Through the eyes of the physician

Valorization

Common to any academic pursuit is the generation of knowledge to expand our understanding of science. In addition to this contribution, the implications of this dissertation have the added potential for real-world application in the short-to-medium-term.

Relevance

With varying frequency, physicians across the spectrum of almost all medical specialties are involved, to some degree, in resuscitating their patients. There is now a public expectation that physicians trained in all residency programs will demonstrate basic competence in this area. With the recent move toward competency-based medical education (CBME), an increasing number of residency programs have begun formalizing this expectation in teaching and assessment of their medical trainees.

Though basic competence is necessary, the goal of any residency program should be on supporting trainees as they progress toward expertise along the novice-expert continuum. Prior to undertaking this PhD thesis, we did not have a good understanding of how expertise in resuscitation medicine developed, nor were we able to reliably measure it. A key reason for this is that many of the decisions made by a physician while resuscitating a patient in a high-stakes and time-constrained environment occur at a cognitive level. As a result, they have traditionally been difficult to measure and describe.

The studies presented in this dissertation describe methods of getting beyond this challenge. Grounded in analyses of physician cognitive load and cognitive processes, we have shown that progression along the novice-expert continuum in resuscitation medicine can be described and measured reliably.

These findings are timely and relevant given the move toward CBME and in the current era of patient safety.

Target groups, activities and products

The results of the studies presented in this dissertation will be of interest to a number of groups. In particular, the results will be of interest to medical educators. Up until now, teaching and assessing the crisis resource management (CRM) skills that underpin physician performance during a resuscitation case has been mostly *ad hoc*. Simulation has provided a vehicle to start teaching and assessing these skills, but most simulation training has relied on exposing medical learners to a high volume of cases and assuming they will learn CRM skills with this exposure. What has been lacking is a complete understanding of how these skills are naturally acquired by learners as they progress along the novice-expert continuum in resuscitation medicine. As a result, much of the teaching and assessment practices in resuscitation medicine have taken a one-size-fits-all approach. By understanding how physicians' cognition changes as they gain expertise, medical educators should now have a more nuanced approach to teaching and assessing their learners.

Moreover, armed with new knowledge about how expertise develops in resuscitation medicine, medical educators may take the insights afforded by the studies presented here to design thoughtful competence-based curricula. Knowing how experts make decisions during medical crises will allow educators to focus on these elements specifically during simulation design and debriefing. In addition, this knowledge may allow for the creation of more accurate learning objectives and assessment frameworks in a CBME context. This, in turn, will lead to a more accurate characterization of residents' abilities in resuscitation medicine.

Resident learners themselves will also find the results of this dissertation informative. We have described, in detail, how cognitive load and cognitive processes change as a resident's knowledge matures in resuscitation medicine. We have also provided an overview of these processes in experts themselves. With an appreciation for this cognitive maturation process, physician learners should be better able to assess where they currently lay on the novice-expert continuum. This knowledge can help learners to set appropriate, realistic and relevant learning goals as they will now better understand what they are specifically striving for. This type of self-reflection activity has the potential to motivate residents and ensure they remain engaged in learning over the long-term.

Finally, corporate entities may have an interest in quantifying expertise in medicine. As we move toward the next generation of simulation, there is an appetite for increased automation and a more tailored learning experience for individual trainees. At the same time, financial constraints of medical schools and time constraints of medical educators are becoming important factors. One key challenge in creating simulations that are adaptive to a learner's ability is being able to measure that ability accurately. Building on the deeper understanding of expertise in resuscitation medicine that we have presented in this dissertation, corporations will now have better tools to start to solve these problems. If simulation can be built to respond (using artificial intelligence) to an individual learner's measured level of expertise, then there is a potential to create learning that is more targeted and that relies to a lesser degree on the limited time of medical educators. This type of technology will be needed by educational institutions, and as a result, will be attractive from a corporate investment perspective.

Innovation

We have shown that expertise in resuscitation medicine can be reliably measured and described using a variety of methodologies, even though many decisions in this field are made and processed at a cognitive level. One novel example of this type of methodology, presented in this dissertation, is the introduction of eye-tracking devices to measure expertise development and to support training and assessment in medicine.

These innovative methodologies and the subsequent insights that they afforded were made possible by bringing together knowledge from the domains of medicine, educational psychology and expertise science. Presenting this work at conferences and in peer-reviewed publications from each of these respective domains has contributed to reminding educators of the importance of grounding their practices in scientific theory, while at the same time ensuring that science continues to answer the questions that are most relevant to the needs of medical educators. The marriage of these interests is primarily what makes the results of this dissertation innovative.

Schedule and implementation

A number of initiatives have borne out of the results of the studies of this dissertation. For example, based on the finding that physicians develop an ability to appropriately de-prioritize irrelevant information while prioritizing what's relevant during a resuscitation case has led to the implementation of realistic distractors in simulation-based resuscitation examinations at our institution. This has allowed educators to more accurately assess residents and has opened up avenues for new discussion during simulation debriefs. Anecdotally, residents have mentioned that this has been beneficial for their learning.

In addition, we have started to use eye-tracking augmented debriefing, as was introduced in this dissertation, into some of our local simulation activities. This has been well-received by our learners who find that the technique adds to their educational experience.

Finally, we have created a research collaborative, called the Centre for Augmented Human Performance at Queen's University. This group brings together experts in medicine, simulation, engineering, education and social sciences as it strives to be the leader of the next generation of simulation training. This group has partnered with virtual reality, augmented reality and educational corporations on a number of projects as well as grant applications. The work that has come out of this dissertation serves as the starting point for many of the projects that this collaborative is currently working on.

The cost of these initiatives is relatively high, especially in the short-term. However, as the technology advances and requires less time of medical educators, the expectation is that the overall cost savings of this program will be substantive.