Engineering Strategies for Making Social Justice Visible & Valuable

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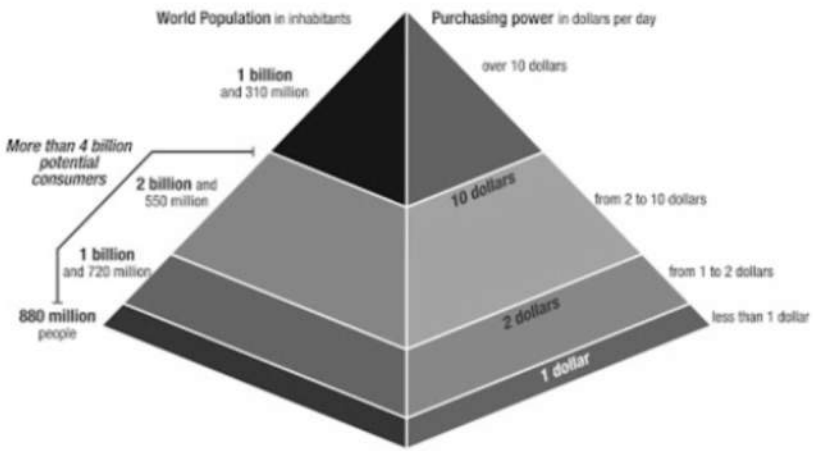
Main claim of this presentation

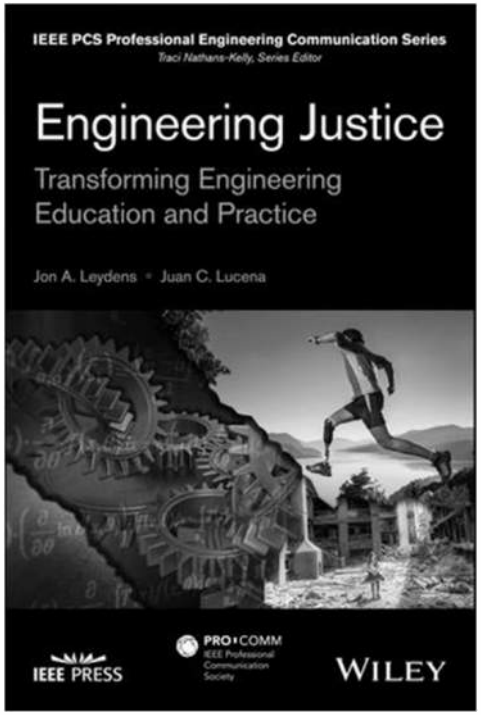
Until we show explicit relevance of the engineering curricula to the issues, problems, challenges, etc. facing communities historically underserved by engineering, we will only achieve very limited positive change for society.



Why Social Justice Matters

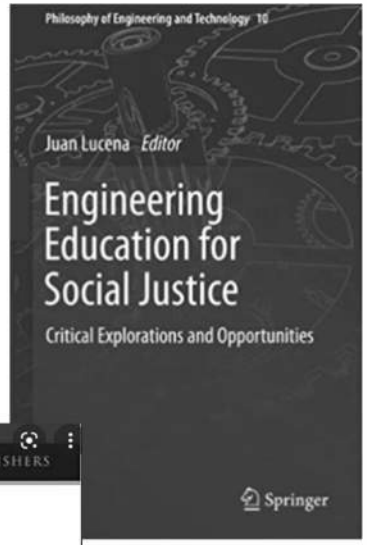
"With great power, comes great responsibility… engineering has the power to transform the world: the water we drink, air we breathe, infrastructure we use for transport, energy we produce, methods we use to conduct warfare and peace, and much more. Given the power of engineering, we need an engineering education that is tailored to the great responsibility engineers will assume in transforming life in the rest of the 21st century and beyond."

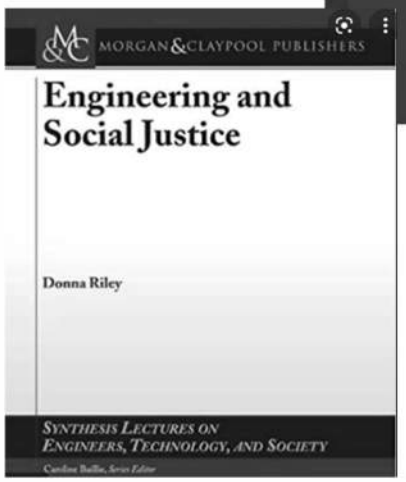
--Leydens and Lucena, 2017, *Engineering Justice* (Wiley-IEEE)



What we are up against: Engineering Mindsets

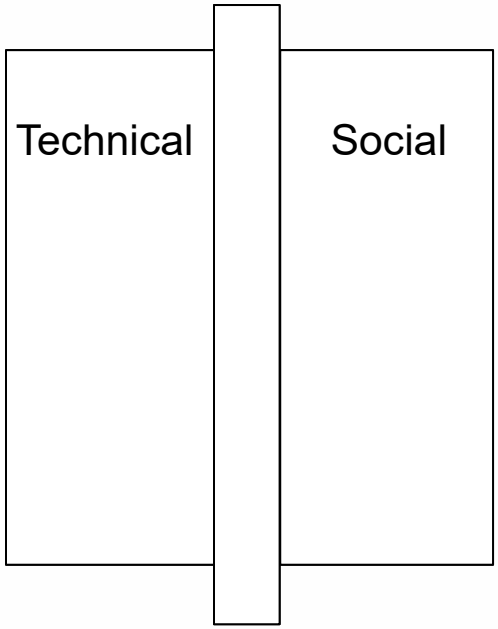
1. Centrality of corporate/military organizations
2. Desire to help
3. Uncritical acceptance of authority
4. Technical narrowness
5. Positivism and myth of objectivity





What we're up against: *The ideology of depoliticization*

- Engineers value and reify the "technical" side of the divide; HU/SS the "social" side
- Recreated and perpetuated through process of acculturation in engineering education/practice
- Visible everywhere in our universities: building layout, curriculum, language, salaries, etc.



- **But wait… engineering is socio-technical**

Engineering Practice is Sociotechnical

"In our research, we found that more experienced engineers, those who had stuck with it for a decade or more, had mostly realized that ***the real intellectual challenges in engineering involve people and technical issues simultaneously***. Most had found working with these challenges far more satisfying than remaining entirely in the technical domain of objects."

(Trevelyan, 2014 emphases added) Similar conclusions: Stevens, Johri, & O'Connor, 2014; Martin, Maytham, Case, & Fraser, 2005

How to challenge engineering mindsets and ideologies while enhancing socio-technical integration?

- **Problem space (Textbook problems)**
  - **Most basic unit of teaching in engineering science courses; reinforces engineering identity, engineering mindsets/ideology hence important space for action**
- Project space
- Course space (One course)
- Boundary space (Lectures, events, conferences, etc.)
- Program space (minors, certificates, majors, etc.)

Engineering Problem Solving (EPS)

1. Given: **Problem statements** given **to students**
2. Find: **students asked to find a numeric solution**
3. Free-body diagram**: An abstract model of the problem**
4. Science: **Identify scientific principles that apply to the problem at hand**
5. Assumptions: **Learn to make assumptions to simplify problem**
6. Math: **Use math and tricks to solve equations**
7. Solution: **Reward or punishment for ONE solution (must have units!)**

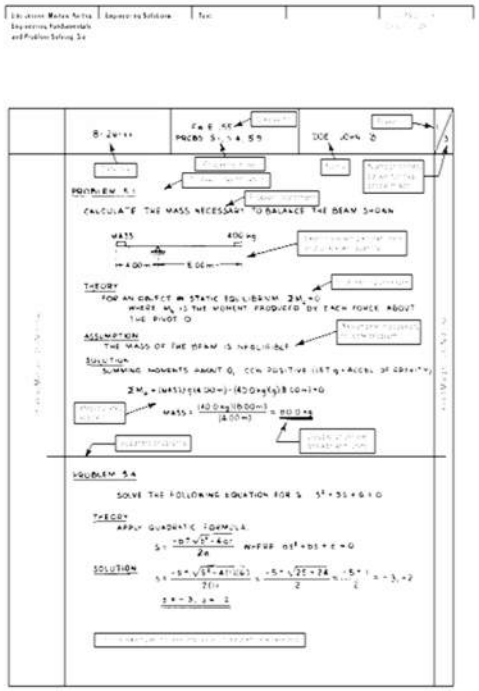
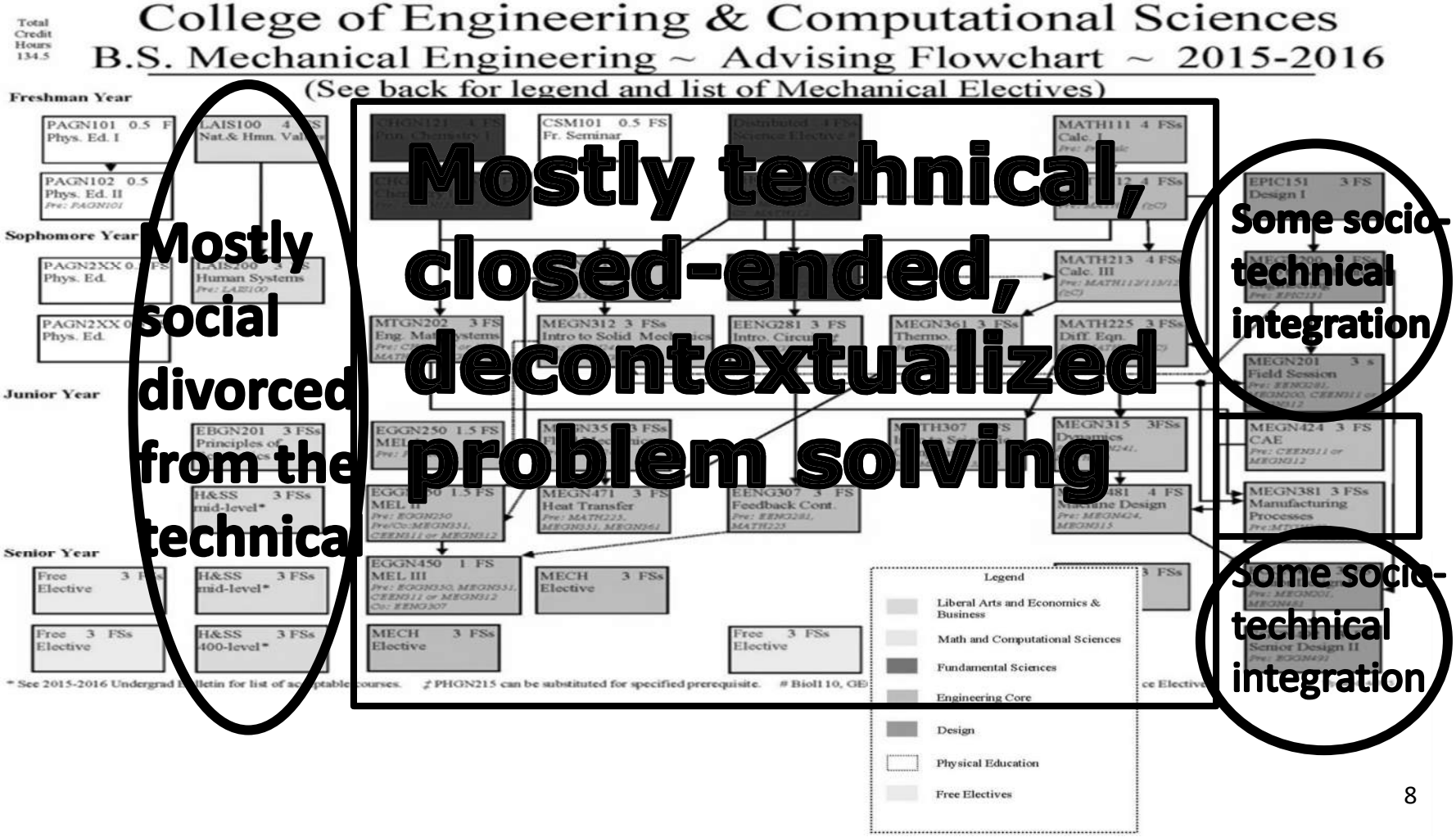


Figure 1


College of Engineering & Computational Sciences
B.S. Mechanical Engineering ~ Advising Flowchart ~ 2015-2016
(See back for legend and list of Mechanical Electives)
Total Credit Hours 134.5
Freshman Year
Sophomore Year
Junior Year
Senior Year
Mostly social divorced from the technical
Mostly technical, closed-ended, decontextualized problem solving
Some socio-technical integration
Some socio-technical integration
Legend
Liberal Arts and Economics & Business
Math and Computational Sciences
Fundamental Sciences
Engineering Core
Design
Physical Education
Free Electives

No other method gets this much time and energy from our students

Rough estimates of how many problems, using EPS, our students would have solved by the time they graduate.

- Civil: 1400 - 2130
- Environmental: 2100- 2800
- Electrical: 2000- 3000
- Mechanical: 3290- 3800
- Eng Physics: 3000- 5000
- Chemical: 1100 – 2250
- Petroleum: 1700 - 2300

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When Students Resist: Ethnography of a Senior Design Experience in Engineering Education*

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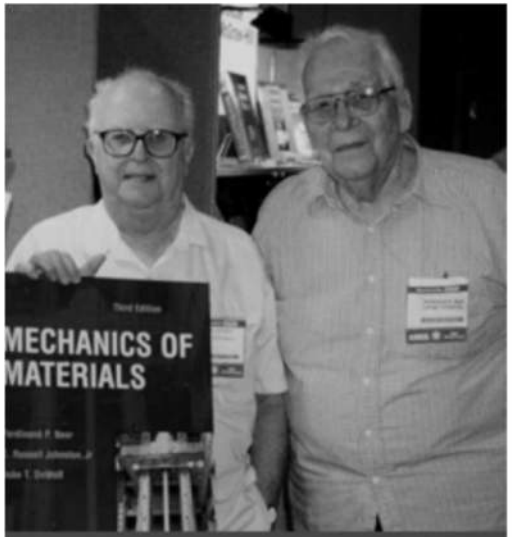
This ethnographic study explores how engineering students in a traditional senior design course interpreted design assignments in terms of the engineering sciences. These students, who had been taught to value the distinction between 'science' and 'design,' tended to resist design education. They had learned to think about design as a trivial extension of mathematical problem solving. This predisposition made it difficult for activist faculty to convince students that design introduces entirely new learning issues. Although limited in scope, this study suggests that for reform in engineering education to be successful, it may need to go beyond engineering design to rework

- Problems often defined elsewhere often by Cold War engineers w/o interest in SJ
- What is important to FIND also established elsewhere by someone else, often not related to SJ interests
- FBD further isolates problem from its social context
- MATH-BASED SCIENCE becomes <u>only option</u> to analyze problem.
  - What if problem is unjust to begin with?
- <u>One-solution</u> requirement leads students to think that problems have only one solution; no extra points for SJ inclusion



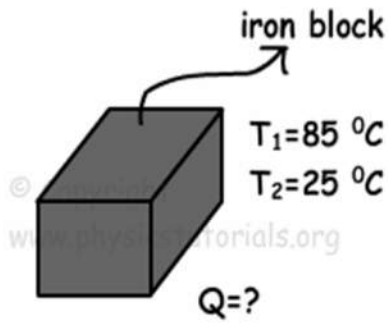
Drs. E. Russell Johnston and Ferdinand Beer

"The books authored by Drs. Johnston and Beer have retained their place as mainstays used by millions of students in colleges and universities worldwide, and they have been translated into Japanese, Greek, Chinese, Spanish, Portuguese, Turkish, French, Indonesian and other languages."

Problem rewrite

Example: Temperature of the iron block decreases from 85 ºC to 25 ºC. If the mass of the block is 1,2kg, calculate the heat lost by the block.

(c_{iron}=0.115cal/g.ºC)



Q_{lost}==$m_{iron}.c_{iron}.\Delta T$

Q_{lost}=1200g.0,115cal/g.^0C.(85 ^0C-25 ^0C)

Q_{lost}=8280 Calorie is the heat lost by the block

Rewriting problems to counteract ideologies and mindsets of engineering

The number of homeless persons increases due to foreclosures. Hypothermia kills approx 700 homeless people each year**.** A homeless man sleeps in open park with benches without designs to prevent homeless sleeping in them and where police do not harass them even though park is colder and windier than other locations.

Rewriting problems to counteract ideologies and mindsets of engineering

While our body temperature falls only 2 degrees at night in our comfortable beds (from 98.6F to 96.6F), in this open park, the temperature of a human body decreases from 98.6F to 88F in one hour. If it falls below 80F one will die. Calculate the heat lost by the man in one hour.

- Conservation of Energy: Qgained = Qlost
- m1.c1.T1 = m2.c2.T2
- $Q_{lost} = m.\ C_{human}.\ \Delta T$
- C_{human} = 3470 J/kg.°C (average and assuming that 60% of human adult body is water)
- 1 J/kg.°C = 2.389 x 10 -4 Btu/lb. F

Rewriting problems to counteract ideologies and mindsets of engineering

Because many homeless persons are afraid of sleeping in shelters, they prefer to continue sleeping in the street. Design a moveable shelter that allows a homeless person sleep through the night with a decrease of body temperature of 1F per hour

“The best part about these problem rewrites was that they are involved with what I am studying, and it opened opportunities for me to **finally figure out how I can “make a difference” using my engineering skills**. Although these are just problem rewrites, they have **opened my mind to how I can incorporate social justice into my engineering career**, and there is not a better feeling than finally **understanding that it is indeed possible to do good with my career**.” (Student reflection, Spring 2021)

Challenging engineering mindsets and ideologies while enhancing socio-technical integration

- Problem space (Textbook problems)
- **Project space**
- Course space (One course)
- Boundary space (Lectures, events, conferences, etc.)
- **Program space** (minors, certificates, majors, etc.)

Project space: E-waste and the informal sector

- **E-waste increased generation:** 25% t/y (2018-2020)
- More **informal* workers:** 600 -> 2,000 (2017-2019)
- Increase in the number of **cooperatives in Bs As** (2022)

- **Fundamental** actors, but historically **not recognized.**
- **Disadvantaged** labor conditions.

- **Harmful practices** and effects reported: e.g. children with high levels of **lead in blood.**
- Lack of information to **perceive/understand risks.**

- No reported interventions to **minimize risks in the short-term**.

Sources: Paiva & Banfi, 2016; Schamber, 2006;Schettini & Herrero, 2017; Clinckspoor & Ferraro, 2020; Castillo et al., 2022; Maffei et al., 2020;Maffei & Burucua, 2020…

Program Space: From small faculty/student interest to institutional priority

MS in Humanitarian Engineering & Science at Mines with tracks in…

- Environmental Engineering
- Geological Engineering
- Geophysics
- Humanitarian Robotics
- Data Science
- Interdisciplinary

Humanitarian ENGINEERING
SOCIAL JUSTICE COMMUNITY SUSTAINABILITY
COLORADO SCHOOL OF MINES

Questions?

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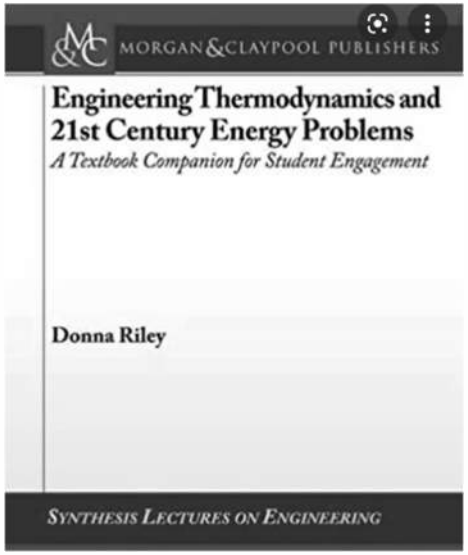
Engineering for Social Responsibility
COLORADO SCHOOL OF MINES

Humanitarian ENGINEERING
SOCIAL JUSTICE COMMUNITY SUSTAINABILITY

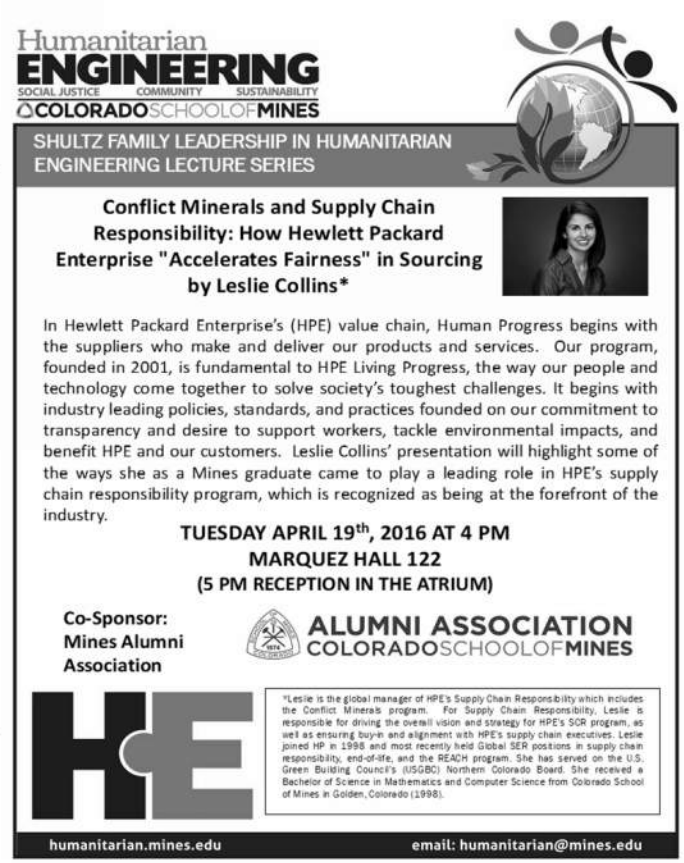
Encouraging examples

- Circuits and Materials at U of San Diego
- Semi-conductors and Feedback Controls at Mines
- Thermal/Mechanical Systems at CalPoly
- BME at UWA



Boundary space: Alumni engagement

- Invited lectures
- Visiting courses
- Alumni interest group
- Participating in research projects
- **All of these become reference points to challenge technical/social dualism**



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SHULTZ FAMILY LEADERSHIP IN HUMANITARIAN ENGINEERING LECTURE SERIES

Conflict Minerals and Supply Chain Responsibility: How Hewlett Packard Enterprise "Accelerates Fairness" in Sourcing by Leslie Collins*

In Hewlett Packard Enterprise's (HPE) value chain, Human Progress begins with the suppliers who make and deliver our products and services. Our program, founded in 2001, is fundamental to HPE Living Progress, the way our people and technology come together to solve society's toughest challenges. It begins with industry leading policies, standards, and practices founded on our commitment to transparency and desire to support workers, tackle environmental impacts, and benefit HPE and our customers. Leslie Collins' presentation will highlight some of the ways she as a Mines graduate came to play a leading role in HPE's supply chain responsibility program, which is recognized as being at the forefront of the industry.

TUESDAY APRIL 19th, 2016 AT 4 PM
MARQUEZ HALL 122
(5 PM RECEPTION IN THE ATRIUM)

Co-Sponsor: Mines Alumni Association

ALUMNI ASSOCIATION
COLORADO SCHOOL OF MINES

*Leslie is the global manager of HPE's Supply Chain Responsibility which includes the Conflict Minerals program. For Supply Chain Responsibility, Leslie is responsible for driving the overall vision and strategy for HPE's SCR program, as well as ensuring buy-in and alignment with HPE's supply chain executives. Leslie joined HP in 1998 and most recently held Global SER positions in supply chain responsibility, end-of-life, and the REACH program. She has served on the U.S. Green Building Council's (USGBC) Northern Colorado Board. She received a Bachelor of Science in Mathematics and Computer Science from Colorado School of Mines in Golden, Colorado (1998).

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