemic frame (Geisler,1994; Herrington and Curtis, 2000), or a cognitive frame (Freedman & Pringle, 1980)" (Beaufort). A *rhetorical frame* can productively incorporate appropriate linguistic, social, and cognitive elements while acknowledging other critical factors such as communities of practice (e.g., Wenger), activities (e.g., Russell), and expertise (e.g., Scardamalia & Bereiter).

Assumptions about communication and the implications for assessment

Assessment of communication in engineering can bring together colleagues with interests in engineering, engineering education, rhetoric and professional communication, and assessment. They need to establish a common understanding of several assumptions about communication and their implications for assessment:

- **Multi-modal communication**. The acquisition of written, oral, visual, and electronic (WOVE) communication skills is critical for engineering students—for academic success and for professional success. This WOVE approach is a cornerstone of ISUComm. Assessment should acknowledge the multi-modal synergy of communication.
- **Approaches to communication**. Communication skills in engineering programs should be learned initially in two critical ways: a focus on *learning to communicate* in an accessible, appropriate manner and a focus on *communicating to learn* to increase the comprehension and recall of disciplinary subject matter. Assessment should consider both *learning to communicate* and *communicating to learn*.
- **Expert-like behaviors**. Students should be developing expert-like behaviors related to communication: attitudes, actions, and performance. Assessment should consider the quantity and quality of students' expert-like behaviors in communication.
- **Rhetorical focus**. A well-established body of research indicates that workplace experts attend to rhetorical elements when they plan, draft, and revise; non-experts focus largely on content and may virtually ignore rhetorical elements. Assessment should consider these widely accepted rhetorical elements that typically include content, context, purpose, audience, organization, visuals, document design, usability, and language conventions.
- **Reflection**. Becoming skillful communicators includes students' learning to reflect regularly on their own communication attitudes, actions, and performance. Assessment should consider the quantity and quality of students' reflection about their own communication.
- **Nature of assessment**. Assessment can focus on students' *immediate change* (one assignment), *short-term change* (one semester), *long-term change* (the course of their program), and *extended change* (as students move into the workplace and become

professionals, which may track change during a multi-year period). Programmatic assessment can include all four levels of assessment.

- **Mixed methodologies**. Despite the extreme positions taken by some researchers in the protracted data wars, both quantitative and qualitative data provide valuable insights about students' acquisition of communication skills and the growth of their expert-like behaviors. Assessment should include both quantitative and qualitative data that are triangulated.

The problem then becomes making decisions about selecting the most appropriate data to help answer the specific research question(s)—given limited financial resources, limited time, and the criticality of having assessment promote rather than interfere with students' learning.

Assessment strategies

The following figure indicates some of the ways that both the process and the product of written, oral, visual, and electronic communication can be assessed, depending on the question(s) the study is investigating. The figure identifies representative rather than comprehensive methods for collecting data.

Types of communication	**Assessment**	
	Selected ways to assess process (e.g., consider inventing, planning, revising, collaborating)	**Selected ways to assess product** (e.g., assess accessibility, comprehensibility, usability)
Written communication (e.g., reports, articles, proposals, manuals, correspondence)	▪ Conduct face-to-face interviews ▪ Collect think-aloud protocols ▪ Track revisions in drafts	▪ Assess rhetorical features ▪ Conduct usability tests ▪ Assess selected linguistic characteristics (e.g., sentence structure, mean clause length)
Oral communication (e.g., conversations, presentations, face-to-face and virtual meetings)	▪ Conduct process-tracing interviews ▪ Video tape practice and final presentations ▪ Audio tape meetings	▪ Assess nonverbal performance ▪ Use audience feedback ▪ Assess selected linguistic characteristics
Visual communication (e.g., tables, figures, graphs, maps, charts, diagrams, document design)	▪ Track design changes in drafts ▪ Collect key-stroke data ▪ Video tape design process	▪ Assess visual rhetoric and design ▪ Conduct reading protocol ▪ Examine growth in portfolio
Electronic communication (e.g., e-mail, PPT, databases, CAD)	▪ Conduct discourse-based interview ▪ Track response time to e-mail ▪ Track message trails	▪ Conduct compliance check ▪ Conduct focus groups ▪ Conduct reading protocols

Pedagogical integrity

Large-scale communication assessments can be designed so that some (or even all) of the assessment tools are part of the course. For example, imagine that at the beginning and end of their first semester, engineering students read parallel workplace scenarios that present technical problems appropriate to the course. Then they individually complete these communication and reflective tasks as part of assigned class work:

- Create a visual based on a technical scenario and related quantitative data presented in Excel.
- Use MSWord to draft and then revise a paragraph, for a specific audience, that suggests an interpretation of the visual.
- Prepare and present a 2-minute oral presentation explaining the visual (videotape the presentation).
- Reflect on the processes creating the visual, textual, and visual communication and the quality of the final products.

The analysis of these data—both process and product—could be used to define a baseline to examine the ways in which engineering students develop expert-like attitudes, actions, and performance. Such data can also productively influence curricular design in undergraduate engineering education.

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