Writing in the Disciplines for Engineers: Implementation and Assessment of Student Learning

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Jordan Trachtenberg received her PhD in bioengineering from Rice University. She has been passionate about STEM education and outreach throughout her undergraduate and graduate studies. Her broad teaching interests include teaching K-12 outreach programs in 3D printing and computer-aided design, mentoring undergraduate laboratory and design teams, and organizing graduate professional development opportunities in science communication. She works on collaborative pedagogical research projects to understand student learning in engineering problem-solving and design.

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ABSTRACT

Research Questions:

1) What does writing look like in engineering?
2) Which skills do engineering students develop when they write?
3) How can we assess the development of these skills?

Writing in the Disciplines is an integrated approach that ties ***writing assignments*** to the ***learning outcomes*** of a technical course and provides relevant opportunities for students to develop expertise in their field. In order to ameliorate the public's scientific literacy, we need scientists to communicate in a clear and concise manner. As we prepare students for science and engineering careers, it is crucial to help them improve their technical writing and presentation skills to wide audiences. It is well-supported that students who engage in discipline-specific writing develop important professional and critical thinking skills. There are specific engineering writing assignments that scaffold student learning in laboratory, design, or research-related courses. After implementing these scaffolded writing assignments in the engineering curriculum, it is then possible to qualitatively and/or quantitatively assess student perceptions of learning, development of critical thinking skills, and alignment of our courses with accreditation standards. Improvement of writing feedback and assessment methods in the future will then inform educators about the effectiveness of their teaching, as well as provide measurable standards for students as they pursue professional careers.

SIGNIFICANCE

"Soft skills" necessary for the professional world

What are the most important skills that we should teach our engineering students? Writing like an engineer is a way to learn…[Winsor 1989].


Practical job skills


Interpersonal skills / teamwork


General education


Societal responsibility

L to R: http://ibb.rice.edu/MedIntoGradContent.aspx?id=1271, http://oedk.rice.edu/, https://cwovc.rice.edu/, http://www.rice360.rice.edu/,

ABET 2017 3a-k require communication skills

Not only do we value these skills in the engineering profession, but the accreditation board for engineering and technology (ABET) requires that, among other professional skills (outlined in these criteria), students are able to communicate effectively.

Graduates from accredited programs must demonstrate:

3a	an ability to apply knowledge of mathematics, science, and engineering
3b	an ability to design and conduct experiments, as well as to analyze and interpret data
3c	an ability to design a system, component, or process to meet desired needs
3d	an ability to function on multidisciplinary teams
3e	an ability to identify, formulate, and solve engineering problems
3f	an understanding of professional and ethical responsibility
3g	***an ability to communicate effectively***
3h	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
3i	a recognition of the need for and ability to engage in lifelong learning
3j	a knowledge of contemporary issues
3k	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Adapted from [Felder 2003], http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2017-2018/#outcomes

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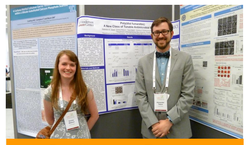
LEARNING FRAMEWORKS AND ASSESSMENT METHODS

1) Situated cognition: Writing in engineering as apprenticeship

Theory of ***situated cognition:****
A newcomer (engineering undergraduate) learns how to integrate into a professional community by engaging in activities that simulate the various communication exercises that engineers practice in academia and industry.

1) Development of higher-order critical thinking skills
2) Self-identification as a professional

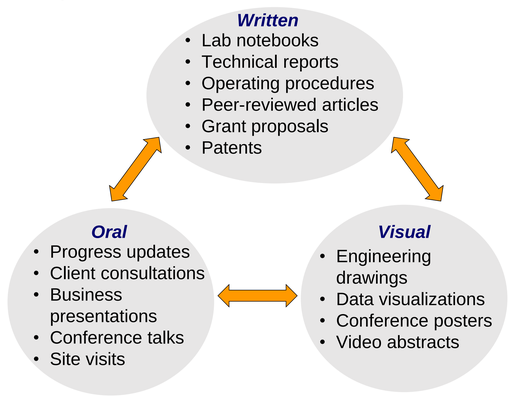

Lab Reports


Conference Posters

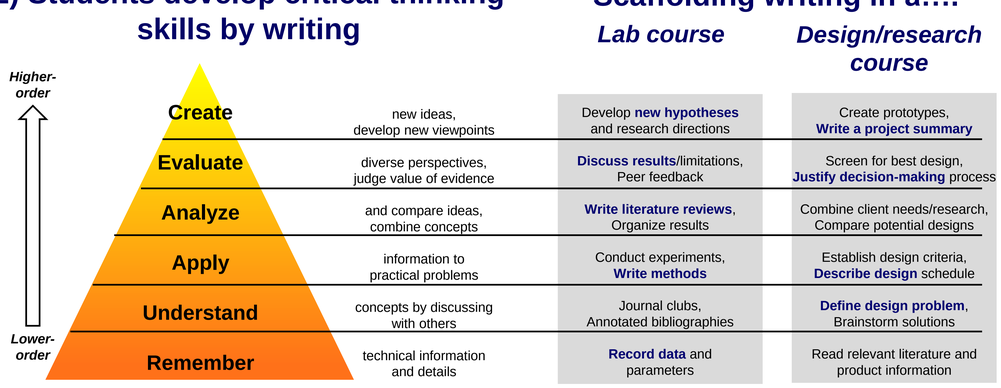
Lower-order thinking ⟹ *Higher-order thinking*
Foundational lab course — Independent research

*The theory of situated cognition was developed in the late 80s and has been discussed in the technical communication literature. [Lave 1988; Carter 2007; Bazerman 2009].
Left image: http://news.rice.edu/2015/09/28/scientists-decode-structure-at-root-of-muscular-disease/

Written, oral, and visual communication exercises:
- Are interrelated and essential
- Help to assess students' critical thinking skills
- Can be flexibly implemented to fit the learning objectives for a course



2) Students develop critical thinking skills by writing



[Anderson 2015; Saterbak 2016]
Bloom's taxonomy figure adapted from: http://www.psia-nw.org/newsletter-articles/blooms-taxonomy-levels-of-understanding/

3) Examples of qualitative, quantitative, and mixed-methods assessment

Qualitative	Assessment type	Ref.	Quantitative	Assessment type	Ref.	Mixed-methods	Assessment type	Ref.
Student interviews	Summative	Carter 2007	National Survey of Student Engagement	Summative	Anderson 2015	Research paper, student survey, demographics	Formative	Barlow 2007
Student surveys	Formative	Chong 2012	Calibrated Peer Review	Formative, Summative	Carlson 2008	Student and community questionnaires, statistical analysis	Formative	Elrod 2010
Student behaviors, perceptions	Formative	DeTurris 2012	Calibrated Peer Review	Formative, Summative	Volz 2009	Triangulation, review of program-level and course-level assessments	Summative	Felder 2003
Student misconceptions of content	Formative	Etkina 2002	Exam, Gantt Chart, statistical analysis	Summative	Saterbak 2016	College Learning Assessment Plus Test (CLA+), AAC&U VALUE rubrics, Transferable Learning Orientations (TLO), Motivated Strategies for Learning Questionnaire	Formative, Summative	Frank 2015
			Force concept inventory	Formative, Summative	Hake 1998	Survey (weekly), interviews, student demographics, public rating of student presentations	Formative, Summative	Ing 2013
						Surveys correlated with performance on a paper	Summative	Jerde 2004

PROPOSED IMPROVEMENTS

Approach feedback effectively:

- Increase peer and instructor dialogue in feedback [Chong 2012]
- Focus on content and skills-based feedback [Troy 2014]
  - Weekly concept journals
  - Documented problem solutions

Assess critical thinking skills:

- Follow up with in-depth qualitative and quantitative assessment [DeTurris 2012, Elrod 2010]
- Develop assessment rubrics [Frank 2015] that directly relate writing assignments to different levels of critical thinking
- Standardize assessments for specific courses [Barlow 2007]

Inform curricular and departmental decisions on innovative teaching and assessment

Establish models for other institutions to follow

CONCLUSIONS

- How we teach writing will depend on the level of the course and learning objectives
- Writing teaches different skills depending on student's prior knowledge
- Assessment can be used as formative feedback to improve course design and understand student learning

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