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A Single Lecture on the Political Economy of the Total Cost Curve Measurably Influences Engineering Students' Views on the Balance of Human and Planetary Value

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A Single Lecture on the Political Economy of the Total Cost Curve Measurably Influences Engineering Students' Views on the Balance of Human and Planetary Value

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Abstract

Engineering decisions increasingly require balancing economic feasibility with societal expectations for environmental stewardship and human well-being. Yet traditional coursework often emphasizes capital and operational costs while giving limited attention to unpriced dimensions of value. This paper investigates whether a single lecture introducing engineers to economic concepts foundational to true cost accounting – including the Tragedy of the Commons, Opportunity Cost, and the Total Cost Curve – can shift students away from philosophical absolutes and toward quantification of public value.

The intervention (see Appendix A) employs the prompt "How much would you pay to watch a beautiful sunset?" to elicit conceptions of environmental value ("everything", "nothing", "something") before and after instruction. Across eight matched course offerings (N = 479 from Spring 2017 through Spring 2025), responses before and after instruction shift markedly away from "everything" (from 25% to 11%, before and after, respectively) and "nothing" (from 47 to 22) toward "something" (27 to 68) following the lecture.

This highly reproducible pattern suggests that brief instructional interventions can advance student capacity to integrate environmental and social externalities into economic reasoning – skills aligned with ABET student outcomes and emerging expectations for engineers to participate in Environmental, Social, and Governance (ESG) leadership. The findings of this study also connect to ongoing work describing the care penalty – the systematic under-compensation of work linked to caring for people and the planet – and the Nurse+Engineer framework, a convergence model that translates patient-centered valuation from nursing practice into engineering design.

Introduction

ABET-accredited engineering programs require students to consider economic, social, and environmental dimensions when applying engineering design to produce solutions [1]. However, students sometimes approach environmental and social benefits as difficult to measure or external to engineering design decisions [2] [3]. This disconnect persists despite increasing expectations for engineers to lead in Environmental, Social, and Governance (ESG) frameworks, where public value must be articulated beyond direct financial project costs.

The National Academy of Engineering's "Changing the Conversation" campaign attempted to reframe public perceptions of engineering by emphasizing care-centered values such as helping people, improving quality of life, and protecting the planet [4]. Subsequent scholarship examined whether this reframing may have unintentionally emphasized work associated with the care

penalty, a concept originating in economics and describing how value linked to care labor is often under-compensated [5]. In the engineering domain, work associated with environmental protection and public welfare may similarly be undervalued when externalities are excluded from financial cost structures [5] [6] [7].

Recent educational efforts have sought to internalize public value into engineering reasoning. These include (i) integrating triple bottom line sustainability and full-cost accounting across courses [8] and (ii) translating patient-centered approaches from the caring profession of nursing into engineering ethics and design practice through the Nurse+Engineer convergence model [9] [10]. In the Nurse+Engineer model, engineers are asked to aggregate individual human values into a public-value construct, analogous to how nurses synthesize patient-level needs into care plans. This aggregation is the mechanism by which unpriced values enter engineering economic analysis. Collectively, these works present the case that engineers must be able to articulate value from the perspective of individuals and communities, not solely from regulatory or financial market constraints.

The present study builds on this prior work by examining whether a single lecture (see Appendix A) that combines concepts from political economy and environmental economics with valuation of environmental experience can shift student perceptions of value. The prompt "How much would you pay to watch a beautiful sunset?" functions as an analogous tool to those used in environmental valuation literature such as contingent valuation [11] and stated preference approaches [12], which seek to assign monetary value to traditionally non-market goods. While the educational intervention in this study does not constitute an example of full valuation, the approach incorporated into a department-wide, required, sophomore-level undergraduate engineering course is meant to engage students to recognize that environmental amenities can be valued in systematic ways.

This paper demonstrates that even a modest intervention – in this case, a single lecture – can serve as a powerful entry point for students to situate sustainability as an economic concern, which should have implications for a positive impact on ethical practice.

Methods

Eight cohorts enrolled in a department-wide, required, 2000-level (primarily sophomore-level) course, "Fundamentals of Environmental Engineering," offered at the Missouri University of Science and Technology and taught by the same instructor completed an anonymous survey – implemented in Polleverywhere.com – before and after a single lecture on risk, sustainability, and economic valuation.

Before the lecture, students selected one of three responses to the question: "How much would you pay to watch a beautiful sunset?" – (a) everything; (b) nothing; or (c) something.

The lecture (titled “Risk and Sustainability” to align with the textbook chapter titles, see Appendix A) framed valuation through concepts drawn from political economy and environmental economics:

- The Tragedy of the Commons – shared resources degrade when treated as free [13]
- Opportunity Cost – value is constrained by finite resources and tradeoffs [14]
- The Total Cost Curve – sum of costs of action and inaction used to estimate optimal investment [8]

The same prompt was administered after instruction.

Aggregated distributions were compared across eight course offerings (spring semester 2017, 2018, 2019, 2021, 2022, 2023, 2024, 2025; spring 2020 was not completed due to modified instruction associated with the COVID-19 lockdown).

Results

As shown in Figure 1, before instruction, the dominant response from students was “nothing” (mean 47%, standard deviation 14); with “everything” and “something” selected by 25% ± 13% and 27% ± 14%, respectively. After instruction, the proportion of students choosing “something” more than doubled to 68% ± 20%, while responses for “nothing” and “everything” declined to 22% ± 11% and 11% ± 12%, respectively.

These trends held across all but one offering (spring 2022, where “everything” was 52% before the lecture), suggesting a consistent shift away from unbounded or zero valuations toward quantified reasoning following exposure to economic framing concepts (Appendix A).

Discussion

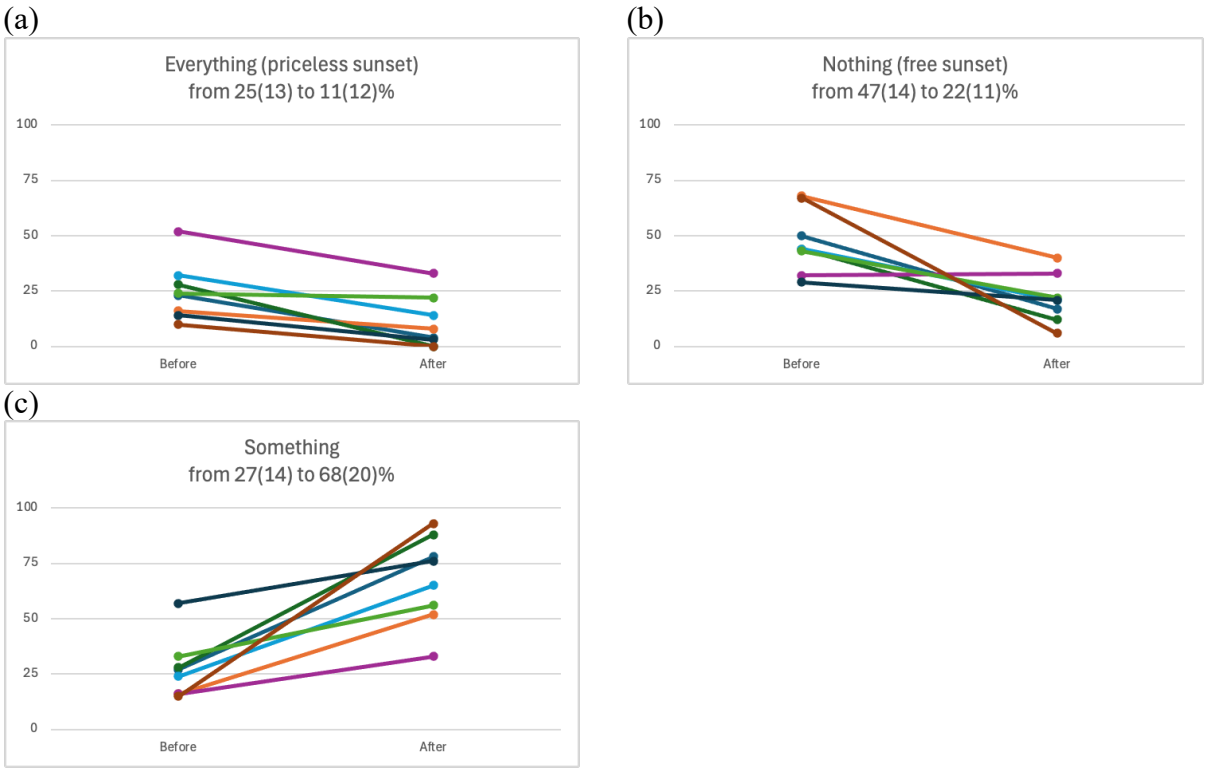
While the formal quantification of environmental value is ethically and methodologically contested, the practice of professional engineering requires assigning some measure to support decision-making as part of evaluating design alternatives. The observed shift toward selecting “something” after instruction indicates that students became more comfortable engaging with tradeoffs central to sustainability and ESG frameworks.

Although this module is presented to students under the standard curricular heading of “Risk and Sustainability” (Appendix A), the underlying mechanism of the shift appears to be the introduction of concepts from political economy and environmental economics - specifically the tension between individual self-interest and collective resource management. Furthermore, the use of the prompt “beautiful” (i.e., rather than “perfect” sunset) was intentional. While a “perfect” sunset may be understood to imply an infinite or spiritual value that defies pricing, and a sunset without any adjective may imply something of “no value”, a “beautiful” sunset was selected as the frame for the question to represent the environment as a high-quality, yet finite, amenity subject to economic trade-offs.

This work aligns with research demonstrating that care-centered engineering practices – those improving public health, safety, and welfare – may be undervalued when externalities are

excluded from standard financial accounting systems [5] [6] [7]. Introducing valuation frameworks – even simply frameworks such as zero and unbounded versus some value – may help future engineers articulate these dimensions in economic analyses, potentially counteracting the current concerns surrounding a lack of financial valuation, which often corresponds to a lack of explicit consideration in the design process.

Figure 1. Percentage of students responding (a) Everything, (b) Nothing, and (c) Something to the question "How much would you pay to watch a beautiful sunset?" before and after a single lecture.



Additionally, connecting valuation to the Nurse+Engineer model supports ABET outcomes related to informed judgment and societal context [1], as students encounter an alternative to stakeholder sampling that instead aggregates individual values into public value [9].

Importantly, while this intervention is small, it demonstrates that single pedagogical touchpoints can influence conceptual framing, complementing sustained curricular strategies [8]. Future research should examine whether students subsequently adopt numeric valuation or integrate total-cost reasoning in capstone or design contexts.

Limitations

Several limitations of this study should be considered. First, responses were categorical rather than numerical, precluding analysis of the magnitude of valuation and of motivations behind the observed shifts. Second, the three-option response structure ("everything," "nothing," "something") constrains how students can express their reasoning, and therefore, future iterations could incorporate open-ended numeric responses or short-answer justifications to disentangle whether the post-lecture shift reflects internalization of the concepts from political economy and environmental economics or movement toward a middle option as a function of the response structure itself. Third, the sunset prompt may introduce accessibility bias for students whose lived experience with scenic amenities differs, and therefore, future studies could allow students to select personally meaningful environmental goods. Fourth, measurements were taken immediately after instruction, which means that persistence of the conceptual shift was not assessed. Longitudinal follow-up – particularly in downstream design or capstone courses – could be explored to evaluate whether students retain and operationalize the framing introduced by a single lecture. Fifth, data come from a single instructor at a single institution within one required sophomore-level course. Cohort-level variability is evident in the data (notably, the Spring 2022 pre-lecture distribution, where 52% of students selected "everything"). Furthermore, instructor effects cannot be separated from content effects in a single-instructor design. Replication across instructors and institutions – as well as disciplinary contexts – is needed before claims of broad transferability can be supported.

Conclusions

A single lecture introducing foundational concepts from political economy and environmental economics can measurably shift engineering students toward quantifying public value, providing an accessible entry point into sustainability accounting and ESG-aligned reasoning. Integrating valuation prompts into early coursework – in this case during a required, department-wide, sophomore-level course – may help address long-standing structural issues – such as the care penalty – by preparing engineers to articulate how environmental protection and public welfare produce value that extends beyond immediate financial costs.

Artificial Intelligence

Consistent with the recommendation of transparency, accountability, and verifiability (as described in [15]), Claude Opus 4.7 was used to evaluate the near final draft of the manuscript. The specific prompt included: "Assume you are a program chair for the annual meeting of the American Society for Engineering Education. Evaluate the near final draft of the manuscript being submitted by corresponding author Professor Daniel Oerther of the Missouri University of Science and Technology (attached) and offer specific recommendations to improve the manuscript given the following: 1) instructions to authors for the meeting as originally published by ASEE (attached); 2) call for papers as originally published by ASEE (attached); 3) feedback from reviewers and program chair on the original abstract and subsequent draft versions of the manuscript." The author reviewed the feedback from Claude, the author edited the final version of the manuscript, and the author takes full responsibility for the manuscript.

Author approved TL;DR (as recommended by [16]): A single lecture on the political economy of the total cost curve measurably shifts engineering students toward quantifying public value, supporting ABET and ESG-aligned learning outcomes.

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Appendix A

Course: CArE 2601
Title: Risk and Sustainability

Questions, Announcements, Other

- **IF you have a question, you can be sure that at least one other person has the same question**
  - **SO PLEASE ASK!!!!**
- Any questions from prior lecture, lab, or general (syllabus, assignments, schedule, etc)
- Announcements
  - When's the next REQUIRED class meeting?
  - When's the next REQUIRED assignment due?
- Other – ANYTHING?

Review prior lecture
Think-pair-share

- Definition of environmental engineering
- Definition of environmental science
- Are 'all engineers' = environmental engineers?

Professional Engineers have a professional, ethical obligation to consider the environment (public's health, safety, welfare)



From google.com

Review vocab due today

- LD50
- Exposure pathway
- Latency
- Oncogenic
- Extrapolation

Optional

- What are the two reasons for risky behaviors?
- What is the 'precautionary principle'?
  - Do you think it's a 'good thing' or a 'bad thing'?
  - Pair-and-share

Polleverywhere.com:
Which is a risky behavior?
A) Riding a bicycle
B) Walking to work
C) Enjoying a swim
D) Breathing

What is the tragedy of the commons?

Think-pair-share

Tragedy of the Commons: An Argument Against 'Free'

"The tragedy of the commons is a dilemma arising from the situation in which multiple individuals, acting independently and rationally consulting their own self-interest, will ultimately deplete a shared limited resource, even when it is clear that it is not in anyone's long-term interest for this to happen. This dilemma was described in an influential article titled "The Tragedy of the Commons", written by ecologist Garrett Hardin and first published in the journal Science in 1968."

From Wikipedia

Who should pay for the environment?

From google.com

The Time Value of Money: An Argument Against 'Priceless'

From google.com

So, how do we calculate the '$200' answer?

- See example 6-2 from the text book
- How do we map the example problem to the word problem provided in the required homework assignment (where we calculate lifetime risk of benzene exposure for the nurse)?
- What are the assumptions and how do we document our assumptions?

Quantifying risk (exposure)

- Material (physical/chemical form)
- Exposed (biology)
- Duration/intensity/dose
- Single or multiple materials - synergy

Quantifying risk (exposure)

- Material (physical/chemical
- /biology)
- /intensity/dose
- Single or multiple ma nergy

chemistry

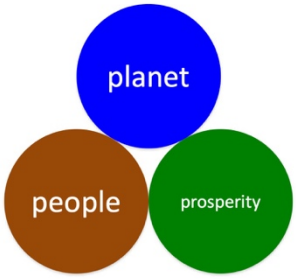
biology

Mass balance

Costs

- Costs of treatment – do you really want to use titanium as the building material for the Golden Gate Bridge?
  - (and won't one form of 'treatment' merely mean that you have some other 'yet-to-be-internalized-cost' somewhere else?)
- Costs of exposure – set to zero?
- Sum of total costs – attempt to minimize?

Which is more important?



From google.com