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Enabling Technology as an Active Contributor to Human Learning of Complex Skilled Activities (2017-2019)

PI:

Gregory Hager, Ph.D.
Mandell Bellmore Professor
Department of Computer Science
Whiting School of Engineering

Co-Investigators:

Gina Adrales, M.D. MPH
Associate Professor
Department of Surgery
School of Medicine

Anand Malpani, Ph.D.
Assistant Research Scientist
Malone Center for Engineering in Healthcare
Whiting School of Engineering

Swaroop Vedula, MBBS MPH Ph.D.
Assistant Research Professor
Malone Center for Engineering in Healthcare
Whiting School of Engineering

Bethany Sacks, M.D. M.Ed.
Assistant Professor
Department of Surgery
School of Medicine

Christina Harnett, Ph.D. MBA
Associate Professor
School of Education

Linda Tsantis, Ph.D.
Associate Professor
School of Education

Research Question: Can technology enable effective and efficient learning of skilled tasks, e.g., surgical technical skills?

Interdisciplinary Approach: This work will bring together scientific principles from peer learning in adults, machine learning, and surgical skill assessment to deliver a scalable methodology to augment technology to support humans learning complex skills.

Potential Implications of Research: This research will deliver expert-like coaching in the absence of mentors to make virtual reality-based surgical training more effective and efficient than conventional training, thereby reducing time to operating room readiness of surgical trainees. Our methodology will be applicable to other domains where humans learn complex skills through interaction with technology, e.g., learning social skills in autism spectrum disorders, learning to interface with industrial and space robots, and humans learning to drive cars or to fly planes.

Surgery is a prototype for contexts in which human learning can be significantly transformed with technology. Besides transforming patient care, technological advances are now beginning to play an increasingly central role in graduate surgical education. Several factors are driving this transformation, including the large number of procedures in which trainees must gain competency, and learning constraints in the operating room (OR) due to patient safety concerns, variable teaching opportunities, and resource limitations. Virtual Reality (VR) simulation is an exemplar technology that enables skill acquisition in humans outside of real scenarios like the OR, but to a limited extent. We hypothesize that *augmenting technology with human intelligence in a coaching paradigm will transform its role in how surgeons acquire technical skill*.

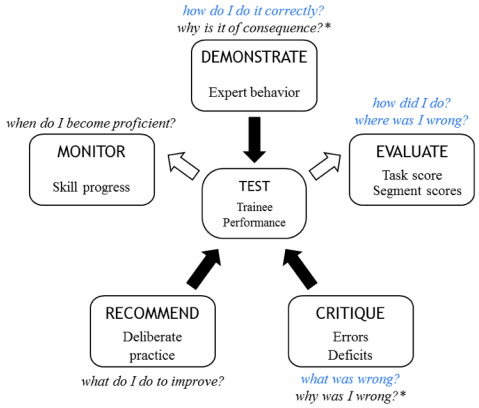

Figure 1. Virtual Coaching Framework.

Surgical coaching by an experienced surgeon is effective for imparting technical skill. Lack of resources required to replicate expert coaching at scale is a critical barrier to designing effective technical skill training curricula that minimize time to *OR readiness*. Automating coaching in VR provides a scalable solution to replicate expert feedback in the training laboratory. We hypothesize that augmenting automated coaching with human insights can more effectively replicate expert coaching at scale. To this end, we will draw upon methodologies from peer learning in adults, machine learning, and data science, and ground them in the context of a basic surgical skills training curriculum for novices.

We will assemble a cohort of novices to serve as peers and capture a corpus of structured feedback from them on others' performances of the study task. We will structure the feedback to enable subsequent mapping to task performances. We will use machine learning approaches to learn a mapping between data captured during a performance and feedback. We will develop a trainee-centered, clear, concise, efficient and effective score card to

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deliver the coaching interventions per principles of universal design for learning. Finally, we will conduct a randomized controlled trial to determine the effectiveness of the VC augmented with automated feedback.

Using surgical technical skills as the test-bed, our project's main innovation will be to bring in machine intelligence to enable technology to play an "active" role in the human learning of complex skilled activities.