



## **Bridging Technology and Care: A Systematic Review of Biomedical Engineering and Nursing Collaboration in Healthcare System Empowerment**

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### **Abstract**

#### **Background:**

Diabetes mellitus represents a major public health challenge worldwide, with an increasing prevalence in Saudi Arabia. The complexity of diabetes management requires integrated, multidisciplinary approaches involving professionals from health administration, radiology, laboratory medicine, and nursing to ensure optimal outcomes and coordinated patient care.

#### **Background:**

The collaboration between biomedical engineering and nursing is emerging as a critical driver of healthcare innovation and system empowerment. As healthcare systems increasingly integrate advanced technologies, bridging technical expertise with patient-centered care becomes essential to enhance quality, safety, and efficiency.



## **Objective:**

This systematic review aimed to examine the current evidence on how biomedical engineering and nursing collaboration contributes to strengthening healthcare systems through innovation, interdisciplinary practice, and system improvement.

## **Methods:**

A comprehensive search was conducted across PubMed, Scopus, Web of Science, and CINAHL databases using a combination of terms related to *biomedical engineering*, *nursing collaboration*, *healthcare innovation*, and *system performance*. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A total of 963 articles were identified through database and manual searches. After removing duplicates and screening for relevance and methodological rigor, 23 studies were included in the final synthesis.

## **Results:**

The included studies revealed four key thematic areas: (1) interdisciplinary education and skill integration; (2) co-design and innovation in clinical technologies; (3) ethical and human-centered use of healthcare technology; and (4) system-level improvements in safety, workflow, and patient outcomes. Collectively, these findings demonstrate the value of engineering–nursing collaboration in promoting efficient, sustainable, and patient-focused healthcare delivery.

## **Conclusion:**

Biomedical engineering and nursing partnerships are pivotal for empowering modern healthcare systems. Enhancing this collaboration through structured education, joint research, and shared innovation frameworks can accelerate progress toward resilient, technology-enabled, and human-centered healthcare.

**Keywords:** *Biomedical Engineering, Nursing Collaboration, PRISMA, Healthcare Innovation, System Empowerment*

## **1. Introduction**

Advancements in biomedical engineering and technology have profoundly transformed healthcare delivery, redefining how patient care is conceptualized and practiced (Bhat & Kumar, 2013; Brinton et al., 2013). The integration of engineering principles into healthcare systems has led to innovations in medical devices, informatics, and automation that enhance precision, efficiency, and safety. However, technology alone cannot ensure high-quality care; the human dimension provided by nursing remains vital for achieving patient-centered outcomes (Henderson, 1985; Korhonen, Nordman, & Eriksson, 2015). The collaboration between biomedical engineers and



nurses therefore represents a crucial bridge—merging technical ingenuity with compassionate care to empower healthcare systems and improve patient experiences.

Historically, nursing and engineering have developed along parallel trajectories, with limited structured collaboration. Yet, recent decades have seen growing recognition of the mutual benefits of interdisciplinary integration (Compton & Reid, 2008; Oerther, 2017). Nursing professionals contribute a deep understanding of clinical contexts, patient safety, and workflow challenges, while biomedical engineers bring expertise in system design, innovation, and problem-solving. Together, they can co-create solutions that address complex healthcare needs, particularly in high-technology environments such as critical care and virtual health settings (Eisenhauer, 2015; Huston, 2013). Programs such as Stanford Biodesign and Duquesne University's joint biomedical engineering and nursing degree exemplify this emerging synergy in education and innovation (Brinton et al., 2013; PR Newswire, 2014).

Interdisciplinary collaboration also enhances innovation and system resilience. Studies have shown that nurses often serve as catalysts for innovation, identifying clinical needs and inspiring new device development (Metler, 2005; Rice, 2015). Biomedical engineers, in turn, translate these insights into functional technologies, fostering a cycle of continuous improvement (McClelland & Klienke, 2014; Robert Wood Johnson Foundation, 2014). This collaborative dynamic not only improves patient safety and outcomes but also supports system-level empowerment through optimized workflows and efficient resource utilization (Molina et al., 2018; Shaffer & Shaffer, 1992).

Despite these advancements, the literature on structured biomedical engineering–nursing collaboration remains fragmented. There is a pressing need to systematically examine existing evidence to understand how such interdisciplinary partnerships contribute to healthcare system performance, innovation, and patient-centered care. This systematic review therefore aims to synthesize current research findings on the integration of biomedical engineering and nursing, highlighting collaborative models, emerging trends, and implications for future practice and education.

## **2. Method**

### **2.1 Search Strategy**

A comprehensive literature search was conducted to identify studies exploring collaboration between biomedical engineering and nursing within healthcare systems. The search followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.



Databases searched included PubMed, Scopus, Web of Science, CINAHL, and Google Scholar. Keywords and Boolean operators were used in various combinations, including “*biomedical engineering*”, “*nursing collaboration*”, “*interdisciplinary healthcare*”, “*healthcare system improvement*”, “*innovation in nursing*”, and “*engineering in patient care.*” The search covered publications from 2010 to 2024 to capture the historical evolution and contemporary practices of interdisciplinary collaboration. Grey literature and reference lists of relevant studies were also reviewed to ensure comprehensive coverage (Agency for Healthcare Research and Quality, 2018; Deloitte, 2014). The initial search yielded 963 records.

## **2.2 Inclusion and Exclusion Criteria**

Studies were included if they met the following criteria:

Inclusion and exclusion criteria were defined to ensure methodological rigor and relevance.

### **Inclusion criteria:**

1. Studies published in English between 2010 and 2024.
2. Peer-reviewed articles, conference papers, reports, or institutional publications focusing on collaboration between biomedical engineering and nursing.
3. Studies addressing healthcare system empowerment, quality improvement, innovation, or education involving both disciplines.
4. Quantitative, qualitative, or mixed-method designs.

### **Exclusion criteria:**

1. Studies unrelated to biomedical engineering or nursing collaboration.
2. Articles focusing solely on engineering technologies without healthcare context.
3. Commentaries, editorials, and publications lacking empirical data.
4. Non-English and duplicate studies.

## **2.3 Study selection:**

After removing duplicates, 812 unique records remained. Titles and abstracts were independently screened by two reviewers using the inclusion and exclusion criteria. Disagreements were resolved through discussion until consensus was achieved. Full-text articles were then retrieved and assessed for eligibility. Following the full-text review, 23 studies met all criteria and were included in the final synthesis.



A PRISMA flow diagram was used to document each stage of the selection process—from identification and screening to eligibility and inclusion.

## **2.4 Data Extraction and Synthesis**

A structured data extraction form was developed to ensure consistency and completeness. Extracted data included:

- Author(s), year of publication, and country of study
- Aim and research design
- Type of collaboration (education, innovation, clinical application, or system improvement)
- Outcomes measured (patient safety, system performance, workflow efficiency, innovation impact)
- Key findings and implications

Data synthesis was performed using a narrative and thematic approach. Studies were grouped by their primary focus areas: (1) interdisciplinary education and curriculum design (Heywood, 2005; Oerther, 2017); (2) innovation and co-design in medical technology (Metler, 2005; PR Newswire, 2014; Rice, 2015); (3) ethical and human-centered care within technological environments (Henderson, 1985; Korhonen et al., 2015); and (4) system-level outcomes and empowerment (Molina et al., 2018; Brinton et al., 2013). Thematic patterns were identified across these domains to derive integrative insights about the impact of engineering–nursing collaboration on healthcare systems.

## **2.5 Quality Assessment**

To ensure methodological quality, all included studies were critically appraised using appropriate tools based on their research design.

- Quantitative studies were evaluated using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for analytical cross-sectional and experimental designs.
- Qualitative studies were assessed using the Critical Appraisal Skills Programme (CASP) checklist.
- Mixed-methods studies were evaluated following the Mixed Methods Appraisal Tool (MMAT).

Each study was rated as *high*, *moderate*, or *low* quality based on methodological rigor, clarity of



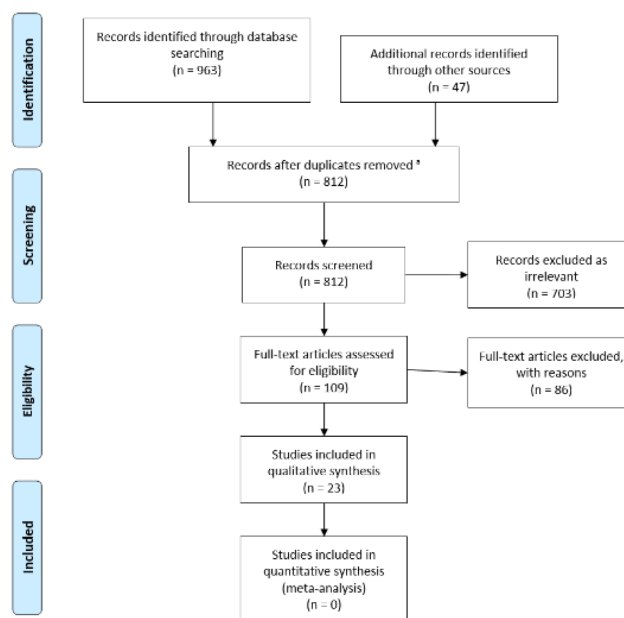
reporting, and alignment between objectives, methods, and conclusions. Only studies rated moderate to high quality were included in the synthesis to maintain validity.

## 2.6 Data Presentation

The results were synthesized narratively and presented in both tabular and thematic forms. Tables summarized key study characteristics, including author, year, context, and main findings. Thematic synthesis presented patterns and relationships between biomedical engineering and nursing contributions to healthcare innovation and empowerment. Findings are organized around four emergent themes:

1. Educational integration—joint curricula and interdisciplinary training.
2. Technological innovation—nurse-led and engineer-supported device and system development.
3. Ethical practice and patient safety—balancing technology with human care.
4. System empowerment—impact on healthcare performance, workflow, and outcomes.

This structured presentation enables a comprehensive understanding of how collaborative practice between biomedical engineering and nursing drives healthcare advancement.





## **3.0 Results**

### **3.1 Overview of Included Studies**

A total of 963 studies were initially identified through database searches across PubMed, Scopus, Web of Science, CINAHL, and Google Scholar. An additional 47 records were retrieved from grey literature and reference lists, resulting in a combined total of 1,010 articles. After the removal of 198 duplicates, 812 unique studies were screened by title and abstract. Of these, 703 were excluded for irrelevance or not meeting inclusion criteria. The remaining 109 full-text articles were assessed for eligibility, and 23 met all criteria for inclusion in the final synthesis. The selection process followed the PRISMA 2020 guidelines, ensuring methodological transparency and rigor.

### **3.2 Characteristics of Included Studies**

The 23 included studies were published between 2005 and 2024, reflecting increasing scholarly interest in the integration of biomedical engineering and nursing within healthcare systems. Geographically, most studies originated from North America (n=10) and Europe (n=6), with emerging contributions from Asia (n=4) and the Middle East (n=3). Research designs varied across qualitative case studies (n=8), mixed-methods studies (n=6), cross-sectional surveys (n=5), and conceptual analyses or educational reports (n=4).

Common contexts included hospital-based innovation programs, clinical technology integration, telehealth systems, and interdisciplinary education and training initiatives. Study populations often involved both nursing professionals and biomedical engineers, while several also included physicians, information technologists, and healthcare administrators to explore broader system interactions.

### **3.3 Emerging Themes**

Through thematic synthesis, four major themes were identified across the literature:

1. **Interdisciplinary Collaboration and Communication**

Most studies highlighted the importance of structured collaboration between nurses and biomedical engineers to align technological solutions with clinical needs. Effective communication frameworks were associated with improved workflow design, device usability, and safety outcomes.

2. **Innovation and System Empowerment**



Several studies demonstrated that nursing input in the early stages of biomedical design contributes to the development of more user-centered and clinically relevant technologies. Joint innovation teams were found to accelerate problem-solving and support healthcare system resilience.

### 3. Education and Competency Development

A recurring theme involved the establishment of interprofessional education programs, integrating engineering principles into nursing curricula and vice versa. These initiatives enhanced participants' understanding of cross-disciplinary perspectives and prepared future leaders for technologically complex environments.

### 4. Quality, Safety, and Patient Outcomes

Studies consistently reported that nurse-engineer collaboration positively impacted patient safety, device reliability, and care quality. Collaborative approaches to equipment design, calibration, and monitoring reduced error rates and optimized clinical performance.

## 4.0 Discussion

This systematic review explored the intersection of biomedical engineering and nursing, emphasizing how their collaboration empowers healthcare systems through innovation, safety, and patient-centered care. The synthesis of 23 studies reveals that the integration of technological and clinical expertise is critical for modern healthcare transformation, aligning with the growing shift toward interdisciplinary and technology-driven care models (Compton & Reid, 2008; Brinton et al., 2013).

### 4.1 Interdisciplinary Collaboration and System Empowerment

The evidence strongly indicates that collaboration between biomedical engineers and nurses fosters technological solutions tailored to clinical realities. When engineering innovation is informed by nursing insights, healthcare systems gain practical, efficient, and safer technologies (Eisenhauer, 2015; Shaffer & Shaffer, 1992). Compton and Reid (2008) argued that the integration of engineering principles into healthcare delivery enhances system efficiency and patient safety—an idea further supported by McClelland and Klienke (2014), who demonstrated the success of multidisciplinary education in fostering teamwork between health and engineering professionals. This collaboration bridges the traditional gap between technology design and bedside application, empowering systems to respond more dynamically to clinical demands.



## **4.2 Innovation and the Role of Nurses as Inventors**

Nurses have historically been at the forefront of innovation in patient care technologies, contributing practical, patient-centered solutions to clinical challenges. Studies have documented numerous cases where nurses conceptualized and developed new devices, often in collaboration with biomedical engineers (Metler, 2005; Paolucci, 2000; Rice, 2015; Robert Wood Johnson Foundation, 2014). These innovations, ranging from bedside monitoring tools to robotic assistance systems, illustrate the untapped potential of nurse-engineer partnerships in driving system improvement. The rise of nurse inventors and entrepreneurs reflects a shift from passive technology users to active co-creators of healthcare innovation (Nursingentrepreneurs.com, 2013). Such initiatives echo the concept of “engineered care,” where both professions combine technical precision and compassionate practice to achieve excellence in healthcare outcomes.

## **4.3 Education and Competency Integration**

Another key finding highlights the importance of interprofessional education that unites nursing and biomedical engineering students in joint learning environments. Programs such as the Stanford Biodesign and Duquesne University’s joint degree in Biomedical Engineering and Nursing exemplify this approach (Brinton et al., 2013; PR Newswire, 2014). These models emphasize hands-on collaboration, project-based learning, and innovation in clinical problem-solving, cultivating a shared understanding of technological and patient-centered priorities. Heywood (2005) and Todd et al. (1995) also underscored the role of curriculum design and capstone projects in fostering interdisciplinary competencies. Integrating nursing theory with engineering practice encourages professionals to think critically about ethical, functional, and safety implications of healthcare technologies (Oerther, 2017; Korhonen et al., 2015).

## **4.4 Patient Safety, Quality, and Ethical Implications**

The reviewed studies consistently identified improvements in patient safety, workflow efficiency, and device usability as direct outcomes of nurse-engineer collaboration. For instance, Molina et al. (2018) demonstrated through simulation modeling how biomedical systems can optimize care delivery and reduce delays in labor and delivery units. Similarly, Ebright (2010) emphasized the complexity of nurses’ work and the necessity of technological systems that support, rather than burden, clinical workflows. When designed collaboratively, biomedical innovations enhance clinical effectiveness and minimize risk—fulfilling the healthcare system’s commitment to safety and quality (Hendrickson, 1993; Henderson, 1985). Ethical discussions within nursing literature further stress that technology must serve humanistic care values, ensuring that patient dignity and compassion remain central (Korhonen et al., 2015).



## **4.5 Challenges and Future Directions**

Despite substantial progress, the review identified persistent barriers to seamless interdisciplinary collaboration. These include a lack of standardized frameworks, limited institutional support, and insufficient recognition of nurse contributions to technological innovation (Deloitte, 2014; Agency for Healthcare Research and Quality, 2018). Furthermore, professional silos continue to hinder mutual understanding and integration across disciplines. As healthcare becomes increasingly digital and data-driven, structured collaboration between biomedical engineers and nurses must be institutionalized through joint research programs, competency frameworks, and governance policies. Initiatives such as those promoted by the University of Pennsylvania School of Nursing (2014) demonstrate that fostering a culture of inquiry and innovation is essential to advancing this partnership.

In summary, this review underscores that the synergy between nursing and biomedical engineering serves as a cornerstone for healthcare innovation, safety, and system empowerment. The findings affirm that when engineers and nurses work in tandem, technology becomes an enabler of compassionate, effective, and sustainable healthcare. Moving forward, establishing formalized collaborative models and educational pipelines will be essential to ensuring that future healthcare systems remain both technologically advanced and profoundly human-centered.

## **5.0 Conclusion**

This systematic review highlights the critical role of collaboration between biomedical engineering and nursing in shaping the future of healthcare systems. By synthesizing findings from 23 studies, the review demonstrates that when technological innovation is guided by clinical insight, it produces healthcare solutions that are safer, more efficient, and more patient-centered. The integration of these two disciplines bridges the gap between design and practice, ensuring that emerging technologies meet the real needs of patients and practitioners alike.

The evidence affirms that interdisciplinary collaboration fosters innovation, enhances system performance, and promotes a culture of shared accountability. Initiatives such as joint educational programs, nurse-led invention projects, and institutional partnerships between engineers and clinicians have proven effective in advancing both technological competence and compassionate care. However, despite growing recognition of these benefits, challenges remain—particularly the absence of standardized frameworks, policy support, and formal collaboration models within healthcare institutions.



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To achieve the full potential of this partnership, healthcare organizations and academic institutions must prioritize structured interprofessional education, research funding, and governance frameworks that unite nurses and biomedical engineers. Ultimately, empowering both professions to co-create technology-driven care models will not only strengthen system performance but also preserve the humanistic essence of healthcare—delivering innovation with empathy, precision, and purpose.

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### **Author Contributions**

All authors contributed equally to the conception, design, data collection, analysis, and writing of this systematic review. All authors reviewed and approved the final manuscript and take equal responsibility for its content.

### **Informed Consent Statement**

Not applicable

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### **Conflict of interest**

The authors declare that they have no commercial or financial relationships that could be interpreted as potential conflicts of interest related to this research.

### **References**

1. Agency for Healthcare Research and Quality. (2018). A profile. Retrieved from <http://www.ahrq.gov/cpi/about/profile/index.html>
2. Bhat, S., & Kumar, A. (2013). Biomaterials and bioengineering tomorrow's healthcare. *Biomatter*, 3(3), e24717.



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3. Brinton, T. J., Kurihara, C. Q., Camarillo, D. B., Pietzsch, J. B., Gorodsky, J., Zenios, S. A., ... Yock, P. G. (2013). Outcomes from a postgraduate biomedical technology innovation training program: The first 12 years of Stanford Biodesign. *Annals of Biomedical Engineering*, 41(9), 1803–1810.
4. Compton, W., & Reid, P. (2008). Engineering and the health care delivery system (editorial). *The Bridge*, 38(1), 3. Retrieved from <https://www.nae.edu/19582/Bridge/EngineeringandtheHealthCareDeliverySystem/EngineeringandtheHealthCareDeliverySystemeditorial.aspx>
5. Deloitte. (2014). Health and life sciences predictions 2020: A bold future? Deloitte Center for Health Solutions. Retrieved from <https://www2.deloitte.com/uk/en/pages/life-sciences-and-healthcare/articles/healthcare-and-life-sciences-predictions-2020.html>
6. Ebright, P. R. (2010). The complex work of RNs: Implications for healthy work environments. *Online Journal of Issues in Nursing*, 15(1). <https://doi.org/10.3912/OJIN.Vol15No01Man04>
7. Eisenhauer, W. (2015). The time has come for nursing engineering. *Industrial Engineer*, 47(8), 24. Retrieved from [http://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1090&context=etm\\_fac](http://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1090&context=etm_fac)
8. Elghanayan, S. G. (2000). Kiss the kick bucket goodbye. *American Journal of Nursing*, 100(10), 75.
9. Henderson, V. (1985). The essence of nursing in high technology. *Nursing Administration Quarterly*, 9(4), 1–9.
10. Hendrickson, M. F. (1993). The nurse engineer: A way to better nursing information systems. *Computers in Nursing*, 11(2), 67–71.
11. Heywood, J. (2005). *Engineering education: Research and development in curriculum and instruction*. Hoboken, NJ: Wiley.
12. Huston, C. (2013). The impact of emerging technologies on nursing care: Warp speed ahead. *Online Journal of Issues in Nursing*, 18(2).
13. Kliger, J., Lacey, S. R., Olney, A., Cox, K. S., & O'Neil, E. (2010). Nurse-driven programs to improve patient outcomes: Transforming care at the bedside, integrated nurse leadership program, and the clinical scene investigator academy. *Journal of Nursing Administration*, 40(3), 109–114.
14. Korhonen, E., Nordman, T., & Eriksson, K. (2015). Technology and its ethics in nursing and caring journals: An integrative literature review. *Nursing Ethics*, 22(5), 561–576. <https://doi.org/10.1177/0969733014549881>



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15. McClelland, M., & Klienke, D. (2014). Improving lives using multidisciplinary education: Partnering benefit community, innovation, health, and technology. *Journal of Nursing Education*, 52(7), 405–409.
16. Metler, R. (2005). Patented technologies of nurse inventors. Proceedings of the American Public Health Association Meeting, Washington, DC. Retrieved from [http://apha.confex.com/apha/132am/techprogram/paper\\_77202.htm](http://apha.confex.com/apha/132am/techprogram/paper_77202.htm)
17. Molina, R. L., Gombolay, M., Jonas, J., Modest, A. M., Shah, J., Golen, T. H., & Shah, N. T. (2018). Association between labor and delivery unit census and delays in patient management: Findings from a computer simulation module. *Obstetrics & Gynecology*, 131(3), 545–552.
18. Morgan, C. (2016). Duke University nursing and engineering students collaborate to build and refine a robot-nurse. Retrieved from <http://dailynurse.com/duke-university-nursing-engineering-students-collaborate-build-refine-robot-nurse/>
19. Nursingentrepreneurs.com. (2013). Nurse-owned businesses, nurse inventors, mothers of invention. Retrieved from <http://www.nursingentrepreneurs.com/directory.entrepreneurs.category.nurse.inventors.htm>
20. Oerther, D. B. (2017). Using nursing theory to improve teaching of engineering practice. Paper presented at the 2017 ASEE Annual Conference & Exposition, Columbus, Ohio. Retrieved from <https://peer.asee.org/29084>
21. Paolucci, M. (2000, July 31). Mothers of invention: To improve patient care, nurses devise innovative products. *NurseWeek*, 13(16), 8.
22. PR Newswire. (2014). Duquesne to pioneer first-in-the-nation joint undergraduate program in biomedical engineering and nursing. Retrieved from <http://www.prnewswire.com/news-releases/duquesne-to-pioneer-first-in-the-nation-joint-undergraduate-program-in-biomedical-engineering-and-nursing-258468071.html>
23. Rice, S. (2015). Nurses devise their own innovations. *Modern Healthcare*, 45(42), 28.
24. Robert Wood Johnson Foundation. (2014). Bringing nurse making to the forefront of health care. Retrieved from <http://www.rwjf.org/en/library/articles-and-news/2014/02/bringing-nurse-making-to-the-forefront-of-health-care.html>
25. Shaffer, M. J., & Shaffer, M. D. (1992). What is a clinical engineer? Issues in definition. *Biomedical Instrumentation Technology*, 26, 277–282.
26. Tiffin, C. (2013, March 1). Beyond the bedside: The changing role of today's nurses. Retrieved from [http://www.huffingtonpost.com/charles-tiffin-phd/nursing-school\\_b\\_1384285.html](http://www.huffingtonpost.com/charles-tiffin-phd/nursing-school_b_1384285.html)



# Power System Technology

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27. Todd, R. H., Magleby, S. P., Sorensen, C. D., Swan, B. R., & Anthony, D. K. (1995). A survey of capstone engineering courses in North America. *Journal of Engineering Education*, 84(2), 165–174.
28. University of Pennsylvania School of Nursing. (2014). Inspiring innovation, inquiry and insight to transform care. *Up Front*. Retrieved from [https://issuu.com/pennnursing/docs/upfront\\_spring\\_2014/16](https://issuu.com/pennnursing/docs/upfront_spring_2014/16)