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A conceptual framework for interdisciplinary education in engineering and nursing health informatics

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ABSTRACT

This paper discusses a conceptual framework for an interdisciplinary education in engineering and nursing health informatics. A team with diverse scientific backgrounds and perspectives is anticipated to effectively and efficiently address healthcare systems problems, which can be facilitated by highly integrated and interactive team settings. Nursing students, for example, are in the best position to assess the functional health status and technology needs of patients and health professionals given their close interactions with them. On the other hand, engineering students have skills and knowledge needed to develop a fully functioning technology intervention. The students in engineering and healthcare majors will be able to help each other to obtain a deeper understanding about clinical perspective and technology intervention designs to address adequately healthcare systems problems today via the interdisciplinary educational setting.

1. Introduction

Information technology (IT) becomes an essential component in healthcare as more health professionals are responsible for dealing with a great amount of patients' medical information (e.g., a record of a patient's symptoms, medical history, previous medical exam reports, X-ray results, laboratory test results, doctor's diagnoses, or a combination of them). A new initiative by the U.S. government (Health IT.gov, 2016) has been established to promote meaningful use of electronic health technology to improve quality, safety, efficiency, and reduce health disparities. The meaningful use compliance is likely to result in better clinical outcomes, improved population health outcomes, increased transparency and efficiency, empowered individuals, and more robust research data on health systems. This national call for adoption of advanced health information technology also comes with an enormous need for qualified health care technicians and developers. The U.S. Bureau of Labor Statistics (2017) expects that job opportunities for health IT will be tremendous in coming years, which will be, for instance, influential on nursing centers, outpatient care facilities, other home medical services, intensive care units, and physician's offices.

While there is a strong need for graduates who can understand both healthcare and IT, education settings today are less likely to prepare students adequately to respond to this national call. As the healthcare system is complex consisting of many different and connected components (Lipsitz, 2012), healthcare systems education needs to be interdisciplinary by offering a dual-degree program (Davis, 2017). For instance, nursing students can identify healthcare facilitators and barriers in the field while engineering students can design and develop technology interventions while collaborating with nursing students. Yet, many institutions have not offered such an interdisciplinary course such that students have been missing a great opportunity to interact with other peer students from different domains (e.g., nursing and engineering), ultimately leading to a challenge to become a leader in health informatics. Even if nursing (or engineering) students could voluntarily take some biomedical engineering-relevant courses (or nursing-relevant courses) via free online courses (e.g., https://ocw.mit.edu and https://edx.org), those courses are exclusively designed to accommodate either nursing or engineering students without considering a case that a nursing student (or an engineering student) takes a biomedical engineering course (or a healthcare course). As the students have lack of background knowledge to take a course in a different domain, it would also be a challenge for them to take those courses and study by themselves such that they are less likely to obtain a full comprehension, to make connections, and to understand the complicated concepts and theories (Lent, 2012).

Furthermore, an interdisciplinary education is often taught by an instructor who is specialized in a particular discipline (Modo and Kinchin, 2011). Instructors in higher education tend to have expertise in a particular discipline, leading to a challenge to engage with other instructors if there is a lack of a common vocabulary and education vision. An instructor is anticipated to share a common vision to prepare and provide an appropriate curriculum for students. Incoherence in the teaching curriculum between instructors from different disciplines is likely to have students obtain a fragmented knowledge and concept. When health IT courses are taught by instructors who are knowledgeable only in either healthcare or information technology, the course is likely to focus on one branch of knowledge only, which is less likely to accommodate students who would like to obtain a set of skills and knowledge needed to develop a comprehensive understanding of healthcare and its relations with technology. Those students in such poorly, unbalanced education settings would graduate with fragmentary and unconnected knowledge. A consistent framework guiding a structured learning context is essential for students to assimilate complex ideas into a cohesive knowledge structure.

From a theoretical point of view, the course offering fragmentary knowledge is not in accordance with Bloom's Taxonomy either

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(Anderson et al., 2001). Bloom defines six components of educational objectives at the cognitive domain, including knowledge, comprehension, application, analysis, evaluation, and synthesis. Based on the theory, students who study health informatics with biased course modules that are designed by focusing toward either health care or engineering would fail to obtain a comprehensive view and knowledge of healthcare systems. Given the partial knowledge, students would encounter a difficulty comprehending the health system, its barriers or facilitators. As a result, students' cognitive information processing might not be able to approach next levels of the Bloom's Taxonomy such as application, analysis, evaluation, and synthesis.

2. Model of Interdisciplinary Health Informatics Course

With acknowledgement of such educational gaps, we propose a model of an interdisciplinary course to support integrative, inclusive health informatics teaching and learning environments. The proposed interdisciplinary course is a cross-listed course that students from engineering and other healthcare–relevant domains (e.g., Nursing) are allowed to take as an elective course. The course would also welcome other students, such as those from computer science, communication and information. The interdisciplinary program is anticipated to produce graduates with fundamental skills in health services and processes along with a strong background in health systems engineering. Graduates will ideally be suitable for skilled professional management roles aimed at improving quality, streaming processes, and improving efficiency in the constantly evolving healthcare systems.

2.1. Team-based Learning

It is well documented that knowledge can effectively be obtained in the collaborative interchange settings among students – e.g., team-based learning (TBL) (Fatmi et al., 2013). The proposed course can help students to team up with other peer students who have different backgrounds and create an Interdisciplinary Team (iTeam) (see Fig. 1). The following scenario would occur in class. Graduate students in nursing tend to have full-time jobs as a nurse and seek an advanced degree simultaneously (Ketefian and Redman, 2015). Many of those nursing students have extensive clinical experience in real healthcare settings. For instance, the nursing students (e.g., graduate nurse informatics students) are likely to observe and face many of health technology-related problems (e.g., usability and accessibility problems) during their service in the hospital, but also they often tend to already have developed abstract intervention or innovative ideas to address the problems. Yet, they would need a collaborative partner who has engineering background to develop a working prototype intervention. Engineering students normally have technological knowledge and skills needed to design and develop the user-centered technology interventions. The nursing students would bring those problems to the class, form the iTeam, and work with engineering students to immediately begin designing and developing a fully working prototype to resolve such real world problems in healthcare systems or generate a new idea of technology interventions together.

2.2. Teaching Principles

The proposed course will teach students by referring to the validated guidance such as the Technology Informatics Guiding Education Reform (TIGER) (Hebda and Calderone, 2010) and the Quality and Safety Education in Nursing (QSEN) (Cronenwett et al., 2007). For example, the TIGER will guide students to obtain deeper understanding of the following three components: basic computer competencies, information literacy, and information management (Tiger Initiative, 2006). Thus, students will learn various aspects of information technology such as hardware, software, networks, security, and operating systems. Their information literacy will also be improved by obtaining the ability to determine the nature and extent of the information needed, access the information effectively and efficiently, evaluate the

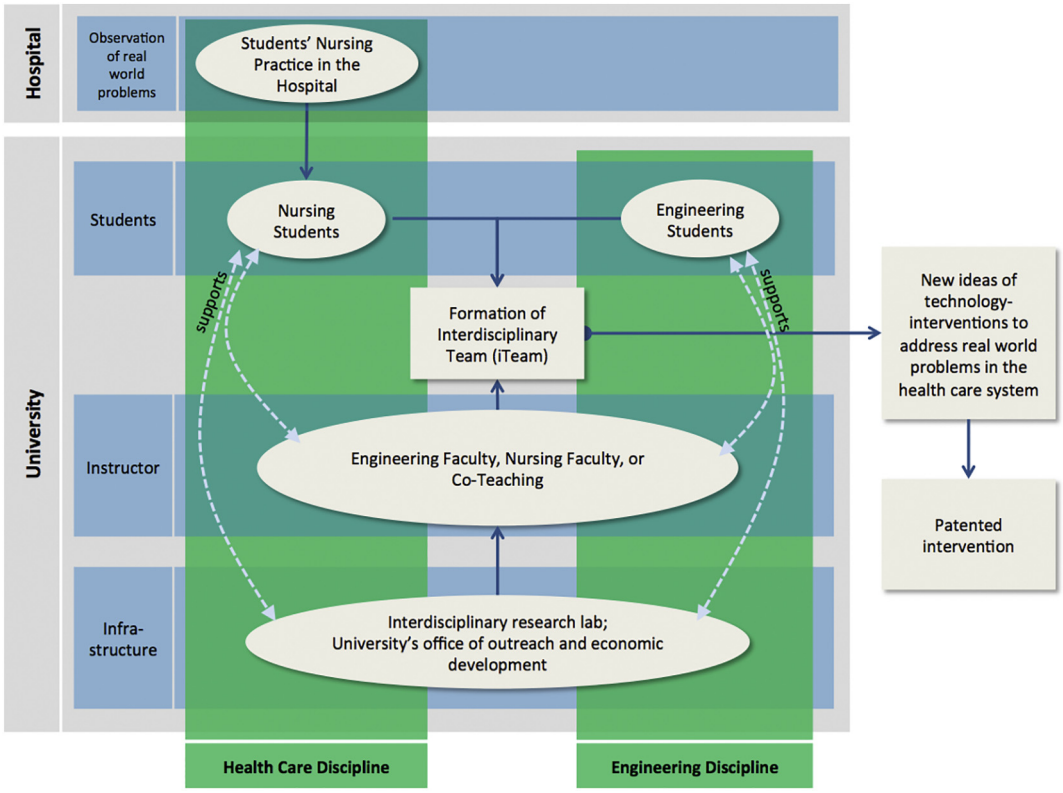

Fig. 1. Conceptual framework for the interdisciplinary course in engineering and nursing health informatics.

information to incorporate selected information into his/her knowledge base, use information to accomplish a goal, and evaluate the outcomes of the use of information. Students will also be trained to understand various types of health information systems, the importance of health information systems, and its confidentiality and security. The QSEN's guidance can contribute to improving students' six competencies, including patient-centered care, teamwork & collaboration, evidence-based practice, quality improvement, safety, and informatics. Students who have successfully completed the proposed course can function effectively in the inter-professional teams fostering open communication, mutual respect, and shared decision-making to achieve quality patient care. In addition, those students would become competent to use information and technology to communicate, manage knowledge, mitigate error, and support decision-making.

2.3. Patented Interventions

As the primary goal of this course is for students to learn skills and knowledge required to create innovative technology solutions and work collaboratively in the iTeam, evidence of their new knowledge and skills could, for example, be through the patented intervention. Low-fidelity prototypes (e.g., paper sketchy) are also considered and acceptable. The intervention could be a type of health information and communication technology (ICT) applications such as mobile health (mHealth) applications (apps) or mobile friendly websites. In order to facilitate the educational practice, each student is given access to mobile devices and relevant software development tools, and use as his or her prototype development kits. In addition to class lectures, each team has a series of informal regular meetings to proceed with their projects, and they are encouraged to fully use the instructor's office hours to develop the concept of their interventions. Each team is also recommended to consult a University's office of outreach and economic development about their projects and patent opportunities. Students are also advised to develop a weblog for their own project and keep track of their progress with time and date. As the patent system in the U.S. rewards the first person that invents a new idea or product, the students' weblog would help them facilitate the process of the patent applications. In addition, students can discuss with a University's office of technology transfer to move their interventions from the lab to the market. The office would directly work with students to build a pipeline of novel products and concepts with commercial value.

2.4. Potential for Educational, Social or Environmental Impact

As a primary educational objective and benefit, students can get an opportunity to observe how the overall health care systems work together, which is also supported by the socio-technical systems theory (Hendrick, 2006) with its contention "*the whole is more than the simple sum of its parts*." It means that we will get a better–functioning system (e.g., a well-integrated health informatics course) when the overall system is properly designed to adapt to its environment (i.e., interdisciplinary learning with a combination of nursing and engineering students in class) and also when the parts are in harmony with it (i.e., learning of students with different backgrounds, instructor's inclusive pedagogy based on TIGER/QSEN guidelines and Bloom's Taxonomy, and the university's supportive infrastructure). Students' technology intervention ideas could ideally be evolved to be commercialized to enhance the health care systems.

2.5. Instructor

The instructor could be an individual who has experience in both healthcare and engineering. An engineer who has completed a postdoctoral training in healthcare could be an ideal instructor. For example, Johns Hopkins Department of Biomedical Engineering (2018) uses a strong connection and close proximity to the Schools of Medicine and Engineering to offer a postdoctoral program where postdoctoral trainees can obtain various interdisciplinary training opportunities, ranging from daily clinical grand rounds in different specialties to weekly seminars in areas of engineering. A nurse who has earned a dual graduate degree in nursing and biomedical engineering would also be recommended (Davis, 2017). In case of lack of infrastructure in a smaller institution, co-teaching by engineering faculty and nursing faculty could be considered instead. Students in the proposed course are anticipated to work together with an interdisciplinary research lab that could be housed in an engineering school, a nursing school, or a shared facility to advance the science of health information technology, consumers' health outcomes, and professional health education. The lab would ideally have the capability to offer the students an opportunity to experience realistic-looking, simulated hospital units and simulated home that provide a replica of the patient care environments such that students learn to apply cognitive, technical and psychomotor skills. Thus, students can "*learn by doing*" instead of merely using textbooks.

3. Conclusion

This paper has discussed a conceptual framework for interdisciplinary education in engineering and nursing health informatics. Students from different academic backgrounds will study together to address effectively health care challenges, which will ultimately be beneficial to the U.S. and global health care systems.

References

Anderson, L.W., Krathwohl, D.R., Bloom, B.S., 2001. A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Allyn & Bacon.

Bureau of Labor Statistics, 2017. Occupational Outlook Handbook, 2016–17 Edition, Medical Records and Health Information Technicians on the Internet. Retrieved March 2, 2017, from. https://www.bls.gov/ooh/healthcare/medical-records-and-health-information-technicians.htm.

Cronenwett, L., Sherwood, G., Barnsteiner, J., Disch, J., Johnson, J., Mitchell, P., Sullivan, D.T., Warren, J., 2007. Quality and safety education for nurses. Nurs. Outlook 55 (3), 122–131. https://doi.org/10.1016/j.outlook.2007.02.006.

Davis, C.R., 2017. Nurse-scientists and nurse-engineers. In: American Nurse Today. vol 12. pp. 50–51 11.

Fatmi, M., Hartling, L., Hillier, T., Campbell, S., Oswald, A.E., 2013. The effectiveness of team-based learning on learning outcomes in Health professions education: Beme guide no. 30. Med. Teach. 35 (12), e1608–e1624.

Health IT.gov, 2016. Meaningful use definition and objectives. Retrieved February 28, 2016, from. https://www.healthit.gov/providers-professionals/meaningful-use-definition-objectives.

Hebda, T., Calderone, T.L., 2010. What nurse educators need to know about the Tiger Initiative. Nurse Educ. 35 (2), 56–60. https://doi.org/10.1097/NNE.0b013e3181ced83d.

Hendrick, H., 2006. Sociotechnical systems theory: the sociotechnical systems model of work systems. In: Karwowski, W. (Ed.), International Encyclopedia of Ergonomics and Human Factors. Vol. 3. CRC Press, pp. 2966–2968.

Tiger Initiative, 2006. Informatics competencies for every practicing nurse: recommendations from the tiger collaborative. In: Technology Informatics Guiding Education Reform, (Retrieved on November, 20, 2014).

Johns Hopkins, 2018. Postdoctoral Fellowships. From. https://www.bme.jhu.edu/graduate/postdoctoral-fellowships/.

Ketefian, S., Redman, R.W., 2015. A critical examination of developments in nursing doctoral education in the United States. Revista Latino-Americana de Enfermagem 23 (3), 363–371. https://doi.org/10.1590/0104-1169.0797.2566.

Lent, R.C., 2012. Overcoming Textbook Fatigue: 21st Century Tools to Revitalize Teaching and Learning: Ascd.

Lipsitz, L.A., 2012. Understanding Health care as a complex system: the Foundation for unintended consequences. JAMA 308 (3), 243–244.

Modo, M., Kinchin, I., 2011. A conceptual framework for interdisciplinary curriculum design: a case study in neuroscience. J. Undergrad. Neurosci. Educ. 10 (1), A71.

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