Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #45981

Essentials of the Nurse+Engineer: Wake up Engineering Educators, It's Time to Recognize Nursing is STEM!

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.

Essentials of the Nurse+Engineer: Wake Up Engineering Educators, It's Time to Recognize Nursing is STEM!

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

Abstract

In an increasingly competitive global economy, STEM, or science, technology, engineering, and math, are recognized as critical to the future economic prosperity of the United States. Building a more inclusive STEM pipeline, from K-12 and in higher education, has been a priority in US higher education for two and a half decades. Despite all of these efforts, nursing typically is not invited to be part of the STEM effort. Why not? Nurses clearly use and create technology. Nursing science is a robust field of academic scholarship. And nursing, like engineering, is a profession focused on caring for the health, safety, and welfare of the public. Recognizing Nursing Is STEM (NIS) is the policy objective of the NIS Coalition. To raise awareness of NISC within engineering, and to highlight collaboration among the professions of nursing and engineering, a systematic review of the ASEE PEER database and the IEEE Explore database were performed. A total of 35 peer reviewed articles met the inclusion criteria for this review, and the themes of these articles were mapped to a recent literature review of nursing and engineering, which was published in the nursing literature. The results of this study highlight that systematic reviews of convergent areas – such as nursing + engineering – may be prone to the error of omitting important articles for inclusion because of the differences in discipline-specific literature. The results of this study support the importance of educational collaborations among teams of engineers and teams of nurses, as well as highlights that nursing+engineering is an important area for communicating between the professions as well as facilitating the communication of the professions with the public. Collectively, the weight of evidence of the literature identified in systematic reviews supports the inclusion of nursing in STEM.

Introduction

STEM, or science, technology, engineering, and math, is a collection of fields identified as essential to maintaining a competitive advantage for the United States (US) in the global marketplace [1]. The US marketplace, herein measured as the annual Gross Domestic Product (GDP), is approximately twenty five trillion dollars ($25T) [2]. Approximately seventeen percent, or four and one-half trillions dollars ($4.5T) is spent on healthcare annually. And nearly thirty percent of the Federal government total expenditures are on healthcare (i.e., equal to nearly $14,000 per person, per year). In contrast, Federal expenditures on national defense – often considered by many to be one of the single largest discretionary expenses in the US budget – are less than one trillion dollars (i.e., about $820 billion in FY 2023). Clearly, gains in efficiency (i.e., lower costs for the same outcome) or productivity (i.e., better outcomes for the same cost) in healthcare would benefit the US economy, and by definition improve the opportunity to redirect expenditures to additional discretionary areas, such as education and infrastructure, among others. So, to whom should STEM professionals turn as partners in efforts to improve the efficiency and productivity of the US healthcare system?

Within the healthcare sector, nursing is the single largest profession with nearly five million (5M) Registered Nurses (RNs) in the US. And yet, nursing is NOT recognized as a STEM profession by many federal agencies. Why not [3] [4]? Nursing is clearly based in science (e.g. chemistry is necessary for understanding pharmacology). Nursing clearly uses math (e.g. appropriate dosage of medicines requires calculations). And like engineering, nursing is a profession that cares for the public. In fact, the code of ethics of nursing specifically calls for the care of every patient – whether an individual, family, group, population, or community [5]. Nursing is unique among the healthcare professions in that its code of ethics explicitly mentions BOTH the individual and the public (whereas medicine only emphasizes the individual patient and engineering only emphasizes the health, safety, and welfare of the public [6]).

Within the STEM acronym, two of the fields represent "basic" areas, namely math and science. One field is a "thing", namely technology. And one field is a "profession", namely engineering. So, if nursing is to become part of STEM, the question to raise is, "what do nurses and engineers share in common, and what is unique about the profession of nursing and the profession of engineering [7] [8]?" And perhaps even more importantly, how does recognizing nursing as STEM help support workforce development, national security, and the ways the US government spends taxpayer funds (i.e., achieving efficiency and productivity in the massive, expensive US healthcare system)?

In this paper, we advocate for policy to establish that nursing is STEM. We frame our argument using an existing recent scoping review of the peer-reviewed scientific literature, which identified five thematic areas of engagement among nurses and engineers (i.e., [9]). We provide a unique contribution to the literature through a scoping review of articles published in the American Society for Engineering Education (ASEE) PEER Database as well as articles published in the Institute of Electrical and Electronics Engineers (IEEE) Explore Database, specifically the proceedings of the annual Global Humanitarian Technology Conference (GHTC).

To advance our policy objective of recognizing nursing is STEM, the two-fold purposes of this current article include: 1) raising awareness of the importance of identifying nursing as one of the STEM (science, technology, engineering, and math) fields – either by changing the acronym, repositioning nursing as a science rather than a clinical practice, or some yet to be identified alternative; and 2) highlighting thematic areas of collaborations among nurses and engineers – including themes previously published in reviews (i.e., [3] or [9] and new themes identified in our systematic review of the IEEE Explore GHTC proceedings. Our long term goal – to have nursing recognized as STEM – supports the original aspirations of those who created the STEM acronym, namely national security [1].

Methods

One way to understand the relationship between the profession of nursing and the current STEM profession of engineering is to examine the literature to identify examples of effective partnerships. Four relationship among the professions of engineering and nursing were identified by Oerther and co-workers [3], including: 1) the use of "to engineer" as a verb in the nursing literature; 2) the application of engineering practice within the discipline of nursing (i.e., Kansei

Engineering); 3) side-by-side comparisons of the disciplines of engineering and nursing (i.e., discipline-specific definition of ethical practice); and 4) educational innovation at the interface of engineering and nursing (i.e., interdisciplinary team projects). In a scoping review, which examined 60 published studies, Zhou et al [12] noted five areas where nurses and engineers have collaborated extensively, including: 1) patient safety; 2) symptom monitoring; 3) information systems; 4) patient education; and 5) nurse-patient communication.

A search of the ASEE PEER Database for "Title" = "nurse" (available online at: https://peer.asee.org/advanced_search?q=%22nurse%22&q_in%5B%5D=title&collection_id=&year=&published_after=&published_before=) identified a total of 17 published peer reviewed conference proceedings that discussed nursing [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26]. The full texts of these articles were manually reviewed to identify all articles that included a discussion of the profession of nursing in the broadest sense (i.e., including "community health workers" and "clinics"). All 17 articles met the inclusion criteria. The 17 articles were mapped to the five thematic groupings previously proposed by Zhou et al [12].

A search of the IEEE Xplore database for "conference = GHTC" plus "nurs*" (available online at: https://ieeexplore.ieee.org/search/searchresult.jsp?contentType=conferences&queryText=ghtc&highlight=true&returnFacets=ALL&returnType=SEARCH&matchPubs=true&searchWithin=%22nurs*%22) identified a total of 24 published studies appearing between 2011 and 2023. The abstracts of these articles were manually reviewed to identify all articles that included a discussion of the profession of nursing in the broadest sense (i.e., including "community health workers" and "clinics"). A total of 18 articles met the inclusion criteria. Six articles were excluded. Examples for exclusion included the use of "nurs*" as an adjective such as "nursing mothers" or "nursing homes". The remaining 18 articles [27] [28] [29] [30] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42] [43] [44] were clustered to create four new thematic groupings.

Results

A systematic search of the ASEE Peer Database identified 17 peer reviewed conference proceedings, which included the word "nursing" in the title. Table 1 arranges these 17 articles by mapping their content to the five thematic areas of nursing and engineering collaboration previously identified [9]. None of the articles explicitly examined patient safety; although patient safety was one of the most abundant themes identified previously [9]. Only two articles discussed co-creation of devices by nurses and engineers, including devices to identify bacterial pathogens [10] and finding veins for the purpose of access [11]. The workflow of moving patients through the emergency department [12] and general systems approaches understood through modeling [13] were discussed in two papers.

In contrast to the prior review [9], many of the papers identified from the ASEE PEER Database were related to health education, especially the establishments of communities of practice among faculty, among students, and between faculty and students of different disciplines. Three papers

appearing in the ASEE PEER Database examined the collaboration of nurses and engineers in the theme of nurse-patient communication [24] [25] [26].

Collectively, these results suggest substantial differences in the trends of the types of articles that appear in the research-intensive peer reviewed literature examined by Zhou and co-authors [9] as compared to the types of articles published in the ASEE PEER Database (i.e., references [10] through [26]).

Table 1. Arrangement of 17 articles of interest identified from ASEE PEER in the current study in comparison to the five thematic areas of nursing and engineering collaboration previously identified by Zhou et al [9].

Thematic area (number of articles identified in [9]).	**ASEE articles of interest and proposed subtheme**
Patient safety (n=18)	None
Symptom monitoring and health management (n=18)	[10] [11] device creation
Information systems and nursing human resources management (n=16)	[12] workflow [13] system approaches
Health education (n=5)	[14] [15] simulation [16] [17] [18] [19] [20] [21] [22] [23] establishing interprofessional community of practice
Nurse-patient communication (n=3)	[24] telehealth [25] [26] community engagement

A systematic search of the IEEE Explore Database identified 18 peer reviewed conference proceedings, which included the word "nurs*". Table 2 arranges these 18 articles by mapping their content to four new thematic areas of nursing and engineering collaboration. The reason that four new thematic areas are proposed is that all of the articles tended to focus on improving nurse-patient communication through the use of technology. This is not unexpected as the primary purpose of the GHTC includes, "communication/connectivity in support of development".

Table 2. Arrangement of 18 articles of interest identified from IEEE Explore in the current study organized into four new proposed themes.

New thematic areas.	**IEEE articles of interest**
Group one: healthcare providers accessing technology at a distance to provide patient care (remote access to technology)	[27] [28] [29] [30] [31] [32] [33] [34]
Group two: patients accessing healthcare providers at a distance (remote access to personnel)	[35] [36] [37] [38] [39]
Group three: training healthcare workers to design and use technology	[40] [41]
Group four: supporting healthcare workers	[42] [43] [44]

Group one included eight articles, which described improving remote access to technology for patient care, including: ultrasound for pregnancy [27] and digital pen for documenting partograph [28], low-power nebulizer [29], diagnosis of urinary tract infection(s) [30] and preeclampsia [31], a real-time automatic injecting device [32], remote monitoring of vital signs [33], and an intravenous (IV) drip monitoring system [34]

Group two included five articles, which described improving accessibility to healthcare through telecommunications [35] [36], mobile apps [37] [38], and autonomous systems [39].

Group three included two articles, which described training healthcare workers to use [40] and design technology [41].

The remaining three articles were grouped based upon their content describing diverse ways to support healthcare workers, including: a) supporting healthcare workers to educate patients [42]; b) supporting healthcare workers through improved information systems [43]; and c) supporting healthcare workers through improved policy frameworks [44].

Discussion

Prior work has examined the relationship between nursing and engineering, including both *ad hoc* [3] as well as systematic reviews [9] of the peer-reviewed literature. In the current study, a systematic approach was used to identify articles at the interface of nursing and engineering, which appeared in the ASEE PEER database or the IEEE Explore database. Perhaps surprisingly, a total of 35 additional articles (17 from ASEE PEER and 18 from IEEE Explore) were identified. One might wonder why these articles were not previously captured in prior reviews. Perhaps variations in search criteria have played a role, or perhaps the fact that the nursing and the engineering literatures are separate destinations for publication may play a role? While convergence research at the interface among two or more disciplines may be identified as the greatest opportunity to solve pressing societal challenges, the lack of an audience to consume this literature – and the prior existence of separate literatures unique to each of the disciplines – means that "translators" are needed to bridge the gap between nursing and engineering [3].

As reported by the Nursing Is STEM (NIS) Coalition, "Nurses utilize scientific principles, mathematical concepts, and cutting-edge technology to conduct assessments, make diagnoses, and plan the care of patients. They employ evidence-based interventions to address illnesses, sustain human life, and, ultimately, assess the outcomes of the care delivered to patients." Furthermore, "Categorizing Nursing a STEM field additionally helps rectify a long-standing perception that women are not pursuing rigorous math and science fields. More women graduate with nursing degrees than the next 30 STEM-coded degrees combined. (Integrated Post Secondary Education System)" [45].

As argued by the NIS Coalition, it is time to recognize nursing as STEM to support improvements in the efficiency and productivity of the US healthcare system – one of the most expensive systems of care in the world. That nursing should be recognized as part of STEM has been argued for some time [46]. In particular, the economic advantage of STEMpathy, meaning the creation and retention of jobs at the interface of technology and human caring, is an important advantage of the formal collaboration among nursing and engineering [46]. In particular, the discipline of environmental engineering, well known as a caring profession [47], has already presented arguments for the importance of redefining environmental engineers as solving problems of planetary health [48] and partnering with professions such as nursing to scale-up caring to support human flourishing [49].

Conclusion

To build upon the results of prior ad hoc and systematic reviews, the ASEE PEER database and the IEEE Xplore database were examined for articles that included a collaboration between nurses and engineers. A total of 35 articles, which had not been identified in prior reviews, were included in this current study. The majority of the articles that appeared in the ASEE PEER database were focused on health education. All of the articles that appeared in the IEEE Explore database were related to the IEEE GHTC theme of, "communication/connectivity in support of development". These 18 articles were organized to create four additional thematic groupings. Collectively, the results of this review support the policy position of the NIS Coalition, namely that nursing should be considered a part of STEM. The next steps for achieving this policy outcome include raising awareness to government officials that nursing is STEM, and determining how best to accomplish this integration; whether by a further modification of the STEM acronym or by redefining nursing – perhaps moving nursing from being listed as a clinical practice to being listed as a applied science, such as engineering, where scientific knowledge and the scientific method are used to achieve practical goals including holding paramount the health of the public through improvements in the efficiency and productivity of the US healthcare system.

References.

1. NASEM, Rising Above the Gathering Storm, 2007, National Academies Press: Washington, DC.
2. United States Department of Treasury, Fiscal Data. Available [Online]: https://fiscaldata.treasury.gov/americas-finance-guide/federal-spending. Last accessed December 31, 2024.
3. 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, no. 4, pp. 920-923, 2020. [Online] Available: https://doi.org/10.1111/jan.14291.
4. P. Davidson, "Is nursing a STEM discipline – Does it matter and what can we do about it?" *J. Adv. Nurs.*, vol. 76, no. 1, pp. 1-3.
5. ANA, 2015, "Code of Ethics for Nurses: With Interpretive Statements," American Nurses Association, Washington, DC.
6. D.B. Oerther, "Environmental health professionals: Local interprofessional collaborations require global thinking to meet shared ethical obligations," *J. Environ. Health*, vol. 84, no. 5, pp. 26-28, 2021. [Online] Available: https://www.jstor.org/stable/27286304.
7. M.E.S. Glasgow, A. Colbert, J. Viator, and S. Cavanaugh, "The nurse-engineer: A new role to improve nurse technology interface and patient care device innovations," *J. Nurs. Scholar.*, vol. 50, no. 6, pp. 601-611.
8. D.B. Oerther, and M.E. Glasgow, "The nurse+engineer as the prototype V-shaped professional," *Nurs. Outlook*, vol. 70, no. 2, pp. 280-291, 2022. [Online] Available: https://doi.org/10.1016/j.outlook.2021.10.007.
9. Y. Zhou, Z. Li, and Y. Li, "Interdisciplinary collaboration between nursing and engineering in health care: A scoping review," *Int. J. Nurs. Stud.*, vol. 117, no. 103900.
10. D.B. Oerther, and S. Oerther, "Essentials of the nurse+engineer: Chemical engineers and healthcare devices," in *ASEE Annual Conference & Exposition*, Portland, Oregon, 2024. [Online] Available: https://doi.org/10.18260/1-2--47333.
11. R.W. Carlsen, S. Zyhier, and A. Sirinterlikci, "Project-based learning: Engaging biomedical engineering sophomores through a collaborative vein-finder device project with nursing," in Proceedings of the ASEE Annual Conference and Exposition, 2018.

12. R.P. Leland, and R. Valentz, “Collaboration with nursing in computer-aided design of emergency rooms,” in Proceedings of the ASEE Annual Conference and Exposition, 2021.
13. D.B. Oerther, and S. Oerther, “Essentials of the nurse+engineer: Integrating systems engineering modeling,” in *ASEE Annual Conference & Exposition*, Portland, Oregon, 2024. [Online] Available: https://doi.org/10.18260/1-2--47334.
14. M.M. Herbster, and S. Keilson, “Enhancing simulated environmental for nursing education and practices,” in Proceedings of the ASEE Mid Atlantic Section Fall Meeting, 2018.
15. K. Reid, S.M. Montenery, and C.M. Hetrick, “An innovative interdisciplinary student project: engineering and nursing,” in Proceedings of the ASEE Annual Conference and Exposition, 2011.
16. D.B. Oerther, “Using nursing theory to improve the teaching of engineering practice,” in *ASEE Annual Conference & Exposition*, Columbus, Ohio, 2017. [Online] Available: https://doi.org/10.18260/1-2--29084.
17. A.F. Young-Brice, A. Murray, S. Roy, and L. Chase, “Nursing+Engineering: Lessons learned in interdisciplinary facilitator dynamics for faculty development,” in Proceedings of the ASEE Annual Conference and Exposition, 2024.
18. L. Al-Zube, and S. Dorris, “Board 13: Work in progress: Clinical immersion model for biomedical engineering undergraduate students with experienced nurses,” in Proceedings of the ASEE Annual Conference and Exposition, 2023.
19. D.B. Oerther, “Leveraging the NAM’s ‘getting nurses on boards coalition’ to promote NAE’s ‘changing the conversation’ campaign,” in ASEE Annual Conference & Exposition, Salt Lake City, Utah, 2018. [Online] Available: https://doi.org/10.18260/1-2--30771.
20. A. Zahraee, “Preparing successful professionals through an applied interdisciplinary capstone project between engineering technology and nursing,” in Proceedings of the ASEE CIEC, 2022.
21. C.E. King, G. Tolomiczenko, and N.B. Afari, “Work in progress: Novel initiatives for senior design collaborative projects with healthcare workers and undergraduate students – a COVID-19 response nursing hackathon,” in Proceedings of the ASEE Annual Conference and Exposition, 2021.
22. A.A. Dukes, L.A. Sowko, M. Gartner, B.J. Barber, and R.M. Clark, “Board 31: Assessing the impact of embedding nursing students in bioengineering senior design projects: Student perceptions of interprofessional team benefits and challenges,” in Proceedings of the ASEE Annual Conference and Exposition, 2019.
23. G. Baura, F. Fils-Aime, N. Lynn, R. Deichstetter, J.O. Dunderdale, “An engineering and nursing collaborative: Incorporating the concept of empathy into first-year engineering design to increase student engagement,” in Proceedings of the ASEE Annual Conference and Exposition, 2024.
24. D. Eckoff, H. Mansy, D. Turgut, and S.E. Song, “Using telehealth technologies to build nurse practitioner student confidence,” in Proceedings of the ASEE Annual Conference and Exposition, 2022.
25. D.B. Oerther, and S. Oerther, “Essentials of the nurse+engineer: Qualitative methodology applied to food systems in environmental engineering,” in *ASEE Annual Conference & Exposition*, Portland, Oregon, 2024. [Online] Available: https://doi.org/10.18260/1-2--47335.
26. D.B. Oerther, and S. Oerther, “Board 35: Essentials of the nurse+engineer: Defining public value for civil engineers,” in *ASEE Annual Conference & Exposition*, Portland, Oregon, 2024. [Online] Available: https://doi.org/10.18260/1-2--46932.
27. K. K. DeStigter, G. E. Morey, B. S. Garra, M. R. Rielly, M. E. Anderson, M. G. Kawooya, A. Matovu, and F. R. Miele, "Low-Cost Teleradiology for Rural Ultrasound," 2011 IEEE Global Humanitarian Technology Conference (GHTC), pp. 290-295, 2011.
28. H. Underwood, S. Revi Sterling, and J. K. Bennett, "Improving Maternal Labor Monitoring in Kenya Using Digital Pen Technology: A User Evaluation," 2012 IEEE Global Humanitarian Technology Conference (GHTC), pp. 282-287, 2012.
29. R. Dzwonczyk, M. Brockman, D. George, N. Hankins, and M. McHugh, "A Method of Powering a Nebulizer Manually Using Parts Locally Available in Honduras," 2015 IEEE Global Humanitarian Technology Conference (GHTC), pp. 40-44, 2015.

30. G. Warkulwiz, K. Hannon, D. Cabano, and K. Mehta, "Urinary Tract Infections (UTIs) in Rural Kenya: Screening Challenges, Treatment Pathways, and Technological Solutions," 2017 IEEE Global Humanitarian Technology Conference (GHTC), pp. 1-6, 2017.
31. J. Wolman, N. Gomanie, C. Drost, S. Herrick, Z. Day, R. Ekambaram, and K. Mehta, "A Case Study on Integrating a Diagnostic Medical Device into the Health Care System of Sierra Leone," 2019 IEEE Global Humanitarian Technology Conference (GHTC), pp. 1-8, 2019.
32. T. Ahmed, K. S. Rahman, S. S. Shawlin, M. Hasan, A. Bhattacharjee, S. A. Fattah, and C. Shahnaz, "Real Time Injecting Device with Automated Robust Vein Detection Using Near Infrared Camera and Live Video," 2017 IEEE Global Humanitarian Technology Conference (GHTC), pp. 1-8, 2017.
33. T. A. N. Gacharna, A. B. Ostos, M. A. L. Gonzalez, J. J. A. Pallares, V. R. Zuluaga, N. A. D. Castro, E. D. D. Amaya, Y. J. F. Rojas, H. H. Silva, J. A. R. Forero, J. A. G. Laguna, A. J. E. Anaya, M. E. L. Rivera, H. D. V. Amado, and V. H. Vasquez, "Development of Smartbank to Monitor from Home the Vital Signs for Patients with SARS COV 2 Through a Mobile Application from the Central Military Hospital (HOML) Bogota 2020," 2020 IEEE Global Humanitarian Technology Conference (GHTC), pp. 1-4, 2020.
34. K. Venkatesh, D. Karia, and M. Arora, "Clinical Investigation as an Iteration Tool for the Design of Low-Risk Medical Devices: A Case Study of an IV Drip Monitoring System," 2021 IEEE Global Humanitarian Technology Conference (GHTC), pp. 131-137, 2021.
35. P. Singh, S. Kulkarni, E. Keech, R. McDermott-Levy, and J. Klingler, "Making Health Care More Accessible to Rural Communities in Waslala, Nicaragua Using Low-Cost Telecommunication," 2011 IEEE Global Humanitarian Technology Conference (GHTC), pp. 194-2000, 2011.
36. G. D. Sworo, M. Kam, and E. J. Juan, "Design of a Telemedicine-Based System for Clinic-In-A-Can," 2012 IEEE Global Humanitarian Technology Conference (GHTC), pp. 265-270, 2012.
37. M. Cunningham, P. M. Cunningham, D. van Greunen, A. Veldsman, C. Kanjo, E. Kweyu, and B. Tilahun, "mHealth4Afrika Alpha Validation in Rural and Deep Rural Clinics in Ethiopia, Kenya, Malawi, and South Africa," 2017 IEEE Global Humanitarian Technology Conference (GHTC), pp. 1-9, 2017.
38. N. S. Weaver, A. Roy, S. Martinez, N. N. Gomanie, and K. Mehta, "How WhatsApp is Transforming Healthcare Services and Empowering Health Workers in Low- and Middle-Income Countries," 2022 IEEE Global Humanitarian Technology Conference (GHTC), pp. 234-241, 2022.
39. B. Lee, O. Hossain, Z. R. Urbaez, A. T. Kshetri, and K. Mehta, "Leveraging ChaptGPT and Amazon Alexa to Empower Healthcare Workers in Sierra Leone," 2023 IEEE Global Humanitarian Technology Conference (GHTC), pp. 334-339, 2023.
40. E. Lee, J. Alsofrom, M. Streeter, A. Cherukuri, K. DeStigter, J. K. Bwambale, M. A. Njeri, J. F. Anyango, and M. Alphonsus, "Obstetric and Gynecologic Ultrasound Training at the Uganda Nursing School Bwindi: Initial Experiences and Challenges," 2015 IEEE Global Humanitarian Technology Conference (GHTC), pp. 425-430, 2015.
41. V. Carlson-Oehlers, P. J. Jung, and B. A. Cohen, "Implementation of a Global Humanitarian Outreach Experience by Partnering Engineering, Business, and High-Tech Nursing Education With a Non-Governmental Organization," 2017 IEEE Global Humanitarian Technology Conference (GHTC), pp. 1-6, 2017.
42. B. F. Nielsen, and P. Khanal, "A Theory of Change for Cleaner Cooking: Building a Health Belief Model for Service Design Starting With the Slums of Kathmandu," 2021 IEEE Global Humanitarian Technology Conference (GHTC), pp. 327-330, 2021.
43. J. M. R. Mejia, A. Rawal, and D. B. Rawat, "Finite State Automata for Real-Time Health Electronic Record Update: A Survey," 2022 IEEE Global Humanitarian Technology Conference (GHTC), pp. 154-161, 2022.
44. D. B. Oerther, and S. Oerther, "Sustainable Development in the Anthropocene Requires Interprofessional Environmental Health as Science Diplomacy," 2023 IEEE Global Humanitarian Technology Conference (GHTC), pp. 344-349, 2023. [Online] Available: https://doi.org/10.1109/GHTC56179.2023.10354712.
45. NISC, “NursingISstem.org”, Nursing is STEM Coalition, 2023. [Online] Available: https://www.nursingisstem.org.

46. D.B. Oerther, “Nursing should be a STEM discipline!” Nursing Centered [Blog] [Online] Available: https://nursingcentered.sigmanursing.org/stories/view/nursing-should-be-a-stem-discipline.
47. D.B. Oerther, L. Gautham, and N. Folbre, “Environmental engineering as care for human welfare and planetary health,” Journal of Environmental Engineering (United States), vol. 148, no. 6, pp. 04022029, 2022. [Online] Available: https://doi.org/10.1061/(ASCE)EE.1943-7870.0002013.
48. D.B. Oerther, S. Oerther, C.A. Peters, “Environmental engineers solve problems of planetary health,” *Environmental Engineering Science*, vol. 41, no. 1, pp. 3-6, 2024. [Online] Available: https://doi.org/10.1089/ees.2023.0301.
49. D.B. Oerther, S. Oerther, and L.A. McCauley, “Environmental engineering 3.0: Faced with planetary problems, solutions must scale-up caring,” *Journal of Environmental Engineering (United States)*, vol. 150, no. 9, pp. 02524001, 2024. [Online] Available: https://doi.org/10.1061/JOEEDU.EEENG-7764.