Research in Engineering Education

Ontario Library Super Conference 2016

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Engineering Education Research

- Field of inquiry about teaching, learning and curriculum development processes in engineering education

- Growing field in Canada and world-wide; increased interest in last 15-20 years with changing accreditation requirements, growth & greater focus on undergraduate education and an interest in the promotion of the profession

- Graduate programs/departments in multiple institutions; most schools in Canada have a few members in the eng ed research community

Engineering Education @ The University of Toronto

- Offering Canada's first graduate program in Engineering Education
- Diverse research interests with strengths in engineering communication, engineering design, engineering leadership and assessment of learning

Engineering Education

- Relevant publications include Journal of Engineering Education, IEEE Transactions on Education, and International Journal of Engineering Education

- Supported by the American Society for Engineering Education (ASEE), which includes a large annual conference with 51 divisions (including engineering libraries!)

- Canadian Engineering Education Association (CEEA) includes ~25 institutions and ~175 participants

CEEA 2016 June 19-22

Major Research Areas

Assessment	Successes with Two-Stage Exams in Engineering
Design	Encouraging Empathy in Engineering Design
Diversity	Promoting Female Engagement in Computing Education
Discipline-based Practices	Signals and Systems: Bringing Together Modelling, Applications and Computing
Educational Technology	Using Micro-Video Projects in Large Engineering Classes to Differentiate Assessment
Instruction	I Flipped my Tutorials: A Case Study of Implementing Active Learning Strategies

Major Research Areas Cont.

Professional Practice	Addressing Delivery and Assessment of Lifelong Learning and Professionalism
Recruitment & Retention	Engineering Bait-and-Switch: K-12 Recruitment Strategies Meet University Curricula and Culture
Teamwork	Seeing into your Teams: An Instructor Interface to Support Team Learning
Student Learning	Development of Professional Identity through Portfolios
K-12 STEM	Developing Systems Thinking Skills: A High School Course on Engineering Design
Leadership Development	Engineering Leadership Project: How Do Engineers Think About Leadership?

Engineering, Society and the Environment (ESE) in the Teaching Goals and Practices of Engineering Instructors

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Research Questions

1. How do undergraduate engineering instructors describe their teaching goals and practices?

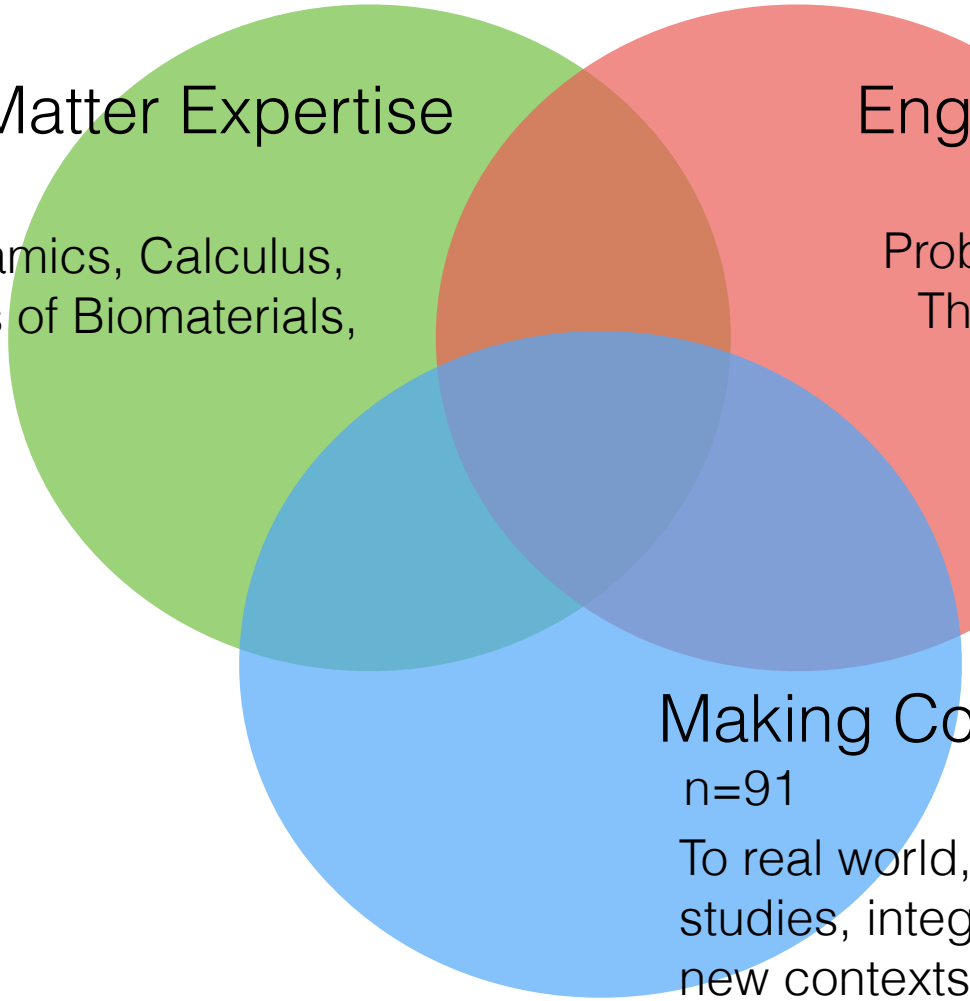
2. How do undergraduate engineering instructors describe their teaching practices with respect to exploring the relationship between engineering, society and the environment?

3. What are the specific challenges or enabling factors in exploring the relationship between engineering, society and the environment, in teaching undergraduate engineering students?

Methodology

- Four Canadian institutions
- Online survey followed by semi-structured interviews
- Survey developed and modified after face validation with engineering instructors
  - Three major components:
    - Demographic items
    - Teaching and learning goals and activities
    - Views and practices with respect to ESE
      - 41 ESE-related practices, on which instructors rated use and importance

Most Important Teaching Goals and Practices



Subject Matter Expertise

n=108

Thermodynamics, Calculus, Applications of Biomaterials, etc.

Engineering Skills and Tools

n=120

Problem Solving and Analysis, Critical Thinking, Design, Quantitative Tools/ Analysis, Communication, Independent Thinking, Creativity, Logical Reasoning, Teamwork, Research

Making Connections

n=91

To real world, future career/grad studies, integration with self/identity, new contexts, other disciplines/ courses, industry, society, “the big picture”

Most Powerful

- Lectures (47)
- Use of Real-World Examples (26)
- Interactive Teaching Activities (44)
- Problem Sets (35)
- Cooperative/Collaborative Learning (26)
- Tutorials (24)
- Design Projects (27)
- Laboratories (21)
- Discussion/Debate (15)

ESE-Related Practices

Use
4: Very Often
3: Often
2: Sometimes
1: Never

Importance
4: Very Important
3: Important
2: Somewhat Important
1: Not Important

ESE Teaching Practice (41 in total)	Current	Use	Imp
I encourage my students to consider the possibility of unintended consequences of engineering products/processes	Appl/Design	2.38	3.12
I give examples of the historical and cultural origination and progression of an engineering, scientific or mathematics concepts	Historical	2.64	2.76
I describe the relationship between engineering and public policy in my classroom	Socio-cultural	1.82	2.58
I encourage my students to consider how engineering knowledge and skills can address social justice issues	Socio-ecojustice	1.56	2.28
I encourage my students to use tools such as risk-benefit analysis and decision-making models	Log. Reasoning	2.18	2.97
I encourage my students to consider their values and/or personal or formal ethical frameworks	Value-Centered	2.15	2.92

Use and Perceived Importance of ESE-Related Practices

How often in my classroom? **How important in engineering?**

Histo 2.98)

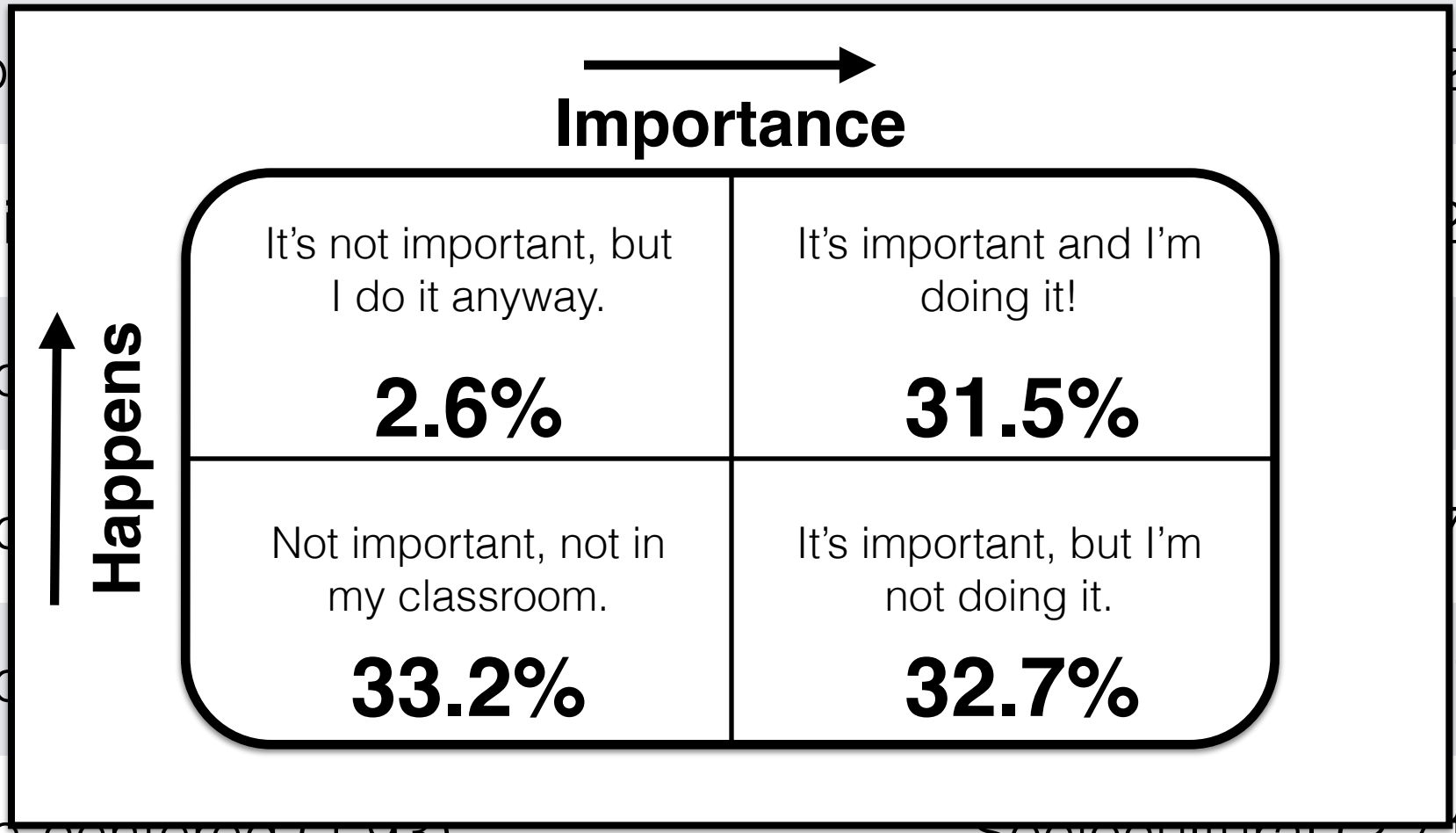
Appli 2.83)

Socio

Logic 76)

Socio 72)

Value-centered (1.93) Sociocultural (2.71)



Using Student Focus Groups to Support the Validation of Rubrics for Large Scale Undergraduate Independent Research Projects

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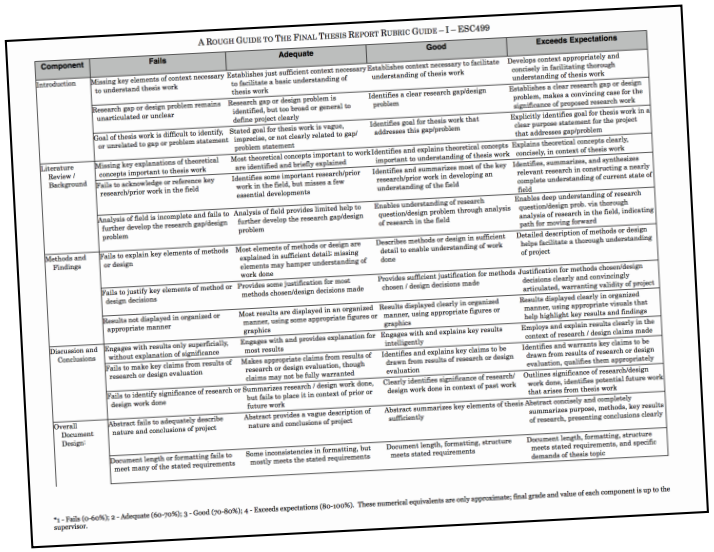
The Rubrics



A Rough Guide to The Final Thesis Report Rubric Guide – I – ESC499

Component	Fails	Adequate	Good	Exceeds Expectations
Introduction	Missing key elements of context necessary to understand thesis work	Establishes just sufficient context necessary to facilitate a basic understanding of thesis work	Establishes context necessary to facilitate understanding of thesis work	Develops context appropriately and concisely in facilitating thorough understanding of thesis work
	Research gap or design problem remains unarticulated or unclear	Research gap or design problem is identified, but too broad or general to define project clearly	Identifies a clear research gap/design problem	Establishes a clear research gap or design problem, makes a convincing case for the significance of proposed research work
	Goal of thesis work is difficult to identify, or unrelated to gap or problem statement	Stated goal for thesis work is vague, imprecise, or not clearly related to gap/ problem statement	Identifies goal for thesis work that addresses this gap/problem	Explicitly identifies goal for thesis work in a clear purpose statement for the project that addresses gap/problem
Literature Review / Background	Missing key explanations of theoretical concepts important to thesis work	Most theoretical concepts important to work are identified and briefly explained	Identifies and explains theoretical concepts important to understanding of thesis work	Explains theoretical concepts clearly, concisely, in context of thesis work
	Fails to acknowledge or reference key research/prior work in the field	Identifies some important research/prior work in the field, but misses a few essential developments	Identifies and summarizes most of the key research/prior work in developing an understanding of the field	Identifies, summarizes, and synthesizes relevant research in constructing a nearly complete understanding of current state of field
	Analysis of field is incomplete and fails to further develop the research gap/design problem	Analysis of field provides limited help to further develop the research gap/design problem	Enables understanding of research question/design problem through analysis of research in the field	Enables deep understanding of research question/design prob. via thorough analysis of research in the field, indicating path for moving forward
Methods and Findings	Fails to explain key elements of methods or design	Most elements of methods or design are explained in sufficient detail; missing elements may hamper understanding of work done	Describes methods or design in sufficient detail to enable understanding of work done	Detailed description of methods or design helps facilitate a thorough understanding of project
	Fails to justify key elements of method or design decisions	Provides some justification for most methods chosen/design decisions made	Provides sufficient justification for methods chosen / design decisions made	Justification for methods chosen/design decisions clearly and convincingly articulated, warranting validity of project
	Results not displayed in organized or appropriate manner	Most results are displayed in an organized manner, using some appropriate figures or graphics	Results displayed clearly in organized manner, using appropriate figures or graphics	Results displayed clearly in organized manner, using appropriate visuals that help highlight key results and findings
Discussion and Conclusions	Engages with results only superficially, without explanation of significance	Engages with and provides explanation for most results	Engages with and explains key results intelligently	Employs and explain results clearly in the context of research / design claims made
	Fails to make key claims from results of research or design evaluation	Makes appropriate claims from results of research or design evaluation, though claims may not be fully warranted	Identifies and explains key claims to be drawn from results of research or design evaluation	Identifies and warrants key claims to be drawn from results of research or design evaluation, qualifies them appropriately
	Fails to identify significance of research or design work done	Summarizes research / design work done, but fails to place it in context of prior or future work	Clearly identifies significance of research/ design work done in context of past work	Outlines significance of research/design work done, identifies potential future work that arises from thesis work
Overall Document Design	Abstract fails to adequately describe nature and conclusions of project	Abstract provides a vague description of nature and conclusions of project	Abstract summarizes key elements of thesis sufficiently	Abstract concisely and completely summarizes purpose, methods, key results of research, presenting conclusions clearly
	Document length or formatting fails to meet many of the stated requirements	Some inconsistencies in formatting, but mostly meets the stated requirements	Document length, formatting, structure meets stated requirements	Document length, formatting, structure meets stated requirements, and specific demands of thesis topic

*1 - Fails (0-60%); 2 - Adequate (60-70%); 3 - Good (70-80%); 4 - Exceeds expectations (80-100%). These numerical equivalents are only approximate; final grade and value of each component is up to the supervisor.

- Developing a common rubric for 190 different projects is challenging
- Needs to be inclusive of different types of projects yet sufficiently specific to be useful
- Graduate attributes tracking introduced a new set of challenges to rubric design
- Rubrics have evolved based on GA needs and some feedback from instructors and students

Methodology

Student Focus Groups for Rubric Assessment:

- Very little in the literature
- Focus groups can produce more thorough and critical responses
- 2 groups of 10 students, 90 minutes in duration
- Key goals:

1. Understand student rubric use
2. Identify confusing aspects
3. Learn about the student perception of the learning objectives of the course

Results: What's missing from the rubric?

- Process/project experience-related criteria
  - Time and project management, working with others in a research environment, learning independently in a new field, learning from failure and self-motivation
  - Congruent with how they described the learning objectives of the course
- Framing/scoping a research problem
- Understanding of relevant knowledge and methods used; what was learned

Results: What was unclear?

My project didn't 'Contribute to scholarship', as noted in the rubric, because my project is more industry related

When I saw 'work has made a measurable impact, I was freaking out. It's an undergraduate thesis!

☐	☐	Work has contributed to scholarship in field / made a measurable impact
☐	☐	Demonstrated initiative, ability to work independently, time management skills and ownership of work throughout thesis project
☐	☐	Thesis work posed a significant challenge, requiring superb engineering & scientific knowledge and skills
☐	☐	Quality of effort and thesis work indicative of potential for future research success
☐	☐	Has incorporated feedback and additional research on initial deliverables to improve final thesis document and work

If it's a new field, how do I know that it's significant?

What's the difference between "demonstrated initiative" and "quality of effort and thesis work"?

How do you define 'superb' in this context?

Opportunities for Engineering Librarians

- Work with students and faculty who are new to educational research
- Bring a unique perspective on student learning to engineering education research
- Research data management

Thank you!

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