# Board 35: Essentials of the Nurse + Engineer: Defining Public Value for Civil Engineers

**Dr. Daniel B Oerther P.E., Missouri University of Science and Technology**

Professor Daniel B. Oerther, PhD, PE, BCEE, DLAAS, FAAN(h) joined the faculty of the Missouri University of Science and Technology in 2010 as the John A. and Susan Mathes Chair of Civil Engineering after serving for ten years on the faculty of the University of Cincinnati where he was head of the Department of Civil and Environmental Engineering. Professor Oerther is internationally recognized for leadership of engineers, sanitarians, and nurses promoting the practice the sustainable development, local to global. Dan is a Past President of the American Academy of Environmental Engineers and Scientists. He is a Diplomate Laureate of the American Academy of Sanitarians. Dan is a lifetime honorary Fellow of the American Academy of Nursing. Professor Oerther's awards as an educator include lifetime honorary Fellowship in the National League for Nursing's Academy of Nursing Educators and the Robert G. Quinn Award from the American Society for Engineering Education.

**Sarah Oerther**

# Essentials of the Nurse+Engineer: Defining Public Value for Civil Engineers

Daniel B. Oerther
Missouri University of Science and Technology, 1401 North Pine Street, Rolla, MO 65409

Sarah Oerther
Goldfarb School of Nursing at Barnes-Jewish College, 4483 Duncan Avenue, St. Louis, MO 63110

## Abstract

Increasingly civil engineers are being asked to incorporate a more inclusive meaning of "public" (i.e., who) and "public value" (i.e., inherently moral concepts) when planning, designing, and supervising the construction and maintenance of building and infrastructure projects. One way to improve the meaning of public and value is to borrow from the adjacent profession of nursing. Nurses are well-known patient-centered care, whether the patient is an individual, a population, or the public. Unlike civil engineers, who access public views by interacting with representative stakeholders, the nurse "builds up" a view of the public by collecting information on individuals, which are grouped into populations, and ultimately assembled into a sum that provides an aggregate measure of public views. To provide civil engineers with exposure to a nursing approach to building up a public view from interactions with individuals, a teaching module was designed to explain the concepts of "risk" and "sustainability". This module was incorporated into a department-wide required course entitled, "Fundamentals of Environmental Engineering." This course is required of undergraduate students of civil engineering, architectural engineering, and environmental engineers. This article includes details of the module. In particular, students are invited to answer an open ended questions, "how much would you pay to watch a perfect sunset?", and the results of student responses are used as part of teaching. The results of student response before and after a lecture module show a clear trend away from extreme answers of "everything" (i.e., a sunset is priceless) and "nothing" (i.e., a sunset is free), and towards a better understanding of public value and an answer that reflects "some dollar amount," which is created from the sum of the values expressed by each individual. A subsequent lecture module introduces students to the concept of full-cost accounting as a way to integrate individual values into a net aggregate public value. We discuss an important limitation of this approach, namely that assessing the "value of a sunset" may be biased for those who are visually impaired, colorblind, or photosensitive. This work highlights the convergent approach known as the nurse+engineer, where transdisciplinary integration across two diverse professions is used to solve a pressing societal challenge, in this case a more inclusive meaning of public value constructed from a collection of individual values expressed by individual people in response to the question, "what is the value of a sunset".

## Introduction

Licensed, professional civil engineers have an ethical obligation to protect the health, safety, and welfare of the public [1]. But how is the "public" defined, and when do students of civil engineering learn to define "public value"? According to ABET criterion 3, student outcomes, the education of future civil engineers requires students to learn design that meets cultural,

social, and economic factors as well as to learn to make informed judgments considering societal and economics contexts [2]. Increasingly, a more inclusive meaning of the public is being considered in light of a goal to achieve social justice while reducing systematic bias, which has been incorporated into historical infrastructure from an era when "separate but equal" was the law of the land in the United States (US) [3].

Recently, engineering educators have argued that collaboration with the profession of nursing offers an improved approach to teaching students of engineering about the meaning of public and "public value" [4, 5]. At the same time, nurses have argued for the importance of diversity, equity, and inclusion (DEI) as part of nursing education [6]. As professions, both nursing and engineering share a common commitment to the health, safety, and welfare of the public [7, 8, 9]. Although nursing is not yet considered part of the STEM professions – science, technology, engineering, and medicine [10, 11, 12, 13], collaborations among nurses and engineers have been described for many years [14, 15]. For example, more than 50 peer reviewed articles on the collaboration among nurses and engineers were included in a recent systematic review [16]. These articles highlighted the opportunity for the two professions to work together at the bedside [17] and into the community [18] to improve the healthcare industry [19, 20], academic partnerships [21], and to train a future generation of professionals [22] with new paradigms of technology [23].

In professional practice, often civil engineers engage broadly with a wide variety of stakeholders – individuals and organizations who make up the public. Because civil engineers work with a "sample" of the public, the approach of civil engineers may be limited to "selection-bias" – in other words the civil engineer may not have a sufficiently representative/comprehensive view gained from a random assembly of diverse individuals representing segments of the community. In contrast to civil engineers, nurses use a different approach to engage with the public. The nurse centers the patient as the chief priority. And nurses are unique among healthcare professionals as the nursing patient may be an individual, a population, or a community [8, 9]. Thus, nurses "build up" a view of the public through a collection of individuals, families, and populations drawn from across a range of diverse backgrounds.

This difference in framing, e.g., the civil engineer working with representatives (i.e., stakeholders) of a "faceless"/"nameless" public versus the nurse who builds up the public "individual-by-individual", block-by-block, while leaving no one behind, provides an important lens to be used when teaching civil engineers about public value from a nursing perspective [9, 24].

Previously research has included adopting a nursing approach to an understanding of the public to evaluate and improve access to safe food and water [25, 26, 27, 28, 29], employed in the information economy [30], and insurance to protect capital from weather-related losses [31]. While this prior research has focused on the topic of sustainable development [32], the approach is generally applicable to training future engineers about the importance of STEMpathy – or the addition of empathy to the practice of engineering – through a focus on "heads", "hands", and "hearts" learning [33]. In particular, understanding the concept of "risk" provides an opportunity to share with engineers an alternative approach from nursing to assess public views [34].

To adapt a nursing approach of public to benefit the education of civil engineers, a teaching modules was developed to highlight for students of civil engineering that "public value" may be assembled through collecting individual data from individual respondents to create an aggregate meaning of public value. The context for this teaching module is the framework of risk and sustainability, where risk is the possibility of loss or injury from a hazard and sustainability includes the responsible use of resources of manage risk. In the modern era, known as the Anthropocene, when human activity is the dominant force for change on planet Earth, we argue that two questions confront humanity [35]. These two questions include: 1) how to use technology to support human flourishing; and 2) how to use social contracts to address inequity [35]?

Previously, we described how engineers and nurses can work together to address the ethical dilemma of placing a value on resources available to the public [36]. Specifically, we noted that a global world view of sustainable development was needed when addressing the local issue of risk, including risk to public health, safety, and welfare [37].

For nurses, risks can be related to finances [38, 39, 40]. These relationships may include simple economic concepts such as return on investment (ROI) or more complicated concepts such as opportunity cost and the tragedy of the commons. Ultimately to understand the consequences of the Anthropocene, predictive models can be used such as a Malthusian world view, which is when the growth in consumption (i.e., by the human population) outpaces growth in production (i.e., as an output of technology and natural resources) such that devastating imbalance occurs resulting in major famine and ensuing conflict.

To link sustainability and risk with the value the public places on health, safety, and welfare, the module to teach the meaning of public value was developed and included in an existing course entitled, "Introduction to Environmental Engineering" [41]. This course is part of the degree requirements for students of civil engineering, architectural engineering, and environmental engineering at the Missouri University of Science and Technology, a large, public, Midwestern university. A super majority of enrolled students opt to complete this course during their sophomore year of study, while a few students complete the course during the junior and senior years.

The purpose of this article is to share the details of the course module as well as the results of the responses of students to the question, "how much would you pay to watch a perfect sunset?" Students are asked this question before and after completing the module, and the results provide an indication of how the module impacts the students understanding of public value. The collective results of this study point to the benefit of convergence of nursing and engineering to educate students of civil engineering to contribute to solving the pressing societal challenges of the Anthropocene.

## Methods

Institutional context. Located in Rolla, Missouri, the Missouri University of Science and Technology was founded in 1870 as the Missouri School of Mines. In 2023, a total of more than 7,000 students (approximately 1,500 graduate and 5,500 undergraduate) are enrolled in

approximately 100 degree programs. Currently characterized as a Carnegie R2, a doctoral university with high research activity, S&T is home to three colleges. Within the College of Engineering and Computing, the Department of Civil, Architectural, and Environmental Engineering (or CArE) is one of the largest and most research productive programs on campus.

Course description. Fundamentals of Environmental Engineering, CArE 2601, is offered every semester as a 2 hour lecture and a 1 hour lab course (i.e., 2 hours of lecture content and 3 hours of lab content, weekly). The course description states, "course discusses fundamental chemical, physical, and biological principles in environmental engineering and science. Topics include environmental phenomena, aquatic pollution and control, solid waste management, air pollution and control, radiological health, and water and wastewater treatment systems." The primary textbook is Principles of Environmental Engineering by M. Davis and S. Masten. Details of the course have been published previously [41].

Details of risk and sustainability teaching module. Without providing students with any background, every student is asked to complete an anonymous, online survey to answer the open ended question, "how much would you pay to enjoy watching a perfect sunset?" The instructor collects the answers, and then reads representative answers to students in the classroom. Together, the instructor and students bin the answers into three primary categories, namely: 1) nothing – a sunset is free and I do not need to pay to enjoy it; 2) everything – a sunset is priceless and I am pleased to pay any amount possible; and 3) a range of dollar values (i.e., $5, $100, $5,000).

After collecting student responses, a lecture is offered to introduce two economic concepts. These two concepts are included as part of a larger lecture, which aims to introduce students of engineering to the important concepts of: 1) the differences between engineering (i.e., solving problems) and science (i.e., exploring hypotheses); 2) the ethical obligation to consider the health, safety, and welfare of the public; and 3) critical definitions of risk and sustainability, which are essential to engineering education (see slides provided in Appendix A).

The first economic concept that is introduced via lecture is the concept known as, "the Tragedy of the Commons." In brief, shared resources are poorly utilized by a group. This may include overuse or underuse because the aggregate of individual choice is poorly connected to the final outcome created by the aggregate choice of the group (i.e., air pollution by individuals may obscure the sunset for everyone – even those who did not participate in producing air pollution). The second concept that is introduced via lecture is the concept known as, "Opportunity Cost." In brief, a situation of limited resources means that trade-offs must be identified among difference end states (i.e., cleaning up all air pollution leaves no resource to clean up water pollution).

After this lecture, the students are allowed to answer the question once again, "how much would you be willing to pay to enjoy watching a perfect sunset?" On this second survey, students select from one of three prepopulated answers, namely: 1) nothing; 2) everything; or 3) some $ amount.

The results of the surveys before and after the lecture are collected each semester.

Subsequently, an additional lecture is provided on a final economic concept; namely, "the Total Cost Curve". In brief, costs of action and costs associated with the consequences of non-action are graphed independently, and a summation of the total costs are determined, and the minimum total cost is identified. Improvements in technology are shown to influence costs of action, and social and cultural values are shown to influence costs associated with the consequences of non-action. The total cost curve represents the public value typically understood by civil engineers, while the exercise in collecting individuals responses to the question of payment for a sunset represents the public value arrived at from a patient-centering approach such as that used in nursing. Collectively, the exercise is intended to converge the traditional approach of civil engineers and the traditional approach of nursing as an example of an essential of the nurse+engineer, namely defining public value.

Limitations of evaluating the value of a sunset. While the question of "how much would you pay to watch a sunset" has great utility for many students, there may be some students who may not respond well to this question. For example, students who are visually impaired, colorblind, or photosensitive may not be able to relate to the question. Therefore, it is important that the instructor consider alternative questions that center each student as a unique learner and do not introduce bias that may hinder the learning of some students.

**Results**

The course, CArE 2601 Fundamentals of Environmental Engineering, is offered every semester at S&T. The module on risk and sustainability corresponds to Chapter 6 "Risk" and Chapter 8 "Sustainability" appearing in Principles of Environmental Engineering and Science by M. Davis and S. Masten. The web site, Polleverywhere.com is used to collect anonymous student responses to the question, "how much would you pay to watch the perfect sunset?" The first time this question is asked prior to completing the module, students are invited to provide a response using an open-ended/free format text box. The second time this question is asked as a follow-up to the module, students are invited to select one of three pre-populated responses, including: nothing; everything; and some $ amount.

The results of student responses – before and after completing the lectures which are part of the module – are included in Table 1. In each of the match pairs provided (i.e., Spring 2021 before the lecture and Spring 2021 after the lecture), the percentage of students who answered some $ amount was substantially lower before as compared to after the lecture (i.e., in spring 2021 the response to some $ amount increased from a low of 24% before the lecture to a high of 43% after the lecture). This recurring trend, a substantial increase in the percentage of students selecting some $ amount strongly suggests that the lecture provided in Appendix A provides the students with new learning that corresponds to a change in understanding of the value of public health, safety, and welfare.

**Table 1.** Aggregate results of students response to the question, "how much would you pay to watch a perfect sunset?"

| Description[2] | N | Nothing %[1] | Everything %[1] | $ %[1] |
|---|---|---|---|---|
| Sp 21 Before[2] | 25 | **44**[3] | 32 | 24 |
| Sp 21 After[2] | 23 | 27 | 30 | **43**[3] |
| Sp 22 Before | 25 | 32 | **52** | 16 |
| Sp 22 After | 33 | 33 | 33 | 33 |
| Au 22 Before | 23 | **61** | 21 | 18 |
| Au 22 After | 19 | 27 | 21 | **52** |
| Sp 23 Before | 21 | **43** | 24 | 33 |
| Sp 23 After | 18 | 22 | 22 | **56** |
| Au 23 Before | 28 | **46** | 21 | 32 |
| Au 23 After | 25 | 13 | 23 | **64** |

1. Results are reported as percentages of the total number of respondents (N) who answered "nothing", "everything" or "some dollar value".
2. The surveys were performed before or after the delivery of the module in the spring (Sp) or the autumn (Au) semester in the year 2021, 2022, or 2023.
3. For each matched pair (before and after), the higher percentage response is emphasized in **BOLD**. Of note: in each matched pair (i.e., Before and After), the results from Before are highest either for the answer Nothing or Everything, while the results from After are highest for $ (with the exception of Spring 2022, where the values from After were equal for all three answers).

Before the lecture, the single largest percentage of students answered either "nothing" or "everything" as the amount they would pay to watch a perfect sunset, which suggests that many students began class with the understanding that nature is something disconnected from the human condition (i.e., in both a positive, and a negative manner). In only one class, the spring of 2022, was the response "everything" the most popular response. In each of the six classes reported in Table 1, the response "some $ amount" was the most popular response after the lecture.

**Discussion**

Civil engineering includes planning, designing, and overseeing construction and maintenance of building structures and facilities, such as roads, railroads, airports, bridges, harbors, channels, dams, irrigation projects, pipelines, power plants, and water and sewage systems [42]. These systems often are built using public funding, and the value the public place on these systems is important to understand. Civil engineers often work with a selection of stakeholders as representatives to understand public value.

In contrast to the approach of civil engineers, members of the nursing profession center the individual patient in their work. In this way, the nurse builds up a view of public value through a summation of the views of every patient, whether these are individuals, families, communities, or populations.

Convergence, or a transdisciplinary approach that blends two disciplines to create a new approach to tackle existing societal challenges, is being used in this study through the lens of the nurse+engineer, a proposed V-shaped professional who is well suited to tackle the challenges of the Anthropocene [9].

Through teaching the module provided in Appendix A, civil engineering students were presented with tools to define public value, including "opportunity cost" as well as the "tragedy of the commons". Students of civil engineering learned to link their individual responses to a question of value with the consensus group response through a lecture on the concept of the "total cost curve". Previously, we suggested that sustainability and life-cycle principles were appropriate topics to be used to teach public value to engineers [43]. We emphasized that caring for human welfare and public health required full cost accounting to internalize values that historically have been externalized (i.e., not counted because they were presumed to not be part of the system) [44].

For civil engineers to address the twin challenges of the Anthropocene – namely excursion from planetary boundaries and inequity – it is important to practice in a manner that simultaneously considers cultural, social, and economic factors as well as considering societal and economics contexts [35]. The results presented in this article demonstrate that a simple exercise, such as asking students to offer their views on a question of individual value, may be used as the foundation to learning how to understand public value.

**Limitations**

While the results of this study demonstrate that a lecture on the economic subjects of "tragedy of the commons" and "opportunity cost" correlate to a change in student response to the question of the value of a sunset, no additional information is collected regarding the motivation for the change in the response by the students. Future research should identify preconceptions held by students on economic concepts before the lecture as well as improved understanding gained by students after the lecture. This type of data collection would help to better understand why the lecture corresponds to a change in student response to the question on the value of a sunset.

For example, the overall purpose of this work is to highlight for students of civil engineering that "public value" may be assembled through collecting individual data from individual respondents to create an aggregate meaning of public value. As currently presented, there is no clear measure that students have learned this concept. Rather, learning is inferred from the correlation observed in the change in response to the question of the value of the sunset from before and after the lecture. Future work should explicitly identify how students of civil engineering conceptualize public value, and measure how these concepts may change as students participate in this course module. Such an approach would better support the goal of leveraging the nursing approach to defining a patient as an individual, family, population or community and provide students of civil engineering with a better way to conceptualize public value by building up the responses of individuals to create a broad understanding of value.

## Conclusion

While civil engineering and nursing are different disciplines, there is benefit to leveraging the educational approaches of nursing to improve the understanding of civil engineers. In particular, public value may be better understood by "summing up" the views of individuals into an aggregate as opposed to "sampling stakeholders" using a more top-down approach. In this article, we show that students of civil, architectural, and environmental engineering develop an improved grasp of the importance of public value through a simple exercise, which includes an anonymous question assessing value as well as brief lectures on important economic concepts. In the future, this work should be replicated at other institutions and by additional instructors to confirm the general validity. None the less, based upon the data presented in this article we highlight that the convergent approach known as the nurse+engineer provides students of civil engineering with a more inclusive meaning of public value.

## References.


[1] ASCE, *Code of Ethics*. Reston, VA: American Society of Civil Engineers, 2020. [Online] Available: https://www.asce.org/career-growth/ethics/code-of-ethics.

[2] ABET, *Criteria for Accrediting Engineering Programs, 2022-2023*. Baltimore, MD: ABET Inc, 2022. [Online] Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2022-2023/.

[3] Library of Congress, *A Century of Racial Segregation, 1849-1950*. [Online] Available: https://www.loc.gov/exhibits/brown/brown-segregation.html.

[4] D.B. Oerther, "Using Nursing Theory to Improve the Teaching of Engineering Practice," in *ASEE Annual Conference & Exposition, Columbus, Ohio, June 25-28, 2017*. [Online] Available: https://www.doi.org/10.18260/1-2--29084.

[5] D.B. Oerther, P. Yoder-Wise, and B. Malone, "Identifying Opportunities for Educators to Pursue Collaboration at the Interface of Nursing and Engineering – and a Word of Caution," *J. Adv. Nurs.*, vol. 76, pp. 920-923, 2020.

[6] T.A. Murray, S. Oerther, and K.J. Simmons, "Anti-DEI Legislation Targeting Colleges and Universities: Its Potential Impacts on Nursing Education and the Pursuit of Health Equity," *Nurs. Outlook*, vol. 71, no. 101994, 2022.

[7] D.B. Oerther, and B. McCormack, "Person-Centeredness Enhances Public Health Approaches to Combat COVID-19," *J. Environ. Eng.*, vol. 147, no. 01821001-1, 2021. [Online] Available: https://doi.org/10.1061/(ASCE)EE.1943-7870.0001874.

[8] D.B,. Oerther, and S. Oerther, "Comparing Oranges Versus Grapes as a Metaphor of the Nurse+Engineer," *J. Clin. Nurs.*, vol. 31, pp. e14-e15, 2022.

[9] D.B. Oerther, and M.E. Glasgow, "The Nurse+Engineer as the Prototype V-Shaped Professional," *Nurs. Outlook*, vol. 70, pp. 280-291, 2022.

[10] P.S. Yoder-Wise, "From STEM to STEAM," *Journal of Continuing Education in Nursing*, vol. 49, pp. 443-444, 2018.

[11] P.M. Davidson, "Is Nursing a STEM Discipline – Does It Matter and What Can We Do About It?" *Journal of Advanced Nursing*, vol. 76, p. 1-3, 2019.

[12] C. Green, and L. John, "Should Nursing be Considered a STEM Profession?" *Nurs. Forum*, vol. 55, pp. 205-210, 2020.

[13] C. Dreisbach, M.L. Wright, R.K. Walker, H.D. Byon, and J. Keim-Malpass, "Nursing Science as a Federally-Recognized STEM Degree: A Call to Action for the United States With Global Implications," *International Journal of Nursing Studies Advances*, vol. 4, no. 100084, 2022.

[14] M.F. Hendrickson, "The Nurse Engineer: A Way to Better Nursing Information Systems," *Computers in Nursing*, vol. 11, pp. 67-71, 1993.

[15] W. Eisenhauer, "The Time Has Come for Nursing Engineering," *Industrial Engineer*, vol. 47, p. 24, 2015.

[16] Y. Zhou, Y. Li, and Z. Li, "Interdisciplinary Collaboration Between Nursing and Engineering in Health Care: A Scoping Review," *International Journal of Nursing Studies*, vol. 117, no. 103900, 2021.
[17] M.E.S. Glasgow, A. Colbert, J. Viator, and S. Cavanagh, "The Nurse-Engineer: A New Role to Improve Nurse Technology Interface and Patient Care Device Innovations," *J. Nurs. Scholarsh.*, vol. 50, pp. 601-611, 2018.
[18] D.B. Oerther, and S. Oerther, "From Interprofessional to Convergence: Nurses Educating V-Shaped Professionals," *Nurse Educ. Pract.*, vol. 53, no. 103047, 2021.
[19] R. McMaster, "Is the Fourth Industrial Revolution Relevant to You?" *Nursing and Health Sciences*, vol. 20, pp. 139-141, 2018.
[20] M. Sguanci, S. Mancin, M. Piredda, F. Cordella, N.L. Tagliamonte, et al, "Nursing-Engineering Interdisciplinary Research: A Synthesis of Methodological Approach to Perform Healthcare-Technology Integration Projects," *MethodsX*, vol. 12, no. 102525, 2024.
[21] K. Landsman, and K.K. Giuliano, "Nurse-Engineer Partnerships in Academia," *American Journal of Nursing*, vol. 123, pp. 44-46, 2023.
[22] Z. Wang, Y. Zhou, Y.D. Wang, and Z. Li, "The Training System and Characteristics of Graduate Education in Nursing Engineering and Nursing Informatics in the United States," *Chinese Journal of Nursing Education*, vol. 19, pp. 414-410, 2022.
[23] J. Bayuo, H. Abu-Odah, J.J. Su, and L. Aziato, "Technology: A Metaparadigm Concept of Nursing," *Nursing Inquiry*, vol. 30, no. e12592, 2023.
[24] D.B. Oerther, and S. Oerther, "Drinking-Water Fluoridation as an Example of the Nurse+Engineer Fostering Informed Decision and Actions," *J. Environ. Eng.*, vol. 148, pp. 01823001, 2023.
[25] D.W. Divelbiss, D.L. Boccelli, P.A. Succop, and D.B. Oerther, "Environmental Health and Household Demographics Impacting Biosand Filter Maintenance and Diarrhea in Guatemala: An Application of Structural Equation Modeling," *Environ. Sci. Tech.*, vol. 47, pp. 1638-1645, 2013.
[26] L.E. Voth-Gaeddert, M. Stoker, D. Cornell, and D.B. Oerther, "What Causes Childhood Stunting Among Children of San Vicente, Guatemala: Employing Complimentary, Systems-Analysis Approaches," *Int. J. Hyg. Environ.*, vol. 221, pp. 391-399, 2018.
[27] L.E. Voth-Gaeddert, O. Torres, J. Maldonado, R. Krajmalnik-Brown, B.E. Rittmann, and D.B. Oerther, "Aflatoxin Exposure, Child Stunting, and Dysbiosis in the Intestinal Microbiome Among Children in Guatemala," *Environ. Eng. Sci.*, vol. 36, pp. 958-968, 2019.
[28] D.B. Oerther, L.E. Voth-Gaeddert, and D.W. Divelbiss, "Improving Environmental Health Practice and Policy Through Convergence Research: A Case Study of Linked Food-Water Systems Enhancing Child Health," *Environ. Eng. Sci.*, vol. 36, pp. 820-832, 2019.
[29] L.E. Voth-Gaeddert, M. Stoker, O.R. Torres, and D.B. Oerther, "The Influence of Local Market and Household Factors on Aflatoxin Presence in Maize and Symptoms of Its Exposure to Children in Guatemala," *Int. J. Environ. Health Res.*, vol. 30, pp. 312-326, 2020.
[30] A. Schriner, and D. Oerther, "No Really, (Crowd) Work is the Silver Bullet," *Procedia Eng.*, vol. 78, pp. 224-228, 2014.
[31] D.B. Oerther, "A Case Study of Community-Engaged Design: Creating Parametric Insurance to Meet the Safety Needs of Fisherfolk in the Caribbean," *J. Environ. Eng.*, vol. 148, no. 05021008, 2022.
[32] A. Squires, F.S. Chavez, D.K.H. Messias, G.L. Narsavage, D.B. Oerther, et al, "Sustainable Development & The Year of the Nurse & Midwife – 2020," *Int. J. Nurs. Stud.*, vol. 94, pp. A3-A4, 2019.
[33] D.B. Oerther, and C.A. Peters, "Educating Heads, Hands, and Hearts in the COVID-19 Classroom," *Environ. Eng. Sci.*, vol. 37, pp. 303, 2020.
[34] D.B. Oerther, and R. Watson, "Risk Communication is Important for Environmental Engineering During COVID-19," *J. Environ. Eng.*, vol. 146, no. 01820002, 2020.
[35] D.B. Oerther, and S. Oerther, "Improving Interprofessional Environmental Health Education Using the Leave No One Behind Framework," *AJPH*, vol. 112, pp. S250-S252, 2022.
[36] D.B. Oerther, "Environmental Health Professionals: Local Interprofessional Collaborations Require Global Thinking to Meet Shared Ethical Obligations," *J. Environ. Health*, vol. 84, pp. 26-28, 2021.
[37] D.B. Oerther, "The Ethics of Professionalism in Environmental Health," *J. Environ. Health*, vol. 85, pp. 40-42, 2022.
[38] K.W. Dion, D.B. Oerther, and P.M. Davidson, "Nurse Leaders and Financial Literacy: Learning to Become CFO of Me," *Nurs. Econ.*, vol. 39, pp. 151-155, 2021.

[39] K.W. Dion, D.B. Oerther, and K.M. White, “Mastering the Health Savings Account,” *Nurs. Econ.*, vol. 69, pp. 255-259, 2021.
[40] K.W. Dion, D.B. Oerther, and R. Lavin, “Promoting Climate Change Resilience,” *Nurs. Econ.*, vol. 40, pp. 139-145, 2022.
[41] D.B. Oerther, “Reducing Costs While Maintaining Learning Outcomes Using Blended, Flipped, and Mastery Pedagogy to teach Introduction to Environmental Engineering,” in *ASEE Annual Conference & Exposition, Columbus, Ohio, June 25-28, 2017*. [Online] Available: https://www.doi.org/10.18260/1-2--28786.
[42] USBLS, *Occupational Employment and Wage Statistics: 17-2051 Civil Engineers*. April 25, 2023. [Online] Available: https://www.bls.gov/oes/current/oes172051.htm.
[43] D.B. Oerther, “Using Modified Mastery Learning to Teach Sustainability and Life-Cycle Principles as Part of Modeling and Design,” *Environ. Eng. Sci.*, vol. 39, pp. 784-795, 2022.
[44] D.B. Oerther, L. Gautham, and N. Folbre, “Environmental Engineering as Care for Human Welfare and Planetary Health,” *J. Environ. Eng.*, vol. 148, no. 04022029, 2022.

**Appendix A.**

1

Missouri University of Science and Technology

Course: CArE 2601
Title: Risk and Sustainability

2

Missouri University of Science and Technology

## 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?

3

Missouri University of Science and Technology

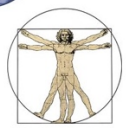
## Review prior lecture
## Think-pair-share

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

4

Missouri University of Science and Technology

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



From google.com

5

Missouri University of Science and Technology

## Review vocab due today

- LD50
- Exposure pathway
- Latency
- Oncogenic
- Extrapolation

6

Missouri University of Science and Technology

## Optional

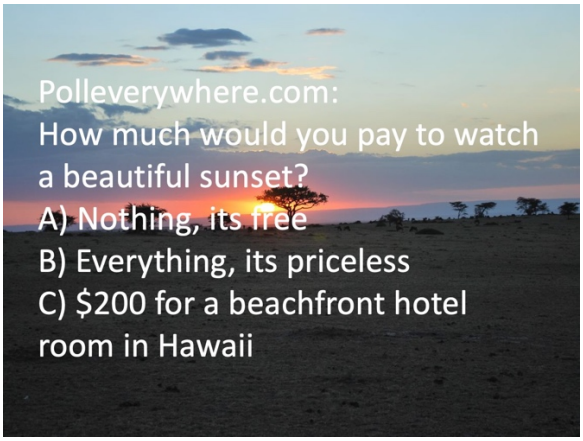
- What are the two reasons for risky behaviors?
- What is the 'precautionary principle'?
  - Do you think it's a 'good thing' or a 'bad thing'?
  - Pair-and-share

7



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

8




9



What is the tragedy of the commons?

Think-pair-share

10



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

11



Who should pay for the environment?

From google.com

12



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

From google.com

13



## 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?

14



## Quantifying risk (exposure)

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

15



## Quantifying risk (exposure)

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

chemistry

biology

Mass balance

16



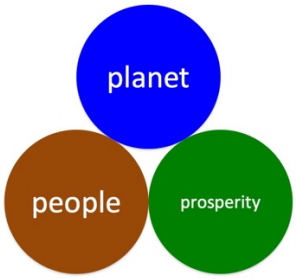
## Costs

- 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?

17



Which is more important?




From google.com