AC 2010-1950: CONSIDERING GRADUATE RESIDENCIES AND CO-OPS IN HEALTHCARE ENGINEERING

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Prof. Caldwell is a Professor in Industrial Engineering, and Aeronautics & Astronautics, at Purdue University. His background includes undergraduate degrees from MIT in 1985 (one in astronautics; one in humanities) and a PhD (1990) in social psychology from the University of California-Davis. He is a research leader and innovator in human factors engineering aspects of information flow, task coordination, and team performance as affected by information technology. His research explores human factors engineering principles of how people get, share, and use information well, including the following:

• Defining quantitative characteristics of information flow and task coordination in team performance;

• Describing effects of tasks, situations, and technologies on effective information exchange in organizations;

• Improving user access to information and knowledge to manage events in complex systems.

Prof. Caldwell's research efforts have resulted in over 100 scientific publications. His projects since 2000 have been funded by a variety of sources including Motorola, NASA, the Regenstrief Center for Healthcare Engineering, and the United Space Alliance. Since 2002, Prof. Caldwell has also served as the Director of the Indiana Space Grant Consortium (INSGC), a statewide STEM education and engagement program funded by NASA.

Considering Graduate Residencies and Co-ops in Healthcare Engineering

Abstract

Co-op rotations and practicum-style internships are common educational and professional development activities at the undergraduate level in engineering colleges. However, this practice is much less frequent in graduate engineering programs, presumably because of the focus on graduate research activity. Should similar limitations extend to graduate students who are conducting field-based research in emerging engineering discipline areas? This concern is especially critical in the field of healthcare engineering, on which there is growing national emphasis as well as a willingness to embrace new engineering techniques and practices in hospitals and medical centers. Ironically, the healthcare environment has an existing model for graduate preparatory training before the start of independent postgraduate practice: the medical residency. This paper describes the author's experience in developing a research lab emphasis on "graduate engineering residencies" in healthcare settings. Multiple models are used, including partnerships between the author's lab and campus healthcare technical assistance programs.

Introduction

The concept of practical education in industry is not a new concept for undergraduate engineering disciplines. Co-operative engineering programs, despite fluctuations in design or student enrollment, remain a mainstay of undergraduate engineering programs across the US. Many students develop a sense of the applications of theoretical principles and useful equations during semesters and summers of professional experience. In addition, employers often find the co-op experience beneficial as a type of "extended interview and recruiting" process, where the employer learns both the skills of the student and the opportunities for applying recent innovations from the university to improving the performance of the organization.

Although this concept is well respected and implemented at the undergraduate level, the extension of the co-op / internship model to graduate education is much more sparsely implemented. Thesis-based graduate students are assumed to be spending their time on campus conducting research. As a result, a graduate-level co-operative education program is still considered a novelty at a number of universities, including the author's current affiliation.

This disconnect between graduate education and industry practice can be seen as damaging to effective partnership and knowledge transfer between campus and company. Even in well-established disciplines, a lack of graduate student experience in the priorities and demands of real-world problems (except as filtered through a research advisor) can represent a dangerous contribution to a perceived gap between university research and workplace priorities. However, this problem is multiplied as engineers begin to work in emerging problem domain areas. For

instance, there has been substantial recent interest in bringing industrial engineering disciplines and students into hospitals to improve quality, patient safety, and cost effectiveness. Hospitals do not function like other production environments, and thus traditional assumptions of production systems performance and organizational management may not always apply. How can students with an interest in this emerging area develop the necessary familiarity with the complexity of the healthcare environment?

(Re) Integrating Industrial Engineering and Healthcare

As several Industrial Engineering departments across the US develop partnerships with healthcare facilities and providers, there is a continuing need for engineers to be able to effectively translate their efforts and approaches in ways that are accepted and understood in the healthcare environment. There are few senior IE faculty who have fundamental training in both engineering and medicine, and thus students working to combine these areas may find it difficult to find an advisor with skills in both the engineering methodological and problem solving approaches, and the practice of medicine with its focus on life-critical performance demands.

In retrospect, previous attempts to integrate industrial engineering and healthcare have suffered from this lack of appreciation of the unique demands of combining these fields. *Hospital Industrial Engineering* is a traditional industrial engineering text that is still used, over 40 years later, to describe time study and shop-floor production approaches to managing hospital performance [1]. However, this text also demonstrated the limits of a manufacturing-based approach to healthcare, uncovering substantial inconsistencies between hospitals and other environments. Perhaps one of the most important lessons from this prior effort is that engineers must make more established efforts to learn about the hospital environment from the healthcare providers' perspective, and develop an awareness of their language, priorities, and concerns.

Production systems engineering and scheduling areas of industrial engineering have been significantly challenged by the healthcare environment, due to considerable uncertainties in patient arrivals, the nature of patient condition, and even patient compliance with healthcare interventions [2]. Thus, in contrast with traditional production systems environments, modern IE approaches must consider patient scheduling where the inputs are intentional entities that are acted on by domain experts who expect and insist on particular and idiosyncratic styles of operations, with objective functions that may be inconsistent, irrational, or nonstationary. In the author's area of human factors and cognitive ergonomics, there was an even greater need for direct involvement of the industrial engineering research team with the healthcare provider environment.

An additional growing emphasis on financial efficiency and quality improvement also draws on the skill sets and demands for engineers to understand the workplace context of hospitals. For instance, multiple sources of insurance, privacy, process, and regulatory compliance demands may be not be seen as value-added compared to other industries, but the healthcare environment makes these demands non-optional. The goal, then, is to improve information system and technology usability, and process flow, to support efficient documentation of activities with low reward for successful completion, but high financial and organizational penalty for failure. Cost-

effective technology integration and utilization have long been a challenge in technology-driven organizations[3, 4]. Pressures for having technologies that are seen as competitive in bringing in patients and delivering high quality care must be balanced against the staffing, training, and workload pressures on a professional workforce (e.g., physicians, nurses, medical physicists) with advanced degrees and significant workplace autonomy.

Human Factors Engineering Experiences and Internships in Healthcare

Based on the demands for ecological validity from field-based research, and the growing interest during the 1990s on patient safety and human factors approaches to reducing medical error, the author began working with healthcare provider teams to learn about team-based expertise and coordinated task performance. Almost immediately, the best gains from these projects in the late 1990s came when the author's students spent significant time in the hospital environment observing task processes and learning about the concerns and context of the range of healthcare providers. As a result, the author began to proactively seek out opportunities for both MS and PhD students with an interest in healthcare engineering to not only collect data from healthcare settings, but to develop an approach of "shadowing" providers. Not only has this approach become more popular for students in this emerging area, the focus on systems engineering studies of complex performance in healthcare has helped to uncover new areas of task coordination and performance in this environment.

Beginning with the development of a healthcare technical assistance program (modeled on industrial engineering technical assistance programs made available to local manufacturing and production companies) at the author's institution, there have been more opportunities to enable student exposures to the hospital, clinic, or pharmacy environment. Master's and doctoral students in the author's lab have worked with these technical assistance projects, and created internships at hospitals, in order to develop an experientially-grounded approach to studying team coordination and information flow in healthcare settings. Since most engineering students do not have operational backgrounds or training in medical practice, the experience of the healthcare environment comes as a distinct departure from other industry and systems engineering contexts. However, some significant gains have come out of the students' ability to directly challenge "conventional wisdom" regarding healthcare information technology use, task coordination, or even the nature and value of interruptions as an important aspect of healthcare team performance.

Over the past 10 years, five of the author's PhD students have utilized this type of field-based practicum / project activity with hospitals as part of their expected graduate progression. Direct healthcare experience by the author's students has helped to uncover a number of inaccurate or inappropriate assumptions that have hampered the application of systems engineering tools and methods to improving healthcare delivery at the level of the provider team. Allowing for such extended "participant observation" experiences within the author's research model enables students to adapt concepts, data collection methods, and implementation techniques to the reality of the healthcare environment. Current and past cases have demonstrated the importance of such residencies in understanding constraints and challenges to describing, modeling, and improving workflow and task coordination among healthcare providers.

The most recent of these residencies involves a student working at a leading oncology research and treatment center in the southern US. The student's position is one in the Office of Performance Improvement, and thus demonstrates the value that the healthcare center places on integrating these skills of engineering analysis and quality assurance / assessment / improvement into a variety of hospital operations. This student already has experience with a campus-based technical assistance / business extension program supporting healthcare facilities, and thus has the capability of understanding the organizational contexts of healthcare quality improvements. However, the organizational complexity of a large, internationally recognized specialty center incorporates opportunities for student learning experiences that are not available in a short visit or remote research analysis project.

Towards a Continued Model of Engineering Residencies

Recent economic climate shifts, combined with growing concerns for healthcare cost containment and information technology integration, continue to increase incoming student interest in applying human factors tools to healthcare settings. In addition, similar pressures for improved patient safety and response to emerging threats (such as the H1N1 pandemic outbreaks in the US) have increased the willingness of hospitals and other healthcare facilities to consider partnerships with industrial engineering programs. For medical practitioners, the concept of a graduate "residencies" to develop additional skills in a specialty is a well-known concept, and one that has helped describe the intended relationship between the author's students and the healthcare facility. (In contrast to a "consultant," who must demonstrate expertise and competence upon entry to the facility, a "resident" is expected to be still in the process of learning skills from their experience at the facility.) It is telling that the doctoral student described above has an office name plaque with the title, "Student Extern," demonstrating that a variety of occupational titles not familiar to engineering programs are available to successfully place students and link them clearly to hospital cultural contexts.

Although not yet formalized in the Industrial Engineering curriculum, more students are considering a graduate engineering residency with a healthcare provider as an effective alternative professional development path. These residencies also address an ongoing problem of perceived mismatches in job classification or title with relevant professional skills. Both hospitals and graduate engineering programs continue to struggle with appropriate definitions of what a new generation of healthcare engineers will be called, and called upon to do, within the hospital or healthcare network. Although many hospitals have a number of high-volume activities with demands for improved quality, awareness of statistical process control or other analytical techniques is limited. Thus, the engineer might have significant challenges explaining to hospital administrators what these skills are, or how the hospital may benefit. Since few hospitals have published job openings for human factors engineers or healthcare engineers, focused work experience over a period of months (rather than days) is frequently the major method for allowing the student to demonstrate and explain their desired job type or skill set. (It is interesting that the student described above, after six weeks of residency, has now been approached by the healthcare center to fill open or anticipated positions with quality improvement or cost containment responsibilities.)

With the growth of interest in healthcare engineering, this ”engineering residency” approach represents a model for improved participation, relevance, and technical quality of engineering education and research applied to healthcare environments. As these students return to campus, there are even more opportunities to engage and excite new cadres of engineers to broaden their understanding and vision of opportunities to apply their systems analysis and problem solving skills to the benefit of the population and the profession.

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