A Comparison of Nursing and Engineering Undergraduate Education

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Abstract
Engineers and nurses have an ultimate goal of improving and facilitating peoples' lives. Although, both disciplines have similar goals, the students are educated differently. A growing focus on interdisciplinary education has provided motivation for analyzing the best practices of nursing and engineering programs and determining if they can be applied to the other discipline. Accreditation standards for undergraduate educations in nursing and engineering were compared. The only differences uncovered were related to professional practice, which are to be expected. Yet, obvious differences between engineering and nursing curricula exist, such as the timing of practical experience (nursing utilizes clinical experiences early in students' education and engineering capstone projects occur later). The purpose of this research project is to undertake a retrospective case study to examine the educational paths of nursing and engineering students, and to identify how and when skills pertinent to each career are addressed. This case study utilized educational outcomes to compare and contrast nursing and engineering students' development over their undergraduate years. The data set was comprised of course materials (syllabi, projects, assignments, tests, etc.), curriculum, and retrospective reflections by two undergraduate students pursuing a Biomedical Engineering and a Nursing degree. Components of the portfolios were analyzed with attention to how course materials contributed to fulfilling essential goals of the respective fields. This study may help identify opportunities to promote interdisciplinary learning and, ultimately, improve the quality of care that nurses can provide for their patients and the quality of products that engineers design.

Introduction
Throughout their undergraduate years, both engineering and nursing students, generally, learn how to identify, analyze, and find solutions to problems. Engineering students are taught to observe unmet needs or areas of improvement with current products, devices and processes. The development of a proper solution involves critical thinking and creativity. In most cases, the end design will either indirectly or directly ease the life of the consumer. Nursing students learn to detect ailments in patients and implement the appropriate interventions, thus helping a patient recover.

While the two fields have an analogous focus of improving the lives of another being, engineers and nurses are exposed to their fields in contrasting ways during their undergraduate education, which therefore influences the way in which problems are solved. For example, nursing students begin working in a clinical setting during the sophomore year, while many engineering students may not be assigned a problem in a real-world setting until their culminating senior design course or during a voluntary internship experience [1]. The undergraduate experiences of engineers and nurses contribute to their readiness to apply knowledge in a real-world setting.

Limited research exists that compares professional education approaches. The most comprehensive effort was completed by the Carnegie Foundation for the Advancement of Teaching when they compared several professional disciplines including engineering and nursing. Their primary publication from this study highlights key issues that need to be addressed across all of the examined fields, namely

identity, community, responsibility, and bodies of knowledge [2]. To our knowledge more detailed comparisons are not available. Our efforts herein provide a preliminary contribution to this area.

The purpose of this research project is to complete a retrospective case study examining the educational experiences of engineering and nursing students. We first match the accreditation standards for engineering with those for nursing in order to compare outcomes deemed necessary by their respective accreditation bodies. Next, two students, one engineering and one nursing, provided a reflection of how these standards were met during four-year undergraduate curricula. Observations about the similarities and differences between the two disciplines were made. In the future, the results can be used to determine how the integration of specific aspects of the engineering curriculum could be incorporated into the nursing curriculum, and vice versa, with the aim to better prepare students for their lives as professionals in their respective field.

Accreditation Standards

Engineering and nursing curricula follow a strict set of standards and criteria for strengthening educational quality. Accreditation standards are tied closely to licensing rules and oversight of preparation for work in the profession. A program that has met accreditation standards produces graduates that are ready to work in the profession [3].

The accreditation board for applied science, computing, engineering and technology program is ABET. The process of accreditation takes about 18 months from the time of a program's formal request for an ABET review [3]. ABET lists 11 outcomes (a-k) that describe what a student should know and be able to do upon graduation from an accredited program. The Commission on Collegiate Nursing Education (CCNE) is one of two accreditation agencies that ensures quality and effective educational practices in nursing baccalaureate, graduate, and residency programs. [4]. Similar to ABET, outcomes (listed as essentials) are associated with the CCNE and the accreditation process. Nine essentials describe the outcomes expected for students graduating from a CCNE accredited baccalaureate program.

Although the ultimate goals of engineers and nurses are similar in that they apply analytical reasoning to improve the well-being of others, the approaches taken, particularly with respect to real-world exposure, appear very different. We, therefore, anticipated finding differences in their accreditation standards. Unexpectedly, the outcomes aligned across the two fields. Table 1 depicts this alignment between the ABET program outcomes and the CCNE essentials.

Curriculum Comparison

While the ABET student outcomes and CCNE essentials are similar on paper, differences exist in how, when, and how often the outcomes are addressed during the four-year curricula. One engineering and one nursing student compiled a portfolio of homework assignments, tests, syllabi, and projects from all core courses taken during their undergraduate years. The senior engineering student was able to refer to her own course work for reference, while the junior nursing student worked with Purdue's School of Nursing's Director of Undergraduate Programs to gather the requisite information about courses she had yet to take.

Using the portfolios and their own knowledge of the courses and curricula, the students identified the outcomes that each core course in their field addressed. The engineering student reflected on 28 core engineering courses (two in the first year, ten in the second year, ten in the third year, and six in the fourth year). The nursing student reflected on 21 core nursing courses (two in the first year, five in the second year, nine in the third year, and eight in the fourth year).

Table 1:Comparison of Engineering and Nursing Accreditation Outcome

Engineering Program Outcomes	Nursing Baccalaureate Essentials
a an ability to apply knowledge of mathematics, science, and engineering	VII Clinical prevention and population health
b an ability to design and conduct experiments, as well as to analyze and interpret data	III Scholarship for evidence based practice
c an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	II Basic organizational and systems leadership for quality care and patient safety
d an ability to function on multidisciplinary teams	VI Interprofessional communication and collaboration for improving patient health Outcomes
g an ability to communicate effectively	
e an ability to identify, formulate, and solve engineering problems	IX Baccalaureate generalist nursing practice (prepared to practice with patients across lifespans and environments; understand and respects the variations of care, the increased complexity, and the increased use of healthcare resources inherent in caring for patients)
i a recognition of the need for, and an ability to engage in life-long learning	
f an understanding of professional and ethical responsibility	VIII Professionalism and professional values
h the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	I Liberal education for baccalaureate generalist nursing practice
j a knowledge of contemporary issues	V Healthcare policy, finance, and regulatory environments (because of their direct and indirect influence on the nature and functioning of the healthcare system)
k an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	IV Information management and application of patient care technology

A numeric summary of the results from this analysis for engineering and nursing courses can be seen in Figures 1 and 2, respectively. The outcomes listed across the x-axis are the a through k outcomes listed in Table 1. As the Figures show, all outcomes were addressed within the two curricula. The patterns of when and how frequently the outcomes were addressed, however, were different for the two programs. We identified three insights from our analysis.

First, the ability to apply specialized knowledge (outcome a) is high in both cases. Further discussion between the two students completing the analysis, however, identified a strategic difference in how this outcome was addressed in the two fields. The predominant approach to knowledge application in engineering requires students to complete class projects that are based on real-world problems, but

generally do not have an active link outside the classroom. Alternatively, nursing students are required to apply their knowledge in a clinical setting. By embedding these experiences in a professional setting, nursing students have the opportunity to apply their knowledge in a context analogous to the one in which they will eventually practice and, at the same time, observe how others in their professional communities conduct themselves in the workplace.

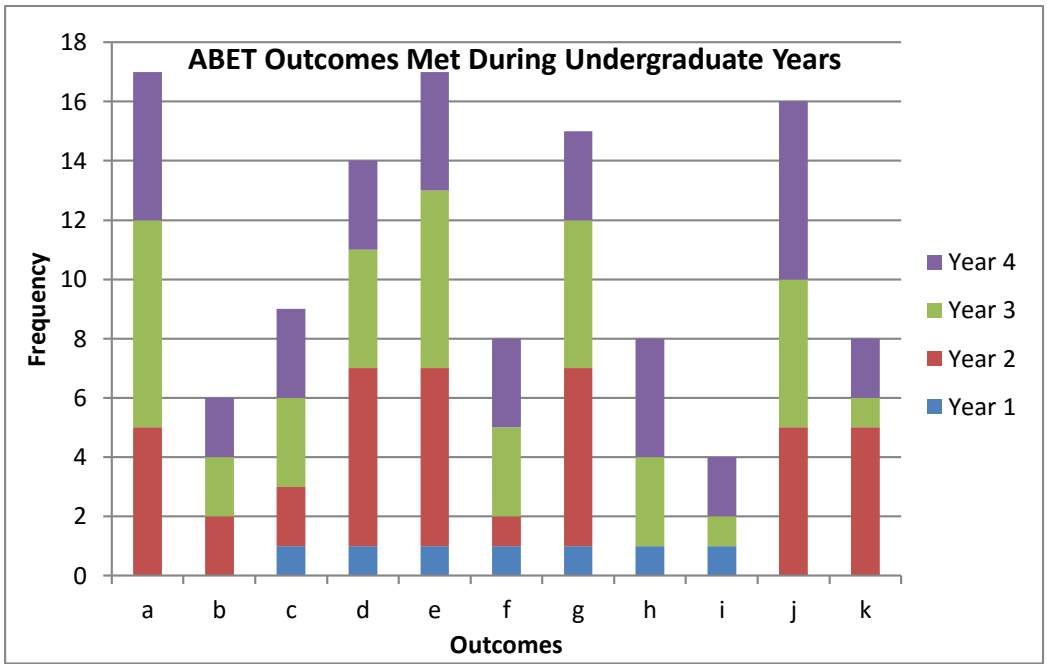

Figure 1: Summary of engineering outcomes met over four years

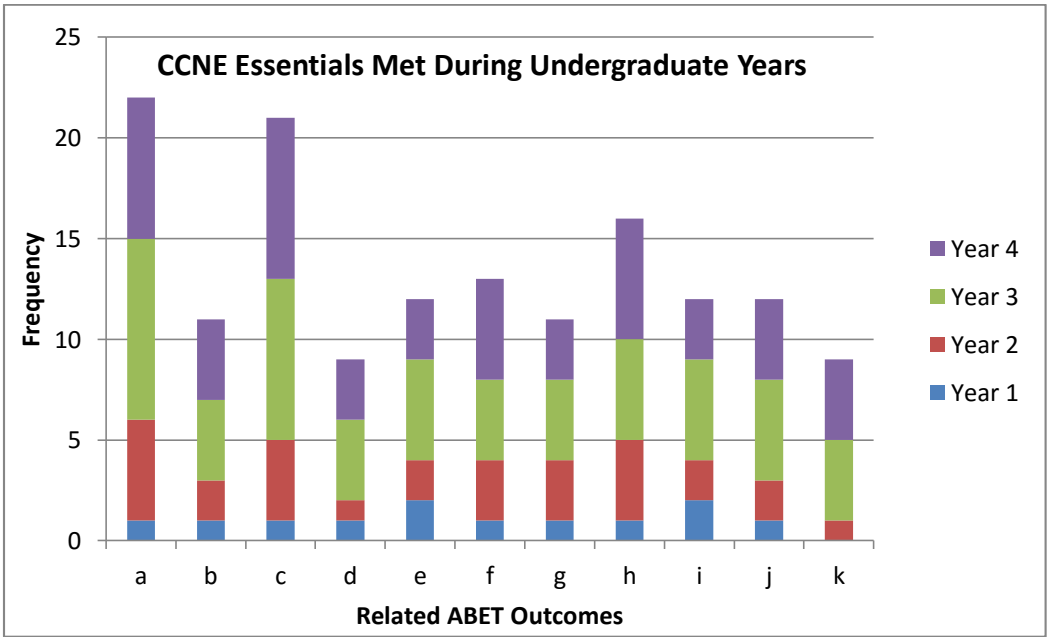

Figure 2: Summary of nursing Essentials met over four years

Second, after outcome a, the most frequently observed outcomes are different for engineering and nursing students. Engineering students have more opportunities to address specific types of contemporary problems that required teamwork and communication (outcomes d, e, g, and j). Nursing students were exposed to a broader, more system-level perspective of the nursing profession (outcomes c and h). This finding may reflect the professional and ethical immediacy experienced by professionals in the two fields. On the one hand, engineers have professional and ethical responsibilities to ensure that the systems and products they design will do no harm in the long term (e.g., a bridge will not fail). To address such problems that rarely require immediate resolution, an understanding of how best to approach, formulate, and solve a problem may be the best foundation. Nurses, on the other hand, experience their professional and ethical responsibilities in real time as they treat patients. This immediacy requires that they possess a broad base of knowledge upon which they can draw and consider any systematic issues as they formulate their plans of care.

Third, the nursing student perceived that the amount of research exposure gained in nursing may be less than in engineering because of the lower emphasis on contemporary issues and communication she identified (outcomes g and j). We investigated this perception further to better understand the research expectations in the two curricula.Engineering students gain exposure to contemporary issues and communication through the projects and lab reports they complete. In these activities, students are required to identify the applicability of their results beyond the current setting (i.e., how it can address other contemporary issues) and articulate their insights to a broader audience that may not have the same professional vocabulary. Alternatively, nursing students address these outcomes in assignments based on their clinical experiences. To that end, they are required to summarize the pathology and physiology of the specific patient to which they are assigned and devise a unique plan of care for that patient. This type of report relies on the existing evidence base (i.e., contemporary best practices associated with the symptoms of their patient) and is a communication tool used with other medical professionals. Thus, the amount of research exposure may not be different, but the outcomes of those experiences are dramatically different.

Conclusions

While our preliminary research has identified that the overall goals of engineers and nurses are similar, as can be seen in the alignment of the two sets of accreditation criteria, the outcomes that were met most frequently throughout a student's undergraduate years are not the same for engineering and nursing students. Further study is needed to ascertain the validity of this initial examination across a broader selection of student portfolios. From a practical perspective, expert educators may find use in identifying the best practices that can be transitioned between the two professional programs. Finally, this study may help identify opportunities to promote interdisciplinary learning and, ultimately, improve the quality of care that nurses can provide for their patients and the quality of products that engineers design.

References

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