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Identifying Opportunities for Educators to Pursue Collaboration at the Interface of Nursing and Engineering -- And a Word of Caution

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EDITORIAL

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Identifying opportunities for educators to pursue collaboration at the interface of nursing and engineering – and a word of caution

1 | INTRODUCTION

A recent editorial explored the relationship between nursing and STEM – science, technology, engineering and math – by asking and answering the question, 'Is nursing a STEM discipline?' (Davidson, 2019). A previous editorial explored the value of including the 'art of nursing' as part of the transition from STEM to STEAM – defined as science, technology, engineering, *art* and math (Yoder-Wise, 2018). And another editorial offered the outright perspective that 'Florence Nightingale was the first environmental engineer' (Oerther, 2018).

Educators, those who serve as the custodians and faithful transmitters of the bodies of knowledge of various disciplines, have an obligation to identify the boundaries among professions and to educate 'T-shaped' practitioners who simultaneously have deep disciplinary training (i.e. represented by the vertical of the T) and a broad view of the world (i.e. represented by the horizontal of the T). In an era of convergent research, practice and policy – where deep interdisciplinary collaboration is being used to solve society's most pressing challenges – an urgent need exists to identify opportunities for educators to pursue collaboration at the interface between nursing and engineering (Oerther D., 2019a, 2019b; Oerther S., 2019c).

As a first step to identify prior examples of collaborations among educators of engineers and nurses, one of the authors (Author 1) performed a search of SCOPUS using the search string [TITLE('nurs*' AND 'enginee*')]. The search produced a total of 141 unique articles. Of these, 74 articles were first published between January 1999 and October 2019, and 55 of these articles included a published abstract in English. After reading these abstracts, the 55 articles were divided into five themes summarized in Table 1.

The first and second themes included a total of 15 articles. The first theme included five articles, which were completely unrelated to the topic of interest, such as the article titled, 'Engineering of coral reef larval supply through transplantation of nursery-farmed gravid colonies' (Horoszowski-Fridman et al., 2011). The remaining 10 articles, which composed the second theme, used 'to engineer' as a verb meaning 'to design', such as in the article titled, 'Nursing's role in engineering a learning healthcare system' (Newhouse, 2009).

TABLE 1 Five themes identified among articles addressing nursing and engineering

Theme	Number of Articles	Example article title
Unrelated to the purpose of the search	5	Engineering of coral reef larval supply through transplantation of nursery-farmed gravid colonies
'To engineer' as a verb	10	Nursing's role in engineering a learning healthcare system
Engineering practice applied to the discipline of nursing	16	A human factors engineering conceptual framework of nursing workload and patient safety in intensive care units
Comparison of the disciplines of nursing and engineering	14	A comparative study of stress among students of medicine, engineering and nursing
Direct relationship to the interface of nursing and engineering education	10	Impact of pedagogical approaches on cognitive complexity and motivation to learn: comparing nursing and engineering undergraduate students

The third theme included 16 articles, which all used one or more practices from the profession of engineering to improve some aspect of nursing. The most highly cited article in this group was titled, 'A human factors engineering conceptual framework of nursing workload and patient safety in intensive care units' (Carayon & Gurses, 2005). Other examples of articles in this group mentioned 'systems engineering' to improve nursing management (Cui et al., 2018) or the use of 'clinical engineering' (Arquilla & Cram 2005) or 'Kansei engineering' (Zhou, Cheng, Wei, & Lee, 2018) to improve technology designed to assist nurses in the performance of nursing care. We characterize these articles as interdisciplinary applications of best practices from the field of engineering to the field of nursing, and these articles focused upon professional practice and continuing education rather than pre-service formative education.

*Editorial note: This editorial has not been subject to peer review and is published at the discretion of the editor.

The fourth theme included 14 articles, which all presented some version of a 'side-by-side' comparison of nurses and engineers as exemplified by the article titled, 'A comparative study of stress among students of medicine, engineering, and nursing' (Behere, Yadav, & Behere, 2011). In this group of articles, nursing was often stereotyped as the archetypical example of a 'female-traditional profession' and engineering was identified as the archetypical example of a 'male-traditional profession' (Karlsen, 2012). While some of these articles leveraged the significant gender bias among the fields of engineering (i.e. >75% male) and nursing (i.e. nearly 90% female) to explore differences in responses in the professional workplace, such as the percentage of females who valued altruism (Hagstrom & Kjellberg, 2007), other articles attempted to propose mechanisms to describe the observed gender bias among the professions of nursing and engineering, such as the article titled, 'Engineers have more sons, nurses have more daughters: an evolutionary psychological extension of Baron-Cohen's extreme male brain theory of autism' (Kanazawa & Vandermassen, 2005). We characterize these articles as case–control and cohort studies exploring particular attributes of nurses and engineers, and these articles range from studies of students to studies of professionals.

The remaining 10 articles were directly related to the topic of interest, namely, identifying opportunities for educators to pursue collaboration at the interface between nursing and engineering. These articles employed diverse methodologies – cross-sectional comparisons; summaries of case studies; evaluation of pedagogical preferences; didactic lecture; and hands-on, experiential learning – in courses that included interprofessional education of both nurses and engineers, together, simultaneously, in a shared learning environment. For example, McComb and Kirkpatrick (2016), in their article titled, 'Impact of pedagogical approaches on cognitive complexity and motivation to learn: Comparing nursing and engineering undergraduate students', evaluated cross-sectional data collected from 1,167 first year through graduating baccalaureate students to identify differences among nursing and engineering majors in students' cognitive complexity and motivation to learn. In a very different approach, Oerther (2017), in his paper titled, 'Using nursing theory to improve the teaching of engineering practice', summarized previously published case studies describing the use of Nightingale's Environmental Theory as the organizing principle for co-teaching teams of nursing and engineering students practicing interprofessional community health under the supervision of an experienced team of nursing and engineering educators.

Five articles formed teams of nursing and engineering students to co-design biomedical devices, including:

1. Tele-health supporting home healthcare (Buckley, Tran, Prandoni, & Clark, 2002);
2. A robotic device for reflexology for breast cancer patients (Wyatt, Sikorskii, Bush, & Mukherjee, 2010);
3. Improvement of a manikin that simulates birth through both cephalic presentation and malpresentation (Reid, Montenery, & Hetrick, 2011);
4. A vein finder device (Carlsen, Zyhier, & Sirinterlikci, 2018) and
5. A variety of devices identified through clinical rotations and prototyped using 'maker space' (Geist, Sanders, Harris, Arce-Trigatti, & Hitchcock-Cass, 2019).

Three articles described broadly the general attributes of courses to facilitate nursing and engineering educational collaboration. Ludwig et al. (2017) created teams of baccalaureate students of engineering, pre-nursing (i.e. not yet admitted to nursing courses) and pre-healthcare professional (e.g. pre-medicine) who were trained to solve wide-sweeping healthcare challenges employing problem solving, interprofessional collaboration and the ability to work with rapidly evolving technologies. Glasgow et al. (2018) described pioneering efforts to create a new hybrid professional known as the 'nurse–engineer'. This new professional was envisioned to 'explore new and innovative solutions that will improve care and patient outcomes'. And recently, Kim (2019) authored an article titled, 'A conceptual framework for interdisciplinary education in engineering and nursing health informatics', where a paradigm for joint training of students of nursing and engineering in health informatics is described.

We characterize these 10 articles in the fifth theme as intentional in their approach to simultaneous, co-instruction of pre-service students of nursing and engineering in the same learning environment. These articles acknowledge the similarities and differences in education in both fields, and also highlight the value to be achieved in improved patient care (e.g. including better technologies), public health (e.g. including better systems) and health policy (e.g. including better frameworks of caring) through shared training. These articles share clear similarities with the guidance prepared by the National League for Nursing on 'Interprofessional collaboration in education and practice' (2015), but differ substantially in that the definition of 'team' includes 'engineers' as part of the healthcare system. Recently, Oerther D., (2019a, 2019b) Oerther S., (2019c) argued that nurses should help themselves and their patients by developing partnerships with other professionals – such as engineers – who can shoulder some of the burden of improving health and wellness. This concept – an expanded definition of healthcare professional, local to global – extends from improved technology at the bedside through comprehensive solutions to global climate change and the disproportionate impact on the health and wellness of the global poor (Travers, Schenk, Rosa, & Nicholas, 2019), to the clarion call for nurses to lead partnerships in achieving the United Nations Sustainable Development Goals (Oerther S., 2019c).

In summary, our first step to identify prior examples of collaborations among educators of engineers and nurses raised to our attention the following as areas for follow-up and future exploration, namely addressing profession-specific biases; sharing educational experiences and considering new roles within the respective professions. These are further detailed in Table 2.

Through our brief analysis of the published literature and our identification of these three areas for follow-up and future exploration, we became increasingly confident in our belief that educators of nurses and educators of engineers serve as custodians

TABLE 2 Opportunities for further interprofessional explorations

1. The professions of nursing and engineering share a common stereotype of gender bias, and educators may look for ways to overcome this bias through shared educational experiences (i.e. a learning environment that attracts and supports stereotypical 'female nurses' and 'male engineers' should have characteristics simultaneous attractive to multiple genders, gender expressions, etc.).
2. Pre-service students in nursing and engineering share a common educational pathway to professional practice, including, acquiring foundational knowledge, skills and attitudes in STEM; pedagogical similarities including hands-on learning through clinics, co-ops and service-learning; and licensure through examination coupled to successful pre-professional supervised practice. In our opinion, educators should look for ways to exploit this shared pathway to formalize interprofessional education.
3. The opportunity exists for the emergence of a new professional, the 'nurse–engineer' (variously described as 'clinical engineer' or 'nursing focused biomedical engineer') who uses engineering design of technology and systems and nursing science and art to improve research, education, practice, and policy for the betterment of both the patient and the public.

of knowledge with an obligation to define and expand boundaries among disciplines. In our opinion, the power of convergence – where deep interdisciplinary collaboration is used to solve a pressing societal challenge – fundamentally includes the need to prevent lessening of profession-specific content. Rather, than 'indiscriminate blurring' between the disciplines of nursing and engineering, we encourage the formation of T-shaped practitioners who have deep disciplinary training and a broad view of the world. We believe that T-shaped practitioners are essential to the success of convergence because disciplines must be, a priori, defined if transdisciplinarity is to be pursued successfully.

CONFLICT OF INTEREST

No conflict of interest has been declared by the authors.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this article.

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