Breaking down dualisms in engineering classrooms: how emotions can support engineering problem solving

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***Abstract*—This special session aims to explore, discuss, and deconstruct different *dualisms* in engineering and engineering education. A broad range of dualisms, such as the rational/emotional, technical/social, and theoretical/practical have strongly influenced engineering education and practice since the 17th century. Engineering education researchers have for a long time raised concerns that these dualisms may deter engineers from taking environmental and social concerns into account when designing new technology, and that they may contribute to excluding certain groups of students from striving to become engineers. Still, the dualisms persist and continue to frustrate engineering educators' efforts to teach subjects such as human-centered design, holistic problem solving, and sustainability thinking. In this session, we will explore how these dualisms manifest in participants' classrooms and how they could be challenged. Specifically, participants will engage in collaborative discussions to explore the impacts of dualisms in engineering classrooms. The session will be of particular interest to engineering educators who wish to create more inclusive learning environments where students engage with holistic approaches to engineering.**

Keywords—engineering dualisms, sociotechnical engineering, emotions in engineering, hidden curriculum

I. INTRODUCTION (*HEADING 1*)

Obituary for Curiosity (by: David Olsen)

In the beginning was the Wonder. The
Big Bang. Galaxies and nebulae. Red
shift. Rings of Saturn. Sputnik.
Our world.

Physical sciences explained
bodies at rest or in motion,
planets and atoms like billiard balls,
polymers like chains
curled up or stretched out,
iron filings aligned,
chaos and entropy.

Amid these miracles came
problem sets in physics,
problem sets in chemistry,
problem sets in math
(odd-numbered problems on page 68,
even-numbered problems on page 82),
the same problems addressed in more
difficult coordinate systems, and labs
as cookbook exercises.

Tonight and tonight and tonight
crept in their petty pace,
with no space for Socrates or
Sophocles, Shakespeare or Schubert,
Dante or Degas, Austen or Auden,
Mozart or Molière.

What remained were drudgery,
boredom, exhaustion. At problem 12
on page 322, Curiosity died.

(cited in [1], author (www.davidolsenpoetry.net) gave permission to reproduce poem.

NB: the formatting has been adapted to match the formatting conventions for this publication.)

Engineering education researchers have been aware for decades that there is a diversity problem, with the number of women in engineering plateauing around 20% for the past 30 years [2]. Even though significant funding and resources have been dedicated to trying to increase diversity, the problem persists. Some scholars posit that this is because much of the gender and diversity research in engineering education is routed in trying to ensure equal rights and opportunities for women without deconstructing the underlying ideals and hierarchies that perpetuate inequality in engineering [3]. To better understand these hierarchies, we aim to explore a range of *dualisms* that have been identified in engineering.

In this special session, we will explore the dualisms that exist within engineering education and how different dualisms are interconnected. Particular focus will be on the emotional/rational dualism and how this presents as a hierarchy (rationalism is valued higher) in engineering classrooms. We believe that when we can move beyond this idea that the teaching and learning of engineering can only be achieved through rational reasoning, we often are able to consider the whole system and we gain more insight into relationships and patterns. Through integrating a more holistic approach to problem solving, we can foster more inclusive learning environments and support developing well-rounded engineers.

II. Background

A. Engineerig Dualisms

Dualisms in engineering and engineering education are not only persistent, they also construct a hierarchy among the pairs in each dualism, that is, one type of thought and perspective is perceived to be superior over another. A summary of common dualisms in engineering is provided below in Table I, with the higher valued items on the left. For example, rational thought is often valued higher than emotional engagement, and technical aspects are valued over societal concerns [4-8]. Often there is a particularly strong emphasis on rational problem solving without consideration for emotional reasoning to support problem solving [9]. Even when engineering educators have tried to integrate emotions into their teaching, students often struggle to understand the nuance and feel they can choose to switch emotions on or off [10].

TABLE I. EXAMPLE DUALISMS PRESENT IN ENGINEERING EDUCATION CULTURE [8].

Higher-Valued	Lower-Valued
Man	Woman
Reason	Emotion
Mind	Body
Active	Passive
Technology	Society

Through exploring dualisms, it is important to remember that a dualism assumes a pair, or a binary, that there are two sides or two perspectives. Thus, we must consider that the goal is not only to disrupt the hierarchy, but also to disrupt the binary division itself [11]. In engineering particularly, there is a tendency to categorize everything with clear black and white divisions, and anything that falls outside the categories is deemed 'not normal' and, consequently, inferior [11]. Through critically deconstructing dualisms, we aim to create broader perspectives that allow students to develop more nuanced knowledge and understanding about engineering phenomena and that can be used to invite more creativity and innovation into engineering classrooms.

Despite the pervasiveness of dualisms and hierarchies in engineering and engineering education, these are often invisible – they manifest as a *hidden curriculum* [12-15] and are therefore particularly resistant to change. The hidden curriculum considers the implicit messages of what is valued in a community, often in relation to ideals, attitudes and structures of the institution [13]. The dualisms that exist within engineering are often part of this hidden curriculum. For example, hidden curriculum analysis has found that there is a strong "prioritizing of technical content and marginalizing ethical and societal issues" in engineering [13]. In this dualism, the technical and the social are seen as opposites. Overall, hidden curriculum and dualisms provide a valuable lens to investigate the rational-emotional dualism prevalent in engineering.

B. Emotions, Learning, and Problem Solving

Scholars have looked at the role of emotions in problem solving activities in mathematics, science, and engineering disciplines. In these disciplines, it is important to understand the role of emotions in learning as students are often engaged in *complex*, or even *wicked*, problem solving, which can be influence by, and trigger, strong emotions [16]. Complex problem solving is differentiated from simple cognitive tasks by five criteria: "(1) complexity of the situation; (2) connectivity of variables; (3) dynamic development of the situation; (4) intransparency or opaqueness; and (5) polytely (pursue of multiple goals)" [17] In addressing wicked problems, students are further challenged by the irreducible presence of conflicting norms and values, different ways of framing a problem, and different views of what makes a good solution to a problem [18]. Discipline-specific approaches to emotional integration can lead to stronger learning outcomes, particularly in disciplines such as science and engineering which are founded in rational and post-positivistic approaches [19]. Within engineering education specifically, there has been effort to create a cohesive research agenda to better understand the role of emotions in teaching and learning [20, 21].

In the wider field of education research, emotions have also been found to be highly important in all aspects and at all levels of education [22]. For example, emotional intelligence has been found to mediate students' transition to higher education, which greatly impacts their first-year grades [23]. Although much scholarly work has found that there is little direct relationship between emotional intelligence and academic achievement, this research emphasizes the importance of emotional intelligence and self-regulation skills in mediating and supporting students and their success in postsecondary education [24].

III. Special Session Overview

This session will provide a thought-provoking discussion and novel approach to considering engineering education. The session will be driven by two main activities. After a short introduction on the literature, participants will engage in the first activity discussing their own experiences with dualisms, emotions, and hidden curriculum in engineering classrooms and problem solving activities. Using the dualism framework resented in Table I, participants will analyse their pedagogical approaches and consider areas for improvements to help further foster an inclusive and rich learning environment.

After a debrief, participants will apply their ideas to problem solving activities from their own classrooms, creating an action plan for integrating emotions into problem solving in their context. The goal of the second activity is to support the participants in creating a counternarrative to the assumed rationality required for problem solving in engineering. The session will end with bringing together the ideas and concluding, where participants will share and learn from each other's ideas.

- 10 minutes: Introduction and overview of research on dualisms, emotions, and hidden curriculum
- 15 min: Activity: Sharing experiences of dualisms, emotions, and hidden curriculum in engineering problem solving
- 15 minutes: Debrief + Set-Up Next Activity
- 20 min: Activity: Developing actions plans for integrating emotional problem solving and counternarratives to assumed need for rationality in engineering
- 20 min: Debrief + Conclude

The hierarchy created by dualisms in engineering classrooms can foster unwelcoming classroom environments, particularly for minoritized identities [3]. Most dualisms are invisible and act as part of the hidden curriculum of engineering, which makes talking about them even more important [13]. Through this work and this special session, we hope to bring light to these hierarchical dualisms that exist in engineering and begin the difficult work of opening up engineering and engineering education to a multitude of perspectives, including emotional aspects of engineering problem solving.

Overall, participants will leave the session being able to describe important dualisms that persist in engineering and engineering education and that limit multi-perspective problem solving and innovation. Participants will have explored these dualisms, developed an action plan for integrating emotional problem solving in their teaching, and discussed counternarratives to the assumed rationality required for engineering problem solving, and they will have created an action plan on what they can do to make changes in their classroom.

IV. Session Facilitators

Robyn Paul is a PhD student at the University of Calgary studying ecofeminism and hidden curriculum. She has facilitated over a dozen workshops nationally and internationally on her PhD work in these areas.

Johanna Lönngren is an Associate Professor in science and technology education at Umeå University. Her research focuses on emotions in engineering education, in general, and in ethics and sustainability education, in particular.

Maria Berge is an Associate Professor in science and technology education at Umeå University. She holds a Ph.D. in Engineering Education Research. Her research focused on interactional patterns and norms in science and technology education.

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