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Case Study: Essentials of the Nurse+Engineer: Differentiating and Integrating Humans and Nature in Civil Engineering

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

Professor Daniel B. Oerther, PhD, PE 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 of the American Academy of Sanitarians. Dan is a Fellow of the Association of Environmental Engineering and Science Professors, the American Academy of Nursing, and the National League for Nursing. In the United Kingdom, he is a Fellow of the Chartered Institute of Environmental Health, the Royal Society for Public Health, and the Society of Operations Engineers. Professor Oerther's awards as an educator include the Excellence in Environmental Engineering Education Award from the American Academy of Environmental Engineers and Scientists, the Gordon Maskew Fair Distinguished Engineering Educator Medal from the Water Environment Federation, the Engineering Education Excellence Award from the National Society of Professional Engineers, and the Robert G. Quinn Award from the American Society for Engineering Education.

Sarah Oerther

Case Study: Essentials of the Nurse+Engineer: Differentiating and Integrating Humans and Nature in Civil Engineering

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 consider a lens of planetary health, which is focused on analyzing and addressing the impacts of human disruptions to Earth's natural systems on human health and all life on Earth. But what are "natural systems"? And how would a civil engineer answer the question, "are people a part of nature, or separate from nature?" One way to improve how civil engineers differentiate and integrate humans and nature is to borrow from the adjacent profession of nursing.

To provide civil engineers with an appropriate theoretical lens to understand humans and nature, two theories from nursing were incorporated into a teaching module that emphasizes engineering ethics, including the ASCE Code of Ethics. The first is the "Environmental Theory" of Florence Nightingale, the founder of modern nursing, who explains that, "…the chief purpose of the [nurse or engineer] is to modify the environment to prevent illness and enhance healing." As part of the same module, students are introduced to the "Nursing Need Theory" of Virginia Henderson who noted that the, "unique function of the [nurse or engineer] is to assist the individual, sick or well, in the performance of those activities contributing to health or its recovery (or to peaceful death) that he would perform unaided if he had the necessary strength, will, or knowledge." Thus, human health, and the health of the environment upon which human health ultimately depends for clean air, clean water, nutritious food, and protection from the elements, are interrelated and inseparable such that damage to the planetary environment must be viewed as damage to human health.

This module was incorporated into an existing department-wide required course entitled, "Fundamentals of Environmental Engineering." This course is required of undergraduate students of civil engineering, architectural engineering, and environmental engineering. This article includes content and pedagogical details of the module as well as evaluations of student learning and assessments of instructor teaching. This study builds upon our prior result, which reported on a module leveraging nursing theory to create an improved understanding of "public" as part of the code of ethics where an engineer "holds paramount the health, safety, and welfare of the public".

As educators equip students of civil engineering to "change the world," there is a benefit of "borrowing" theory from the adjacent profession of nursing to improve understanding within pre-service learning as well as in the professional practice of civil engineering.

Introduction

Licensed, professional civil engineers have an ethical obligation to protect the health, safety, and welfare of the public [1]. But how is health, safety, and welfare defined, and when do students of civil engineering learn to define these terms? 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 "health" is being considered in light of changes being reported in the critical ecosystems that support all life on planet Earth (also known as "exceedance of planetary boundaries") [3].

One way that engineering educators can help students of engineering to define terms like "health" is to turn to adjacent caring disciplines, such as nursing [4] [5]. Both nursing and engineering share a common commitment to preventing illness and promoting wellness [6] [7] [8] [9]. For example, civil engineers consider how the "design" of transportation systems helps to prevent motor vehicle accidents or encourages walkable communities that promote physical health. Nurses have similar approaches to "caring", which help to prevent illness and promote wellness. The profession of nursing presents these approaches as "nursing theories". There are three levels of nursing theories, namely: grand theories; middle-range theories; and practical-level theories. As noted by the American Nurses Association (ANA), all nursing theories incorporate the nursing metaparadigm, which includes the four components of: 1) the person (patient); 2) their environment (physical and emotional; 3) their health; and 4) the nurse's approach and attributes [11].

Previously, we argued that two questions confront humanity in what is informally known as the "Anthropocene" – the current era from 1950 until present day when human activity is the dominant force for change on planet Earth – namely: 1) how to use technology to support human flourishing; and 2) how to use social contracts to address inequity [12]? In particular, in terms of defining "health", we asked if it is time to de-center the emphasis on "human health" and consider a more comprehensive view of "planetary health", which links human health with the health of the natural ecosystems upon which human health depends [13].

Previously, we reported on the use of nursing theory to help to inform the engineering definition of "public" [14]. Specifically we introduced the concept of full cost accounting as a way to integrate the values of individuals into a net aggregate public value [14].

In this current article, we report on the use of nursing theory to help to inform the engineering definition of "health". In particular, we explore the interface of "human" and "natural" and consider health as a complex concept that includes the body, mind, and spirit of people as well as the breadth of natural ecosystems upon which humanity depends.

An existing module in an existing course was modified to include two theories from nursing. The course, "Introduction to Environmental Engineering" 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 a series of questions implemented using Polleverywhere. Specifically students were asked: 1) is protecting the environment important? True or False; 2) which topic is the most important? Environment, Economy, Safety, Education, or Culture. Then a lecture was provided. Following the lecture, the students were asked, do you have to love the environment to be an environmental engineer? And responses included: yes, sure, I'm not sure, no but it probably helps, or not at all. The collective results of this study point to the benefit of convergence of nursing and engineering to solve 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 [15].

Details of introductory module. Without providing students with any background, every student is asked to complete an anonymous, online survey to answer two questions. The first question is, "is protecting the environment important?" and the available answers are, "True," or, "False." The second question is, "which topic is the most important?, and the available answers are, "Environment," "Economy," "Safety," "Education," or, "Culture." The instructor collects the answers and shares them with the students as part of the regular lecture.

The slides used for the lecture are included in Appendix A. The students are introduced to the Code of Ethics of Professional Engineering, including the idea that the Professional Engineer holds paramount the health, safety, and welfare of the public. In Autumn 2024, two additional concepts were added to this lecture, namely, the Environmental Theory of Florence Nightingale and Virginia Henderson's Nursing Needs Theory.

After this lecture, the students are asked to answer a final question, namely: “do you have to ‘love the environment’ to be an ‘environmental engineer’?”, and the responses included: “yes,” “sure,” “I’m not sure,” “no, but it probably helps,” or, “not at all.”

The results of the responses to all three questions are collected each semester.

Collectively, the module is intended to introduce civil, architectural, and environmental engineering students to the field of environmental engineering, and the addition of the two nursing theories is intended to provide an opportunity 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 differentiating and integrating humans in nature.

Results

As part of CArE 2601 Fundamentals of Environmental Engineering, the module on introduction to environmental engineering corresponds to Chapter 1 appearing in Principles of Environmental Engineering and Science by M. Davis and S. Masten. The results of anonymous responses of students to three questions – two before the lecture and one following the lecture – are provided in Tables 1, 2, and 3.

As reported in Table 1, the supermajority of students begins the course with the opinion that the environment is important. This trend holds steady from Spring 2021 through Autumn 2024.

Table 1. Student responses to the statement, “True or False: Protecting the environment is important.”

Semester and year	N (students)	TRUE (%age)	FALSE (%age)
Spring 2021	25	100	0
Spring 2022	25	97	3
Autumn 2022	23	100	0
Spring 2023	21	96	4
Autumn 2023	28	100	0
Spring 2024	37	100	0
Autumn 2024	69	94	6

As reported in Table 2, Education or Environment are among the most important topics as identified by the students. Economy or Safety are viewed as most important to a lesser number of students, and Culture is viewed as important to the fewest number of students. It is important to note that the question is worded to elicit a response to the “most important”, and therefore these data should be used with caution when considering a “rank order” of importance. The trend (education or environment > economy or safety > culture) holds steady from Spring 2021 through Autumn 2024.

Table 2. Student responses to the question, “Which is the most important?”. Students may select one of the following answers, including: “Environment (protecting nature)”; “Economy (creating jobs)”; “Safety (preventing crime)”; “Education (for our future)”; or “Cultural Values (immigration, same sex marriage, abortion).”

Semester Year	N (students)	Environment (%age)	Economy (%age)	Safety (%age)	Education (%age)	Culture (%age)
Sp 21	25	**44**	20	4	24	8
Sp 22	25	15	18	12	**48**	6
Au 22	23	32	12	4	**52**	0
Sp 23	21	**52**	13	4	30	0
Au 23	28	23	13	6	**52**	6
Sp 24	37	20	3	17	**57**	3
Au 24	69	**35**	24	13	24	5

As reported in Table 3, for the Spring 2021 through the Spring 2024 semesters, the supermajority of students responded that “no, but it probably helps” in response to the question, “do you have to ‘love the environment’ to be an ‘environmental engineer’. The results for autumn 2024 reflect a strong change in response, with “definitely YES!” as the response of the supermajority of students.

The primary difference between the semesters reported in this study is the inclusion of the two nursing theories in the lecture presented in Autumn 2024. The emphasis on Nightingale’s Environmental Theory and Virginia Henderson’s Nursing Needs Theory appears to create a meaningful change in the response of students with a significant increase in the response “definitely YES!”.

Table 3. Student responses (reported in percentages) to the question, “Do you have to ‘love the environment’ to be an ‘environmental engineer’? Students may select one of the following answers, including: “Definitely YES!”; “Sure”; “I’m not sure”; “No, but it probably helps”; or “Not at all.”

Semester Year	N (students)	Definitely YES!	Sure	I’m not sure	No, but it probably helps	Not at all
Sp 21	25	8	4	0	**76**	12
Sp 22	25	3	9	3	**79**	6
Au 22	23	8	12	0	**68**	12
Sp 23	21	8	4	0	**71**	0
Au 23	28	0	0	0	**100**	0
Sp 24	37	3	3	0	**76**	18
Au 24	69	**71**	11	0	14	4

As presented in Appendix A, the students in the course are introduced to the code of ethics of professional engineers as originally published by the National Society of Professional Engineers. As part of the course module, the students are introduced to the Fundamental Canons, which include the professional duty to hold paramount the health, safety, and welfare of the public.

During the lecture, the instructor asks students to consider the rhetorical question of "who is the public" as well as the rhetorical question of "what is health"? As described previously, the definition of the public is described in a separate course module using the concept of full cost accounting to integrate the values of individuals into a public value [14]. In the current module, the instructor then introduces two nursing theories – the Environmental theory of Florence Nightingale and the Nursing Needs Theory of Virginia Henderson – to provide the students with a conceptual framework to consider the concept of health. Health is presented as a complete concept, which means that health is not just the absence of disease, but that health is also the presence of wellness promotion and illness prevention.

The presentation of Nightingale's Environmental Theory makes clear that the purpose of the profession of nursing – including Registered Nurses (RN) who pursue a pre-licensure educational program similar to engineers that is grounded in basic sciences and mathematics and includes hands on, experiential learning – is to modify the environment to support health. The instructor notes that this is similar to the role of the civil engineer who designs and oversees infrastructure to create a built environment, which should promote wellness and prevent illness.

The presentation of Henderson's Nursing Needs Theory makes clear that the purpose of nursing is to help to meet the needs of the individual patient – as the patient defines them. And since a health environment is a requirement for a health human, the nurse has an obligation to use nursing knowledge to support the patient acquire environmental literacy – or an understanding that human health depends upon the health of the environment. Furthermore, this acquisition of knowledge by the patient ultimately should result in the self-sufficiency of the patient to pursue for himself or herself a healthy environment.

In this way, the instructor makes clear that the professional nurse – the RN – has a professional obligation to support environmental literacy. Put another way, because nurses support human health, and because human health depends upon the health of the environment, the nurse has an obligation to support environmental health as an approach to support the health of the patient.

As part of the lecture, the instructor helps to explain this concept using the example of smoking cessation and the avoidance of chronic obstructive pulmonary disease or COPD [16]. While 3 out of 4 individuals with COPD include prior chronic exposure to tobacco smoking, 1 in 4 individuals with COPD never smoked. Instead, these individuals may have been subject to occupational exposures or air pollution. In particular, long term exposure to particulate matter of a size of 2.5 nanometers or smaller (PM2.5) is a risk factor for COPD. Wildfire smoke – including both controlled burns as well as uncontrolled fires – is an environmental exposure that is immediately informative to students of civil engineering (as the University is located in proximity to a National forest where both managed and unmanaged fires create smoke that is regularly observed) [17].

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 [18]. Collectively, these systems often are known as the "built environment" and include structures where a majority of the public lives and works. In contrast to the "built environment," the public also spends time in the "natural environment", especially engaged in activities like play. For a variety of reasons, the "built environment" and the "natural environment" increasingly have been identified as "separate". This separation of built and natural – with humans spending a majority of their time in the built environment – contributes to a "disconnect" between humans and nature. The literature notes that "nature deficit disorder," is a non-medical condition where individuals, especially children, spend too little time in nature and therefore suffer from a disconnect with nature that is manifest in a variety of physical, mental, and spiritual ailments [19]. For the profession of civil engineer, one may ask, is the planning, design, and oversight of the built environment dependent upon the health of the natural environment, and therefore, do civil engineers have an ethical obligation to protect the nature environment if they are to uphold their professional obligation to protect the health, safety, and welfare of the public.

As described in the literature of nature deficit disorder, the disconnect between humans and nature may be manifest in "strange" ideas within the public, including perhaps even civil engineers who view the built and natural environment as separate things. For example, the notion that "food comes from the grocery store" is an idea that demonstrates a lack of an appropriate understanding of the origin of food in nature (while ignoring synthetic food such as lab-grown meat or synthetic sugar substitutes). Without an understanding of nature – also known as environmental literacy – members of the public, including perhaps even civil engineers, may fail to recognize that damage to the environment represents a real threat to the health of humans. To help to create an improved understanding of the interrelatedness among systems, the One Health Model is intended to promote an improved understanding that human health, animal health, and environmental health are interrelated and inseparable with a specific focus on preventing illness from zoonic organisms [20]. The One Health Model was cited in the exploration of the potential origins of COVID-19 from bats [21] as well as more recently in the culling of egg laying hens in the United States in an effort to control the spread of avian flu [22].

Through teaching the module provided in Appendix A, including the introduction of theory from the profession of nursing, civil engineering students were presented with tools to understand the connection between humans and nature (also known as the environment). Students of civil engineering learned that protecting the health of the environment represented one approach to protecting human health. And coupled with the ethical obligation to hold paramount the health, safety, and welfare of the public, civil engineers learned that an appreciation for the environment is an essential aspect of the work of environmental engineers [23].

For civil engineers to address the twin challenges of the Anthropocene – namely excursion from planetary boundaries and over consumption of natural resources – it is important to practice in a manner that simultaneously considers cultural, social, and economic factors as well as considering societal and economics contexts. The results presented in this article demonstrate

that including theory from nursing helps to improve the understanding of civil engineers about the connection between human and planetary health.

Limitations and Future Work

The results reported in the current study were limited to a significant change noted in a single course offering. In other words, a steady trend in responses from students was noted for multiple years, a new module was introduced, and a significant new result was observed. While compelling, this result needs to be reproduced to ensure reliability. None the less, the results of this study point to an early conclusion that the integration of nursing theory into the teaching of engineering education creates a change in understanding the importance of the environment for students of civil, architectural, and environmental engineering.

To confirm the validity of this result, reproduction by the team as well as examination of the impact of the approach by different teachers and at different institutions would be valuable to support generalizability of the result. Future work should reproduce and replicate the same approach being used by other instructors at other institutions.

Conclusion

Although nursing and civil engineering are different disciplines, the results of this study point to a benefit of leveraging nursing theory to improve the understanding of planetary health among students of civil engineering. The preliminary results in the current study need to be replicated both at the same institution with the same instructor, as well as with different instructors and students at different institutions. None the less, based upon the data presented in this article, we highlight the benefits of the convergent approach known as the nurse+engineer to improve the understanding of the link between human and planetary health among students of civil engineering.

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Appendix A.

1

[redacted]

Course: CArE 2601
Title: Intro Env Eng

2

[redacted]

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

[redacted]

Homeworks

- Required corrections due ONE WEEK after graded homeworks returned

4

[redacted]

Grades

- To achieve a grade above a C (70%), conventional grading will be performed on OPTIONAL exercises including … SEE SYLLABUS!
- No make up credit will be given for missed OPTIONAL exercises.

5

[redacted]

See poll everywhere

- Environment, important?
- Most important?
- Do you 'have to' love it?

6

[redacted]

Review what was due today

- Vocab:
  - who was John Snow,
  - when was first sewage treatment in the USA
  - what is multimedia
- Can you recall one of those flow-sheet diagrams?
- What's so special about 'dry wall'?

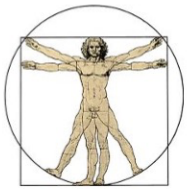
7

One piece of paper, two definitions

1. The environment is…
2. An engineer is…

8

Two views???



From google.com

9

One view???

From google.com

10

A serious question!

- Where does environmental 'ism' stop and engineering 'engineer' begin?
- Do you 'have to' love the environment, to be an environmental engineering?
- Can you do 'real' environmental engineering without at least some interest in the environment?

11

NSPE Code of Ethics for Engineers

- Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

12

Fundamental Canons

- Engineers, in the fulfillment of their professional duties, shall:
  - Hold paramount the safety, health, and welfare of the public.
  - Perform services only in areas of their competence.
  - Issue public statements only in an objective and truthful manner.
  - Act for each employer or client as faithful agents or trustees.
  - Avoid deceptive acts.
  - Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

13

The "Environmental Theory" of Florence Nightingale

- …the chief purpose of the [nurse or engineer] is to modify the environment to prevent illness and enhance healing…
- Environment includes:
  - Cleanliness
  - Fresh air
  - Clean water
  - Sunlight
  - Efficient drainage
  - Social, spiritual, and mental support

14

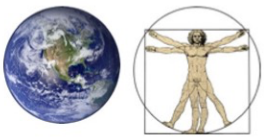
Virginia Henderson's Nursing Need Theory

- …the unique function of the [nurse or engineer] is to assist the individual, sick or well, in the performance of those activities contributing to health or its recovery (or to peaceful death) that he would perform unaided if he had the necessary strength, will, or knowledge…

15

Holding paramount the public, which is the 'right' view???

A



B

From google.com

16

One piece of paper, two definitions

1. The environment is…
2. An engineer is…

17