The Nurse-Engineer: Pioneering a New Role to Enhance Technology Integration and Innovate Patient Care Devices

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Abstract: The integration of nursing and engineering has the potential to drive significant improvements in patient care and healthcare systems. With the increasing complexity of healthcare, driven by advancements in technology, there is a growing need for professionals who can bridge the gap between clinical care and technological innovation. This paper explores the concept of the "nurse-engineer," a new professional role designed to leverage the expertise of both nurses and engineers to address healthcare challenges through technology. It examines the history and evolution of biomedical and systems engineering in healthcare, highlighting successful collaborations between nurses and engineers. These partnerships have led to the development of innovative healthcare technologies, such as telerobotic nursing assistants and assistive devices for patients with disabilities. The paper also discusses existing interdisciplinary programs, including joint nursing-engineering degree initiatives, and outlines the benefits of such collaborations in enhancing patient outcomes and improving healthcare efficiency. Furthermore, it emphasizes the importance of incorporating nurses' clinical insights into the design and implementation of healthcare technologies, ensuring that innovations are both effective and patient-centered. By fostering collaboration between nursing and engineering, the nurse-engineer role has the potential to shape the future of healthcare, creating new opportunities for improved patient care, safety, and technological advancements.

Keywords: Nurse-Engineer Collaboration, Healthcare Technology Innovation, Interdisciplinary Healthcare Integration.

1. Introduction

Biomedical engineering emerged in the 1960s, driven by concerns over patient safety, particularly in relation to the electrical hazards posed by medical devices (Shaffer & Shaffer, 1992). Today, biomedical engineers are tasked with advancing healthcare technologies for both

diagnostic and therapeutic purposes (Bhat & Kumar, 2013). They design solutions for a wide range of healthcare challenges, from surgical robots and rehabilitation devices to tools that improve workflow. A strong foundation in both engineering and nursing care is essential to ensuring these innovations are clinically practical and efficient. Nurses with biomedical engineering knowledge can play a crucial role in developing technologies such as robots, patient care devices, and computer simulations for patient care and nursing practice. Conversely, biomedical engineers with clinical experience are better equipped to address real-world healthcare problems.

An integrated approach that combines the expertise of both nursing and engineering has the potential to revolutionize patient care, nursing practices, and the healthcare system as a whole. Nurses who are educated in both traditional nursing practices and the technical perspectives of biomedical engineering are well-positioned to facilitate the integration of technology into healthcare. These nurses can contribute throughout the entire process of biomedical innovation—from identifying clinical problems to developing technical solutions and evaluating clinical outcomes (PR Newswire, 2014). By acquiring this multidisciplinary knowledge, nurses can create technologies that enhance health outcomes, improve efficiency, and reduce medical errors. This concept paper aims to review existing collaborations between nursing and engineering and introduce innovative joint degree programs that combine these disciplines.

Collaborations between the medical and engineering fields are not new. Past successes include the development of life-saving technologies like the pacemaker (1958), CT scanner (1970), and slow-release medications (1980). Despite these advancements, challenges persist in ensuring safety, continuity, efficiency, and cost-effectiveness in healthcare. One reason for this is the fragmented nature of healthcare systems, which are often seen as a collection of disconnected components rather than a coordinated whole (Compton & Reid, 2008). While improving individual components such as regulations and procedures can help, more significant progress requires greater collaboration across scientific and professional fields. To drive meaningful change in healthcare, it is essential to leverage the expertise of engineers, scientists, and nurses.

The concept of integrating nursing and engineering is still evolving, and the terminology for this emerging field is also developing. This paper focuses on biomedical and systems engineering methods, highlighting the overlap between these two disciplines. Biomedical engineering is a specialized branch of engineering that focuses on human health, while systems engineering applies mathematical techniques to analyze and design solutions at a holistic, systems level. Systems engineering thus intersects with all engineering disciplines, including biomedical engineering, especially in the context of nursing practice.

Healthcare continues to undergo significant transformation, particularly with the increasing shift toward community-based care, population health management, and the expansion of walk-in clinics run by nurse practitioners. However, it is the adoption of new technologies that is expected to have the most profound effect on nursing and patient care outcomes. As new care models evolve and the need to control healthcare costs intensifies, the pace of technological change will likely accelerate. This has led to various "futuristic" predictions about the future of healthcare, such as the widespread use of wearable monitoring devices, personalized genetic treatments, machine learning for diagnostics and treatment, and robotic applications in medicine and social care. These innovations, along with the ongoing development of electronic health records and interconnected data systems, create new opportunities for research and clinical practice. What remains less clear is how nurses will be actively involved in this technology-driven future.

Nursing care is becoming increasingly complex, not only due to rising patient acuity but also because of the integration of new technologies that impact how care is organized and delivered. According to Huston (2013), the greatest challenges nurses face involve adapting to

new technologies and managing the interface between humans and technology. There are also numerous ethical and data security concerns. The debate surrounding the impact of technology on nursing care has been ongoing, with some worrying about the loss of the human touch in a technology-driven healthcare environment. Nurses, however, have opportunities to leverage technology to improve patient outcomes (Tiffin, 2013), but this also requires the ability to engage with and manage technological innovations.

The future of nursing will demand more than just technical proficiency with new tools. Nurses must take a proactive role in research, design, and policymaking related to new healthcare technologies. This requires increased collaboration with professionals from non-traditional fields, particularly engineers. Two examples of successful nursing-engineering collaborations include the development of a telerobotic nursing assistant, designed to provide care with minimal human contact during infectious disease outbreaks, and a collaboration between nurse managers and engineers to improve staff allocation in busy labor and delivery units. Both of these initiatives demonstrate how integrating nursing expertise with engineering solutions can improve patient care, resource management, and clinical outcomes (Morgan, 2016; Molina et al., 2018).

The concept of integrating nursing and engineering has been discussed for nearly 25 years, highlighting the need for a professional that bridges the two disciplines. While nurses and engineers both rely on science and technology, their focuses differ: nurses emphasize care and health promotion, while engineers are concerned with design and construction (Oerther, 2017). Hendrickson (1993) introduced the idea of creating a new professional role—the nurse-engineer—tasked with the development, specification, and education of practitioners and patients on the use of information systems. Eisenhauer (2015) expanded on this by proposing the creation of a distinct discipline, nursing engineering, rather than just combining nursing with biomedical engineering. Eisenhauer suggested that an integrated educational program for nurse-engineering does not yet exist, as nursing is currently viewed as a technical discipline rather than an integrated one. Although no universities have fully developed the nurse-engineer discipline, some have created collaborative programs to enhance patient care and healthcare system efficiency.

The future role of a nurse-engineer would involve designing and implementing healthcare technologies, ensuring patient safety, establishing frameworks for data security and ethics, and fostering effective communication across healthcare stakeholders. Nursing input is crucial during the initial stages of developing new products or systems, as nurses' insights can significantly impact design before it reaches the testing phase. Nurses have historically been more involved in the support and marketing aspects of engineering, but their expertise in healthcare could be invaluable during product development (Kliger et al., 2010). The collaboration between nursing and engineering has led to innovations such as devices for premature infants or tools for treating contaminated fluids (Elghanayan, 2000; Paolucci, 2000). Given that nurses are the primary caregivers in healthcare settings, their unique position allows them to identify areas for improvement in patient care, making their engagement in technological innovation crucial.

Nurses have been an underutilized resource in technology development, particularly at the interface between healthcare and patient care technology. A major challenge, however, is the sequential nature of education in both fields, which makes it difficult for individuals educated in one discipline to independently transition to the other (Heywood, 2005). Nursing and engineering education require extensive and distinct training, which complicates the development of professionals skilled in both areas. However, some institutions have introduced joint graduate programs that allow nurses to gain advanced knowledge in biomedical engineering. These programs aim to prepare graduates for careers at the intersection of technology and patient care.

Several institutions have established interdisciplinary initiatives to foster collaboration

between nursing and engineering. One example includes partnerships between nursing and engineering programs to design assistive devices for individuals with disabilities. These collaborations aim to teach students from both fields to innovate and create devices that address specific healthcare needs, such as a wheelchair-accessible baby carrier or a smart walker to assist patients during falls (McClelland & Kleinke, 2013). Additionally, programs like MakerNurse, supported by the Robert Wood Johnson Foundation, encourage nurses to create their own medical devices with engineering support, improving patient care through innovation (Rice, 2015).

The establishment of nurse-engineering programs could have a significant impact on healthcare by equipping graduates to work at the technology–patient care interface. For example, nurse-engineers could play a critical role in startup companies focused on developing medical devices, bridging the gap between engineering and clinical evaluation, thus streamlining the product development process. This dual expertise would allow for cost-effective, clinically relevant innovations. By applying Florence Nightingale's environmental theory, interdisciplinary teams of nurses and engineers could generate creative solutions that address healthcare challenges from both a technical and human-centered perspective.

Educational programs that combine nursing and engineering could facilitate the development of nurse-engineers, enabling these professionals to contribute to healthcare in meaningful ways. As evidenced by dual-degree programs in other fields, the synergy created through combined education can lead to innovative solutions that would not emerge from isolated disciplines. For example, interdisciplinary capstone projects in engineering and nursing can encourage students to merge their knowledge and skills to address complex healthcare issues. The efforts to develop joint nursing and engineering programs indicate that universities are beginning to recognize the potential of such a combined education to meet the evolving needs of healthcare systems.

2. Overview: A Collaborative Pathway in Nurse-Engineering Education

A joint degree program combining nursing and engineering has been in development, built on a foundation established in 2008 with support from alumni donations. These contributions, amounting to $25,000 annually, were intended to foster interdisciplinary research between the two fields, aiming to address real-world healthcare issues using engineering solutions. The primary goal was to promote a collaborative approach to solving complex healthcare challenges, which require expertise from both nursing and engineering.

The fellowship program provided financial support for PhD students from both fields to engage in joint research projects, addressing critical healthcare problems. To date, 12 fellowships have been awarded, with six students completing their doctoral studies. These projects generally focus on improving patient safety, healthcare service optimization, and enhancing information services. Some examples of the research include designing electronic fall-reporting systems for geriatric care facilities, evaluating the effectiveness of health informatics platforms for chronic disease management, and exploring the use of wearable technologies for monitoring patients' health.

This fellowship program has facilitated unique opportunities for doctoral candidates to work alongside faculty members from both colleges, encouraging cross-disciplinary research while also providing funding for their academic pursuits and research materials. The collaboration has led to increased joint efforts between nursing and engineering faculty, particularly in areas such as wearable health devices and eye-tracking technologies. However, the nursing college faced challenges, such as a lack of experimental labs and the need to realign research priorities. To address these, a self-assessment was conducted, resulting in a clearer focus on areas like symptom management, healthy aging, social justice, and healthcare systems, which further guided faculty recruitment and research development.

2.1 Examples of Collaborative Projects

Several joint projects have emerged from the collaboration between nursing and engineering, addressing key healthcare challenges. One project involved creating an electronic falls-reporting system for elderly care facilities, which continues to be used for monitoring patient safety. In another example, a Fellow developed a simulation model to optimize inpatient bed allocation in a large hospital, improving patient flow and operational efficiency. These projects have not only contributed to advancing healthcare technology but also provided valuable postdoctoral opportunities for the involved researchers.

2.2 Collaborative Space: Institute for Applied Life Sciences (IALS)

The opening of the Institute for Applied Life Sciences (IALS) in 2016 further facilitated this collaborative effort. IALS aims to bridge basic science with practical applications in medical technology and biomolecular research, and it supports the development of new devices, delivery systems, and treatments for improving human health. The Institute is home to over 175 faculty members across various disciplines and houses core research facilities that are accessible to both academic researchers and industry partners.

Among its key research initiatives is the Center for Personalized Health Monitoring (CPHM), which focuses on developing wearable, wireless sensor systems for personalized health care and biometric monitoring. The nursing and engineering collaboration is especially prominent within this center, where researchers from both fields are working on technologies to improve chronic illness management through wearable devices. This collaboration has led to significant funding, including a major grant from the National Institute of Nursing Research, and the establishment of the UManage Center, which focuses on symptom management for chronic conditions.

2.3 Early Stage Projects in Health Monitoring

Some early-stage research includes studies on the use of eye-tracking technology to measure fatigue in breast cancer survivors, and the development of a real-time cortisol sweat sensor to monitor stress. Other projects involve wearable devices for pregnant women to track their sleep patterns and tools to help elderly individuals manage chronic pain through improved sleep. These projects represent significant advances in healthcare technology, with the potential to improve patient outcomes by empowering individuals to manage their own health more effectively.

2.4 Joint Faculty Hires and Curriculum Development

As the collaboration between nursing and engineering grew, the need for joint faculty appointments became evident. In 2017, the first such hire was made, a faculty member with expertise in both fields. This move was part of a broader effort to develop a joint nursing-engineering curriculum and to ensure that the new program would meet the healthcare needs of the future. The College of Engineering introduced a biomedical engineering degree in 2017, and the nursing college simultaneously reviewed its undergraduate curriculum to better integrate engineering concepts.

Ongoing work in curriculum development, along with faculty hires and the establishment of the IALS, continues to support the creation of a joint nursing-engineering degree that will address emerging healthcare challenges through a multidisciplinary approach.

The pioneering 5-year dual-degree program in Nursing and Biomedical Engineering (BME/BSN), launched in 2015, combines a traditional 4-year engineering curriculum with an accelerated 1-year nursing program. This innovative approach equips students with the expertise to integrate engineering principles into healthcare solutions, with an emphasis on patient-centered care. Each cohort is limited to about 20 students to ensure a personalized learning experience and mentorship in research.

The curriculum is highly structured and rigorous. In the first three years, students complete core university requirements alongside foundational BME courses, along with two nursing prerequisites: nutrition and human development. The fourth year focuses primarily on nursing coursework, while also including electives and other core curriculum requirements. The fifth year is a blend of advanced nursing courses and the final BME capstone project. Upon graduation, students are eligible to take the registered nurse licensing exam (NCLEX-RN). The program is accredited by relevant nursing and engineering bodies, ensuring that graduates are prepared for licensure exams in both fields, including the Fundamentals of Engineering Exam, which is the first step toward professional licensure.

The capstone project is a key element of the BME curriculum, providing students with the opportunity to apply their combined knowledge of engineering and nursing to solve healthcare-related challenges. Students collaborate in teams to tackle clinical issues, developing solutions such as medical devices or processes. This involves problem analysis, solution design, prototype construction, testing, and both engineering and economic evaluations. At the end of the fifth year, students present their projects to faculty, healthcare professionals, and industry leaders.

The program also benefits students enrolled in either the BME or BSN tracks. The curriculum fosters a culture of innovation through cross-disciplinary collaboration, guest speakers, internships, hackathons, and collaborative events. These activities offer all students the chance to engage with real-world healthcare problems and creative problem-solving. Every spring, students showcase their capstone projects at healthcare engineering conferences, alongside other presentations that encourage engagement with industry developments.

To assess academic outcomes, the program uses new evaluation methods that blend the standards of both nursing and engineering accreditation. Evaluation includes establishing educational outcomes, tracking early career progression, and using feedback from students and employers to guide improvements. An internal review committee, composed of faculty from both fields, monitors the program’s effectiveness and ensures that the dual-degree model remains relevant to both academic and professional landscapes. Additionally, an external advisory board, made up of industry and academic experts, provides ongoing input on curriculum development and professional trends.

Currently, the program is in its implementation phase, and while there is no final outcome data yet, initial feedback has been positive. With 12 students enrolled in the program so far, two are entering their fourth year, where they will begin intensive nursing coursework. Though the program's first three years are primarily BME-focused, efforts are being made to increase students' connection to the nursing community earlier on through mentorship and health-related engineering experiences. For example, one student is already working on a research project with a local hospital to enhance healthcare simulation technologies.

3. Conclusion

Collaborations between biomedical engineering and nursing degree programs, along with movements like MakerNurse, have the potential to significantly reshape the intersection of nursing and technology. Nurse-engineers and their collaborations are poised to drive a shift in the way healthcare technologies are developed and clinical problems are addressed. These innovative programs create opportunities for uniquely trained nurses, whether formally or informally, to play a more active role in advancing patient care and improving outcomes through their contributions to the development of patient care devices. Beyond attracting new nursing students, these programs set a precedent for other nursing schools to adopt similar models, leading to a growing population of nurse-engineers.

Key stakeholders focused on improving healthcare quality and patient safety are increasingly calling for interdisciplinary approaches to tackle the complex and ever-changing

challenges in healthcare delivery, diagnosis, and treatment. Organizations such as healthcare research agencies and the Robert Wood Johnson Foundation are specifically advocating for and funding these collaborative, innovative solutions to enhance the safety and effectiveness of care.

As the healthcare sector becomes more technology-driven, nurses and frontline healthcare workers will need to possess both technical and clinical expertise. This will require greater collaboration between fields like healthcare information technology, nursing, and engineering to ensure workforce development and economic growth. Health systems, biomedical engineering firms, and science organizations will likely seek nurses who possess the technical skills and problem-solving abilities necessary to navigate the increasingly technological healthcare environment.

A new generation of nurses with a unique perspective on patient care will inevitably raise important questions about how to improve the delivery of care. These questions will likely fuel research and innovation, leading to the development of new patient care devices, robotic technologies, and workflow improvements that contribute to better health outcomes. Nurses, with their close patient interactions, are in the ideal position to assess health needs and identify technological solutions. Ongoing collaborations between nurses and engineers will be essential to harness the creativity of nurses and drive meaningful changes in patient care.

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