SURGICAL EDUCATION: DEVELOPMENT OF CURRICULA TO OPTIMISE TRAINING AND EVALUATE COMPETENCY

J HOOGENES

PhD 2018

SURGICAL EDUCATION: DEVELOPMENT OF CURRICULA TO OPTIMISE TRAINING AND EVALUATE COMPETENCY

JEN HOOGENES

A thesis submitted in partial fulfilment of the requirements of
the Manchester Metropolitan University for the degree of Doctor of Philosophy by Published Work (Route 2)

Faculty of Health, Psychology, and Social Care,
Department of Nursing
The Manchester Metropolitan University

2018

CONTENTS

Abstract

This PhD by Published Work (Route 2) thesis is comprised of a collection of significant papers I have published with co-authors between the years of 2010 and 2017. These published works are supported by supplemental papers, abstracts, and conference proceedings and comprise a body of work that has sought to understand how surgical education is carried out in surgical residency programs, with particular interest in learning about how surgical educators teach, how surgical trainees perceive the teaching they receive, the creation, use, and evaluation of new tools for surgical education, and the development of new surgical training curricula in an era of competency-based medical education.

My research began out of a need to evaluate the problem of a lack of formal guidelines and direction to aid surgical educators in the development, delivery, and evaluation of competency-based residency education programs throughout Canada. Without formal guidelines driving curricula development, surgical trainees could potentially be graduating at different levels of proficiency, which is problematic. In addition to existing standardised testing procedures, other surgical education researchers and I believe that residents must also be evaluated via ongoing thorough assessments of their level of competency when performing in the high stakes environment of the operating room.

The Royal College of Physicians and Surgeons of Canada (RCPSC) is well-known for their Canadian Medical Education Directives for Specialists (CanMEDS) physician competency

framework, which has been adopted by medical and surgical training programs worldwide. In its most recent CanMEDS iteration (2015), the RCPSC has released a new initiative called Competence by Design (CBD), which will affect all Canadian residency programs. The primary goal of this initiative is to completely remove the time element of residency training and focus on residents' progression through their respective programs solely based on the passing of pre-defined competency "milestones". This will cause a paradigm shift whereby the traditional apprenticeship model long-used in surgical teaching may eventually cease to exist.

With this thesis, I have included papers that have focused on surgical education within competency-based frameworks and means by which to optimise curricula for surgical training. My research began with the exploratory work around how surgical educators teach and how trainees perceive they are taught, and is followed by a description of simulation and the development of new tools for surgical simulation and training. I then describe the development of new curricula that are focused on competency-based initiatives and can be used to begin the development of residency curricula for CBD. This research is timely, as many accrediting bodies worldwide are currently in the process of adopting and developing competency-based curricula at different training levels. The research presented in this thesis significantly contributes to the existing body of surgical education research, and future work, some of which is described, will focus on expanding the reach of our research initiatives via collaborative efforts with other surgical residency programs within Canada and also abroad.

Acknowledgements

I have many people to acknowledge for having a positive effect on my journey to obtaining a PhD. Following my military service as a combat medic and then undergraduate and masters training at the University of Michigan in the United States, I headed to McMaster University in Hamilton, Ontario, Canada to begin additional graduate training in health research methodology, with a goal to complete a PhD, which would allow me to conduct surgical education research on a more independent level, yet still within a team environment. During my first years of study at McMaster, I required multiple open-heart surgeries due to an injury sustained in the military. Although I completed all of the requirements for PhD candidacy, I had yet to begin my thesis. As I had to take multiple leaves of absence from the surgeries, I was not well enough at the time to continue. I was awarded a MSc in health research methodology, and kept working as a clinical research coordinator for the University. As I had recovered, I was still interested in pursuing my PhD – this was a major lifetime goal for me. One of my colleagues from the UK told me about the PhD by Published Works program at Manchester Metropolitan University. I contacted the University to learn more, and was connected to Professor Janet Marsden, in the Faculty of Health, Psychology, and Social Care, who ultimately (and gratefully) became my PhD advisor.

I truly cannot thank Janet enough for taking me on as her student and providing me with such excellent guidance and feedback throughout this portion of my PhD journey. Janet was an absolutely solid source of support and encouragement throughout my entire time working on this thesis. I thank you, Janet, so very much for your guidance, assistance, and resourcefulness throughout this route. I have truly enjoyed the entire process at MMU. Everyone I have met during this time period has been very kind and accommodating, and I am certainly grateful for their help, as well.

I must also thank my colleagues at McMaster University for their amazing support throughout this PhD adventure. First, I would like to thank Drs. Deepak Dath and Edward Matsumoto, who are two of the very best surgical educators I have ever had the pleasure to know and watch while working in the operating room. The skill of being a proficient surgical educator is certainly not lost on me. I am forever thankful for that serendipitous meeting that led to the development of our research team. The support you have given me has been incredible, and I am forever indebted to you both. I would also like to thank additional colleagues who have also shown tremendous support throughout this process – Drs. Bobby Shayegan and Ali Al-Hashimi. Bobby, thank you for all you have taught me thus far – I look forward to our work ahead. Ali, thank you for the support, along with the many laughs we've had while working together, even throughout some of the rough and crazy times (e.g., Newton, London, Pearson, etc.)! I must also give an incredible amount of thanks to Kevin Kim, who has been my research assistant throughout the past seven years. You made the majority of this work possible, and I am forever appreciative of you for your amazing help. As you now go off to begin your MD/PhD program, please don't forget me! I also need to thank all of the residents with whom I have collaborated – it has been a pleasure to be able to train residents in the research process, from the development of the research question through to seeing the work in print as a published manuscript. I'd like to give a special thanks to Dr. Yuding Wang for his enthusiasm and hard work as we move forward with our research. Many thanks also to thank Sharon Reniewick and Lauren Douglas for always helping to keep things squared away. Thank you also to all of my co-authors and collaborators. I am grateful to be able to call my colleagues my friends.

And of course, I am indebted to my family and good friends who have stood beside me through it all. I am grateful to have such a tight-knit family where we are all such good friends – you all comprise an amazing support system. And Dave, my husband of the past ten years, you have been through it all and then some. Thank you so very much for your unwavering support and love throughout this entire time. I would not have ever been able to finish this PhD without you. You forever have my $x^2+(y-3\sqrt{x^2})^2=1$.

DETAILED CONTENTS

This chapter includes each of the published works and their respective narratives, accompanied by a critical appraisal. The RDPUB forms and citation metrics (as of August 2017) for each publication are located in appendices, which indicate my contribution to each published work and the impact my research had on the field of surgical education.

This section provides an introduction to clinical competence as a construct and its role in assessment during surgical education.

Matsumoto ED and Hoogenes J. Assessment of competence. In: Urolithiasis – basic science and clinical practice. Talati, JJ, Tiselius H-G, Albala DM, Ye Z (Eds). Springer. Dec 2012.

To understand how surgical education curricula are employed in practice and how trainees' competence is assessed, it was necessary to first explore how surgical educators teach. We sought to answer the following questions: What are surgical educators' perceptions of how they teach surgical trainees?, and, How do surgical trainees perceive the education they receive?

This section is comprised of Published Work 2 and several conference proceedings to support these questions. A narrative is provided, and a critical appraisal is included at the end of the section.

Dath D, Hoogenes J, Matsumoto ED, Szalay DA. Exploring how surgeon teachers motivate residents in the operating room. Am J Surg. 2013 Feb, 205(2):151-5.

2.2c Related supplementary work

Dath D, Hoogenes J, Matsumoto ED, Szalay, D. Exploring the intraoperative teaching responsibilities of the surgeon teacher. Annual Meeting of the Association for Medical Education in Europe (AMEE), 2011, Vienna, Austria

Dath D, Szalay D, Matumoto E, Hoogenes J, Bhanji F, Frank J. Teaching in challenging environments: Choosing strategies that work. International Association for Medical Education, Prague, Czech Republic, 24-28 Aug. 2013. Managing the teaching environment

Dath D, Hoogenes J, Matsumoto ED, Szalay DA. Surgeon teachers' perceptions of and their efforts to provide feedback during intraoperative teaching. Association for Surgical Education Annual Surgical Education Week. Orlando, FL. April 22-25, 2013.

Dath D, Hoogenes J, Matsumoto E, Szalay D. How surgeon teachers use feedback to assess residents in the operating room. Association for Medical Education in Europe (AMEE): Transforming Healthcare through excellence, assessment, and evaluation. Ottawa, Ontario, Canada, April 25-29, 2014

Hoogenes J, Harlock JA, Vennettilli M, Gowing R, Rasheed F, Szalay D, Dath D, Matsumoto ED. A qualitative exploration of intraoperative teaching using surgical resident focus groups. American Urological Association (AUA) Annual Meeting, San Francisco, CA, May 29 – June 3, 2010.

2.2d Critical Appraisal: Section 2.2

2.2e References for Section 2.2

2.3 Exploring undergraduate surgical clerkship experiences within a competency-based curriculum – what are surgical clerks' experiences during surgical rotations?

Based on the work in Section 2.2, it was important to also explore how surgical educators' teaching styles affect the perceptions of undergraduate medical students during their surgical clerkship rotations, as these experiences may influence their decisions on pursuing a surgical residency – and ultimately a career in surgery. Clerkship surgical training rotations are taught by staff surgeons, primarily in the operating room. Exploring these experiences within an established undergraduate professional competency curriculum provided rich data on how clerks interpreted critical incidents during their rotations, how surgical educators teach medical students, and whether and how these rotations influence students' residency choices. This section is comprised of Published Work 3. A narrative is provided, followed by a critical appraisal.

2.3a Narrative

2.3b Published Work 3

Kittmer T, Hoogenes J, Pemberton J, Cameron B. Exploring the hidden curriculum: A qualitative analysis of clerks' reflections on professionalism in surgical clerkship. Am J Surg. 2013 Apr 205(4); 426-33.

2.3c Critical Appraisal: Published Work 3

2.3d References for Section 2.3

2.4 Current tools for surgical teaching: the role of simulation in training and assessment

Surgical simulation, paired with didactic teaching, has become the primary educational tool for training surgeons prior to exposure with live surgeries. As surgical simulation emerges as a more accessible tool for training, it is important to describe the current status of surgical simulation, including types of simulators, assessment of competence with technical and surgical skills using simulation, and theoretical considerations regarding its use. This section includes a book chapter (Published Work 4) I wrote with a colleague that provides the reader with a comprehensive overview of the current status of simulation (as of 2016).

This section also includes Published Work 5, which is a systematic review and meta-analysis that was completed to examine any differences between commercial video trainers used for laparoscopic surgical training versus inexpensive laparoscopic trainers. As surgical simulators can be very costly, sometimes prohibitively so that simulation laboratories cannot afford them, we wanted to explore differences in cost and fidelity as they apply to trainee outcomes.

Finally, Published Work 6 describes a randomised controlled study we undertook to determine how training on a novel, low-cost surgical simulator (bench model) transfers to a live animal model for conducting the same surgical procedure. Evaluating the transfer of technical skills acquired during simulation to live surgical tasks provides a wealth of information, including the validity of the simulator.

2.4a Narrative

2.4b Published Work 4 – A comprehensive background of current surgical simulation

Hoogenes J and Matsumoto ED. Simulation Surgical Models: Surgeon Perspectives. In: Bioengineering for Surgery: The Critical Engineer Surgeon Interface. Elsevier/Woodhead Publishing, Series in Biomedicine Number 84, Amsterdam. Eds. WA Farhat and J Drake. 2016. (Book chapter)

2.4c Are there differences in training outcomes between expensive, high fidelity simulators and low-cost, low fidelity simulators for laparoscopic surgery?

2.4d Narrative

2.4e Published Work 5

Ngyuyen, T, Braga L, Hoogenes J, Matsumoto ED. Commercial video laparoscopic trainers versus less expensive, simple laparoscopic trainers: A systematic review and meta-analysis. J Urol. 2013 Sep; 190(3):894-9.

2.4f Critical Appraisal: Published Work 5

2.4g Transfer of skills from the simulated environment to live surgical cases

2.4h Narrative

2.4i Published Work 6

Sabbagh R, Chatterjee S, Chawla A, Hoogenes J, Kapoor A, Matsumoto ED. Transfer of laparoscopic radical prostatectomy skills from bench model to animal model: a prospective, single-blind, randomized controlled study. J Urol. 2012 May;187(5):1861-6.

2.4j Critical Appraisal: Published Work 6

2.4k References for section 2.4

2.5 Developing new tools for surgical education

This section describes the development, implementation, and evaluation of new tools and methods we have created for improving surgical education, primarily in the intraoperative laparoscopic and robotic surgical settings, but also for robotic and laparoscopic simulation training. This section includes a description of a study conducted to observe intraoperative laparoscopic training communication, followed by the development of a new endoscopic on-screen frame of reference tool to improve intraoperative teaching.

Published Work 7 describes the development of a competency assessment tool for use during intraoperative resident training of robotic-assisted laparoscopic radical prostatectomy (RARP). Also included in this section is a description of a 3D-printed bladder model we developed for robotic and laparoscopic simulation training. Further explained is a study that compared participants at different levels of training (medical students and residents) who completed a new robotic training curriculum using one of two robotic simulators. The participants were then evaluated on the transfer of their simulation-acquired skills to performing a robotic surgical task on the new 3D-printed bladder model using the da Vinci robotic surgical system in the OR.

2.5a Narrative – Observation of communication during live surgical cases and the development of a new tool to improve teaching during laparoscopic surgical cases

2.5b Communication issues unique to laparoscopic surgical teaching

2.5c Observation of laparoscopic teaching cases

2.5d Development and evaluation of an on-screen frame of reference tool for intraoperative laparoscopic teaching

2.5e Considerations regarding the observational communication and overlay development studies

This section describes the development of new curricula and methods for teaching surgical residents at different levels of training. Published Work 8 was a study that qualitatively observed a curriculum our team developed for technical skills acquisition in a simulation environment, with a particular focus on student-led learning versus a traditional instructional approach. Also included is a paper that describes the use of a medical student-run surgery lecture series and skills lab curriculum, developed and implemented by senior medical students.

Chapter 4: Current and future research and projects

This chapter discusses some of the current research being conducted by our research team at McMaster University, with additional descriptions of future planned research and program development.

4.1 The development of three-dimensional printed anatomical urology models for surgical training and preoperative planning
4.2 Urology Boot Camp program
4.3 Faculty development project based on intraoperative teaching data (from Section 2.2)
4.4 Development and evaluation of objective assessment tools for use in intraoperative and simulation-based trainee evaluation

Chapter 5: Conclusions

Appendix: Declaration of contributions

Chapter 1

INTRODUCTION

1.1 Rationale and aims of the thesis

This PhD by Published Work thesis is comprised of a collection of key papers I have published with co-authors between the years of 2010 and 2017, with research beginning in 2009. These publications and their supporting supplemental papers, abstracts, and conference proceedings comprise a body of work that has sought to understand how the implementation of surgical education at the post-graduate level is accomplished, and to develop and evaluate novel methods to improve surgical education in an era of competency-based surgical training.

This research began out of a necessity to address the problem of a lack of formal guidelines and direction to aid surgical educators in developing, delivering, and assessing competency-based education within post-graduate surgical residency programs throughout Canada. Without formal nationwide guidelines driving the development, implementation, and evaluation of these curricula, especially those which are specialty-specific, the fact that Canadian surgical trainees could potentially be graduating with different skills sets and at different levels of proficiency is problematic. It is imperative that surgical curricula across the country becomes uniform and the assessment of competency is standardised among the 17 Canadian universities that offer post-graduate surgical residency training. This goes beyond the passage of written and oral examinations which serve as the benchmarks of whether a resident graduates from their program.

Although the field of surgical education research is relatively small, there is a consensus among its researchers that surgeons need to be proficient in their craft before they are certified to practice independently – meaning that residents should not only be evaluated via existing standardised testing procedures, which have historically been limited to written and oral examinations, but also by ongoing thorough assessments of their level of competency when performing *in vivo* surgical tasks in the high stakes environment of the operating room (OR). The recently mandated reduction in resident work hours in Canada has caused widespread concern as to whether residents are afforded enough time to train in the OR and if they are proficient enough to practice independently by the end of their formal training. These concerns are perpetuated by an increased responsibility and accountability to the public, as there exists an inherent expectation that surgeons are indeed competent in their specialty and that they provide safe and comprehensive care to the patients they serve.

The Royal College of Physicians and Surgeons of Canada (RCPSC) is well-known for the development of the Canadian Medical Education Directives for Specialists (CanMEDS) physician competency framework, which has been adopted by medical and surgical training programs worldwide. CanMEDS has undergone three revisions since 1996, with the most recent iteration released in 2015. The RCPSC serves as the governing body for all Canadian medical education and licencing, and in its most recent update has released a new competency framework that revolves around the new initiative of "Competence by Design" (CBD), which is expected to begin its rollout in various post-graduate medical and surgical specialties throughout 2017 and is scheduled to continue on for multiple years until all residency programs (medical and surgical) across Canada are entirely CBD-driven. The primary goal of this initiative is to completely remove the time element from post-graduate residency and focus on residents' progression through their respective programs solely based on the achievement/passing of pre-defined competency "milestones". This will effectively cause a paradigm shift whereby the traditional Halstedian apprenticeship model long used in surgical teaching may eventually cease to exist. The CBD initiative is discussed in greater detail later in this thesis.

With the introduction of CBD, my research is timely and significant, as it has the potential to help guide some of the development of the competency-based curricula to be used in surgical residency programs as the uptake of CBD begins and continues, especially for the surgical specialties with which my colleagues and I have conducted our research. Although competency-based medical education (CBME) has been a mainstay of the CanMEDS framework, specialty-specific uniform curricula requirements for residency programs have not existed; rather, CanMEDS has provided a framework of seven professional roles that programs have been encouraged to use to guide the assessment of their residents; however, the means by which residents are assessed have generally been left up to the discretion of individual programs. This has contributed to the lack of standardisation of training among programs, and thus the potential for trainees to graduate with varied levels of expertise. Although CBD does not appear to be the immediate answer to the problem of a lack of standardised formal curricula guidelines for surgical education, it must be acknowledged as a positive and critical step towards unifying residency training and assessment throughout Canada.

Although my research began prior to the development of CBD, it was driven by the need to explore and develop new methods to deliver and evaluate surgical residency training. My colleagues and I felt that the first step in this research was to qualitatively explore how surgical educators teach and to gain insight about how residents feel they are taught by surgical educators. The themes extracted from those data provided us with a solid foundation from which to begin to develop and investigate new methods and tools for curricula design, implementation, and evaluation – tools with the intention of improving surgical teaching and learning. This thesis aims to describe this process, from the inductive inquiry of surgical educators and residents, to the development and use of new methods and tools for surgical training curricula.

Specifically, this thesis aims to:

- Introduce the concept of clinical competency and its definition, and provide information about competency assessment both in Canada and abroad
- Discuss the importance of competency in the development of training curricula for learners at different levels of medical and surgical training
- Describe the current paradigm shift from the traditional Halstedian time-based apprenticeship model of surgical training to one that is solely competency-based (CBD)
- Explore the use of intraoperative teaching techniques and tools surgical educators utilise to improve learner competency in preparation for independent practice

- Describe new approaches to teaching surgical residents using competency-based curricula
- Discuss the role of surgical simulation and how it can improve trainees' proficiency by preparing them for *in vivo* surgical cases
- Describe newly-developed simulation methods for various types of surgical education
- Provide an account of the development of new assessment tools and metrics for surgical training
- Present a critical appraisal of the research presented in this thesis and how it supplements the evolving field of surgical education and its relation to the existing body of surgical education literature, specifically with regard to competency-based curricula development, utilisation, and assessment
- Describe my current research relative to this thesis, as well as plans for future research and strategies for its integration into surgical education curricula

1.2 Descriptions and list of published works

Each of the selected published works for this thesis has been peer-reviewed. Two of the publications are book chapters, which are included to provide the reader with comprehensive overviews of clinical competency and its assessment and the use of simulation in surgical education. Each of the papers have been published in well-known peer-reviewed international journals. For each of the included publications, the analytical commentary will be augmented not only with the broader literature but also with relevant components of additional related publications where I am an author, including peer-reviewed published manuscripts, conference proceedings, and abstracts. This approach will ensure a well-rounded account of my research to date and its contribution to the field of surgical education.

As this thesis serves as a component for completing a PhD by published work (Route 2), it is necessary to describe my roles in the publications which comprise this thesis. I have worked as a clinical research coordinator and health research methodologist in McMaster University's (Ontario, Canada) Faculty of Surgery for the past nine years. In addition to developing and conducting independent research, my role includes training surgical residents in research methods and biostatistics and guide them through the entire research process, from the development of a research question through to dissemination of results. Over time, I have had the unique opportunity of conducting research alongside undergraduate and post-graduate health science students, post-doctoral fellows, medical and surgical residents, surgical fellows, and staff surgeons from eleven surgical specialties. I have also had opportunities to collaborate with investigators from other medical schools and residency programs throughout Canada and abroad. Visiting and McMaster University medical students on surgical rotations are encouraged to become involved in our research while on their electives, so this allows me to also train medical students who are interested in pursuing an academic surgical career.

My research interests in surgical education lend themselves to a variety of methodological approaches and topics, which are typically specialty-specific (e.g., urologic robotic surgical education) but can often be adapted to other surgical specialties. For example, much of my research has been within the specialty of urology, as it offers a wide variety of types of surgical cases as well as a multitude of surgical approaches (e.g., open, laparoscopic, robotic), making it a specialty that is challenging for surgical educators. Much of the research I have conducted within the field of urology is transferable to other specialties that utilise some of the same approaches to their own cases, such as the use laparoscopic and robotic surgical techniques for general surgery, thoracic surgery, and obstetrics and gynecology. This variation has allowed me opportunities to work with students and residents at different levels of training and from multiple surgical specialties.

Due to the varied amount of time trainees are allotted to participate in research while on rotations, they become involved in studies at different points in the research process. Within this structure, trainees are typically “assigned” by a staff surgeon (their rotation supervisor) to a study where they must assume a leading role, thus providing me the opportunity to guide them through the process, providing education at each step. In my opinion, this collaborative method of conducting research is mutually beneficial, as the trainees’ involvement allows them to learn while preparing them for future research opportunities; and furthermore, our studies become more robust due to trainees’ creative and clinical input. Trainees who have meaningfully and significantly contributed to a study are typically involved in the writing of the manuscript, allowing them to become published early in their career, and they may have opportunities to present their research at local, national, or international meetings. As a result, the vast majority of our research papers and presentations have multiple authors. Due to this training structure, I often serve as the supervising author on manuscripts (thus, I am not always in the first author placement), which is a practice seen in most surgical research environments at Canadian universities. This is reflected in the author lists for most of the research-related publications included in this thesis.

With regard to citation and referencing approach throughout this thesis, I have chosen to use the Vancouver citing and referencing style, as opposed to the Harvard style, in order to maintain consistency throughout the entire thesis, including the published works. The Vancouver style is noted as the uniform requirement for manuscripts submitted to biomedical journals. All of my published works have been cited and referenced in the Vancouver style. For this thesis, the Vancouver style will be used for in-text citations, and the reference lists for each section will using this same style. This consistency will allow for the flow of the thesis and will make finding citations and references easier for the reader. For each of the published works, the Manchester Metropolitan University RDPUB form will be provided in appendices, accompanied by the publication metrics for each published work.

List of published works:

1. Matsumoto ED and Hoogenes J. Assessment of competence. In: Urolithiasis – basic science and clinical practice. Talati, JJ, Tiselius H-G, Albala DM, Ye Z (Eds). Springer. Dec 2012. (Book chapter)
2. Dath D, Hoogenes J, Matsumoto ED, Szalay DA. Exploring how surgeon teachers motivate residents in the operating room. Am J Surg. 2013 Feb, 205(2):151-5.

3. Kittmer T, Hoogenes J, Pemberton J, Cameron B. Exploring the hidden curriculum: A qualitative analysis of clerks' reflections on professionalism in surgical clerkship. Am J Surg. 2013 Apr 205(4); 426-33.

4. Hoogenes J and Matsumoto ED. Simulation Surgical Models: Surgeon Perspectives. In: Bioengineering for Surgery: The Critical Engineer Surgeon Interface. Elsevier/Woodhead Publishing, Series in Biomedicine Number 84, Amsterdam. Eds. WA Farhat and J Drake. 2016. (Book chapter)

5. Ngyuyen, T, Braga L, Hoogenes J, Matsumoto ED. Commercial video laparoscopic trainers versus less expensive, simple laparoscopic trainers: A systematic review and meta-analysis. J Urol. 2013 Sep; 190(3):894-9.

6. Sabbagh R, Chatterjee S, Chawla A, Hoogenes J, Kapoor A, Matsumoto ED. Transfer of laparoscopic radical prostatectomy skills from bench model to animal model: a prospective, single-blind, randomized controlled study. J Urol. 2012 May;187(5):1861-6.

7. Morris CM, Hoogenes J, Shayegan B, Matsumoto ED. Toward development and validation of an intraoperative assessment tool for robot-assisted radical prostatectomy training: Results of a Delphi study. Intl Braz J Urol. 2017. 43(1).

8. Hoogenes J, Mironova P, Safir O, McQueen SA, Abdelbary H, Drexler M, Nousiainen M, Ferguson P, Kraemer W, Alman B, Reznick R, Sonnadara R, et al. Student-led learning: a new teaching paradigm for surgical skills. Am J Surg. 2015. 209: 107-14.2.

1.3 Structure of the thesis

This thesis is presented as a compilation of interrelated published works with a narrative provided prior to each publication and a critical appraisal at the end of each chapter section. In addition to the relevant literature, to support the commentary, some additional published works (e.g., published manuscripts and conference abstracts/proceedings) that are related to studies and projects with which I have been and am currently involved are referenced and discussed. These additional references help to describe in greater detail some of the concepts derived from the research presented in the published works that comprise this thesis and further demonstrate my contributions to the study of surgical education and competency assessment. The thesis will begin with an introduction to clinical competency with the support of a book chapter (Published Work 1) to provide a comprehensive background of competency and its assessment, followed by the additional published works, each compiled under sections designed to answer specific research questions and discuss how research objectives were met. Narratives and critical appraisals accompany each of the published work, and discussions about supplementary work are included.

CHAPTER 2

PUBLISHED WORKS AND NARRATIVES

2.1 What is clinical competence?

2.1a Narrative

As described in Chapter 1, the current paradigm shift of medical and surgical training from a time-based model to one that is purely competency-driven has challenged medical school, residency, and fellowship curriculum developers to determine the most successful means of integrating this shift into current, existing curricula. As this shift will be gradual, it will require a great deal of collaboration among accrediting bodies to develop the appropriate milestones trainees will be required to meet in order to be deemed competent in a particular skill or subject, and therefore permitted to progress to the next milestone. In order for this shift to occur, however, curricula developers must recognize the complexity of competence as a construct, as:

> …only then can they effectively delineate the knowledge, skills, and attitudes that learners must acquire to be able to perform within each domain at a predetermined level and to recognize that the expected level of performance within each domain will vary based on the learner's stage of education and the specialty he or she is learning.[1]

The definition of clinical competency is one that has yet to be agreed upon by researchers and educators. Hodges (2012) has stated that an increasingly popular approach to defining competency is to delineate a set of roles that professionals (e.g., medical students, residents, fellows, attending physicians, residency/program directors) should play and determine competence as the degree to which these individuals fulfill these roles.[2] The Royal College of Physicians and Surgeons of Canada (RCPSC) is well-known for its published series of Canadian Medical Education Directives for Specialists (CanMEDS) physician competency framework, which has in fact become "the most widely accepted and widely applied physician competency framework in the world".[3] As briefly described in Chapter 1, the RCPSC has recently released its newest framework, CanMEDS 2015 (the third iteration, followed by the first in 1996, and the second in 2005), which is centred on the new concept of Competence by Design (CBD).[3] This will be described in greater depth in the narrative portion of this section, following published work 1, which is a book chapter titled, "Assessment of competence". This book chapter was written prior to the release of CanMEDS 2015, therefore a discussion of CanMEDS 2015 is necessary to conclude this section. It is important to note that this book chapter was written to cover the assessment of competence in medical and surgical training in the broader sense, and was written for a urology textbook. As noted in the introduction, much of my work has been in the field of urology, as it offers an excellent platform for surgical education research due to the fact it is a multifaceted specialty that consists not only of high-volume clinical patient care, but also utilises multiple types of surgical approaches (e.g., open, laparoscopic, robotic), as well as the use of surgical simulation as a significant component of the training curriculum.

2.1b Published Work 1

Matsumoto ED and Hoogenes J. Assessment of competence. In: Urolithiasis – basic science and clinical practice. Talati, JJ, Tiselius H-G, Albala DM, Ye Z (Eds). Springer. Dec 2012.

Web link: ***www.springer.com/gp/book/9781447143833***

2.1c Critical Appraisal: Published Work 1

This book chapter was written to provide an overview of clinical competency and the competency-based requirements of various licencing and accrediting bodies worldwide, with a primary focus on initiatives in North America. It described different types of currently-used competency assessment measures, such as those for evaluating technical and surgical skill acquisition (e.g., FLS, OSATS). It is clearly noted in the chapter that further research is required to determine the most effective method(s) of assessing competency of surgical trainees in the high stakes environment of the OR. As the majority of the existing assessment measures are formative in nature, and are required by accrediting bodies (depending upon jurisdiction) for moving on to the next level of training (e.g., progressing to the next post-graduate year of residency raining), there exists a paucity of valid and reliable intraoperative competency assessment tools. The lack of these tools is problematic for surgical residency programs in general, as it does not allow for a uniform system of evaluating whether residents possess the surgical proficiency required of them to begin independent practice as a fully certified surgeon.

As CanMEDS is recognized and used worldwide, it is important to augment the book chapter content by describing the new CanMEDS 2015 release, especially to further describe the new CBD initiative. When considering CBME in light of the CanMEDS roles and core competencies of accrediting agencies, it is vital to note that the traditional apprenticeship (Halstedian) model, which is still used in many surgical training centres worldwide, is no longer entirely practicable in modern surgical education, in large part due to the technological advances being made to improve surgical practice and outcomes, such as minimally-invasive and robotic-assisted surgical techniques. Within this model, there are no principles or guidelines for what knowledge or surgical skills are to be taught, who should be trained, when training should start, and how long training should last. These characteristics are what brought about the new approaches being developed and mandated by various agencies, thereby demonstrating a need for a paradigm shift toward CBME, as explained in the book chapter.

The revised CanMEDS framework for 2015 has placed a significant emphasis on competency assessment. Its new initiative, CBD, is a CBME model of resident training that is: 1) geared towards patient needs and excellent care; 2) structured to support continuous learning and increasing skills and abilities; 3) based on the needs of the learner, with more accountability and flexibility; and 4) focused on demonstrating application of knowledge and performance.[3] The CBD initiative will focus on learning rather than the aforementioned traditional time-based approach to residency. The initiation of CBD curricula in Canada will occur through an iterative process of six cohorts (multiple specialties per cohort), which was slated to begin in 2015, but did not officially commence until the beginning of 2017. It is noted that the rollout for all specialties will continue until 2022; however, residency program directors have expressed concerns that for full adoption and integration of CBD, this process will take much longer.

Each specialty's designated committee will spend two years preparing their curriculum before initiation. The RCPSC will evaluate CBD integration by each adopter (specialty), which will provide data to guide necessary modifications. The CBD Competence Continuum breaks down specialist education (unique to each specialty) into seven integrated stages, beginning at the entry to residency stage and ending at the transition out of professional practice. Each stage contains competency milestones which a resident must achieve before progressing to the next stage.[3] Until CBD can be introduced, implemented, evaluated, and modified as necessary to reach its intended objectives, Canadian residency programs will continue using a time-based approach to training and continue using the seven CanMEDS roles as guidance (see Figure 1). It is anticipated that the Canadian experience with rolling out and implementing CBD will provide a template for accrediting agencies worldwide.

Figure 1. The CanMEDS Roles, 2015[3]

This is indeed a significant time to be conducting surgical education research, especially moving forward as CBD becomes a reality in residency programs throughout Canada. A great deal of surgical education research focuses on learners at different levels of training, which has traditionally referred to the post-graduate year (PGY) of residency. Not only will this paradigm shift affect residency and fellowship curricula, it will highly influence how surgical education research will be conducted moving forward, including the development of tools and metrics for evaluating trainee competency. This thesis describes and discusses the teaching techniques surgical educators use in practice, how undergraduate medical student clerks experience surgical rotations, current tools for surgical teaching, the development of new tools and assessment measures for teaching, and the design of new curricula for surgical education. Each of these constructs provide considerations for how surgical education will be conducted moving forward from a time-based to a competency-based model. Understanding the current state of surgical education and the tools currently being used is critical to preparing for the introduction of CBD in Canada and the introduction of other competency-based frameworks throughout the world.

2.1c References for Section 2.1

1. Anderson MB. Foreword. In: Hodges BD, Lingard L, eds. *The question of competence: reconsidering medical education in the twenty-first century*. Ithaca, New York, U.S.A.: Cornell University Press; 2012:xi.
2. Hodges BD. The shifting discourses of competence. In: Hodges BD, Lingard L, eds. *The question of competence: reconsidering medical education in the twenty-first century*. Ithaca, N.Y., U.S.A.: Cornell University Press; 2012.
3. Frank JR, Snell LS, Sherbino J, editors. Draft CanMEDS 2015 Physician Competency Framework – Series III. Ottawa: The Royal College of Physicians and Surgeons of Canada; 2014 September.

2.2 Exploring how surgical educators teach trainees

2.2a Narrative

Although medical students may enter residency from universities that incorporate CBME into their undergraduate medical school curricula, the landscape of a surgical residency is one that new residents will find unfamiliar and thus will have to adapt to new methods of training. Residency is typically referred to by the year of training (such as post-graduate year [PGY] 1-5+), with a general understanding by program directors and residents of what is required per each year of training; however, with the launch of residency-focused competency-based frameworks such as CBD, the year of training may eventually become irrelevant, as CBD will be using established competency milestones that residents must meet in order to move forward in the program until graduation.

In the current "time-spent" model of postgraduate surgical residency, trainees are expected to spend a certain amount of time in both didactic and hands-on training, the latter of which increases as the resident progresses through the program. During this time, residents are expected to gain more and more independence as their program progresses and as they meet the expectations of each year's requirements and exams. There exists the question as to whether this current model ensures that all residents receive equivalent training and that they are competent to independently practice following residency and fellowship. Recent studies have shown that surgical residents tend to report less exposure (including just observation) to surgical cases and actual operating time than residency program directors believe should be required.[1] This is likely due to the fact that there are fewer and fewer opportunities for surgical residents to actual operate due to factors such as technological advances, an increased demand for efficiency in the OR, monetary restraints (especially in a publically-funded healthcare system), increasing concerns about patient safety, and the mandated reduction in resident and fellow work hours, each of which results in less time for residents to learn and surgical educators to teach during live surgeries.[2]

Due to this reduction in actual OR time, surgical educators at many centres have begun incorporating surgical simulation into their residency curricula, which is a topic that will be covered later in this thesis. The introduction of CBD into Canadian residency programs will eliminate the time-spent model, thereby theoretically allowing for enough surgical exposure for residents before they graduate and go on to practice independently. However, since it has not yet begun its roll-out into surgical residency, it will take several years to determine the feasibility and success of CBD within surgical residency. Individual residency programs still have specific "milestones" that must be met within each year of residency that are based on CBME frameworks such as CanMEDS and ACGME, and although these may differ between programs, all residents in a given surgical residency program must pass examinations that are mandated by accreditation agencies (which differ based on location) in order to proceed on to the next year of residency.

Because of the limitations surgical residents face with regards to getting enough live surgical experience, surgical educators are pressured to determine the most effective and efficient ways to teach in the intraoperative setting. Surgical teachers use various techniques to ensure that trainees receive the most comprehensive and best hands-on education as possible for a given surgical case, yet these techniques are rarely described in the literature. Surgical educators typically receive no formal training on intraoperative teaching, and therefore may often rely on using the methods by which they were taught as residents themselves. A crucial part of the long, complex process of surgical training occurs in the OR where the surgeon teacher and the trainee spend time interacting, making the role of communication between the teacher and learner one of significant interest when studying the techniques used to teach in the OR. Attention has recently been paid to the role of the teacher, how best to prepare surgical educators in academic institutions, and to the role of institutions themselves and the academic teaching mission in general.[3,4] However, the paucity of literature dedicated to *how* surgical educators teach while in the OR led our research team to conduct a qualitative study with the objective of learning the specific approaches and techniques surgeons use while teaching in the OR.

We conducted nine focus groups of surgeon teachers from each division within the Department of Surgery at McMaster University. The data revealed the major themes of motivation, responsibility, management, and feedback, with multiple subthemes identified for each category. Communication was determined to be a concept that pervaded all themes. The identified themes align well with each of the CanMEDS roles. Each of these primary themes will be discussed in this chapter section. (Of note, results surrounding each theme were presented at the Association for Surgical Education annual congress and other local meetings over a three-year time span, each under the same group of authors.) Published work 2 describes the theme of the role motivation plays during intraoperative teaching.

2.2b Published Work 2

Dath D, Hoogenes J, Matsumoto ED, Szalay DA. Exploring how surgeon teachers motivate residents in the operating room. Am J Surg. 2013 Feb, 205(2):151-5.

Web link: ***https://www.ncbi.nlm.nih.gov/pubmed/23062572***

2.2c Related supplementary work

The study described in Published Work 2 brought about the theme of motivation that emerged from our surgical educator focus groups study. As noted in this paper, motivation is a concept that has long been studied in the social sciences, as well as to some extent in the health science literature; however, the role of motivation in surgical training has remained poorly described. To our knowledge, this is the first published paper to have described motivation and its role in intraoperative teaching, specifically with regard to motivational teaching techniques used in the OR by surgical educators.

Of the 34 subthemes identified under the topic of motivation, we derived eight distinct teaching techniques, which were categorized as being either intrinsic or extrinsic in nature. Interestingly, focus group participants agreed that residents at the beginning of their residency and at the end of their residency appear to be more self-motivated than those who are in the middle of their residency, which is something that may change with the introduction of CBD, as residents may maintain their levels of motivation as they strive to meet each defined CBD milestone throughout their training. Participants also discussed the "flattening of the hierarchy" to motivate residents by encouraging a sense of professional belonging, which is a topic also described by medical students in a study that will be described in Published Work 3, potentially suggesting that the hierarchy is pervasive throughout medical training, not just on the learner side, but also among those who teach. It is important to discuss additional themes that emerged from this qualitative study, as it helps to paint a more complete picture of the data acquired during this research, particularly with respect to responsibility, management, and feedback, with a more in-depth discussion of communication in the OR to follow. As these themes were derived from the same study as described in published work 2, the methodology is identical. Furthermore, a description of a resident-based focus groups study will be provided at the end of this section in order to provide additional data on intraoperative teaching from the viewpoint of residents.

1. Responsibility of the surgeon teacher

This sub-section is derived from the following conference proceeding:

Dath D, Hoogenes J, Matsumoto ED, Szalay, D. Exploring the intraoperative teaching responsibilities of the surgeon teacher. Annual Meeting of the Association for Medical Education in Europe (AMEE), 2011, Vienna, Austria

In addition to motivation, responsibility of the surgeon teacher also emerged as one of the main themes in this study. After thematic analysis, we found that surgeons' intraoperative teaching responsibilities include factors affecting the self and interactions with learners, the patient, and others in the OR. Participants expressed that the key, underlying theme in teaching responsibility is first having the intention to teach, by managing the internal distractions and other barriers so that surgeons can behave as responsible, professional, ethical teachers. Surgeons identified their surgeon-to-learner teaching responsibilities as both direct and indirect. Surgeons noted that they directly teach learners in immediate, tangible, and obvious ways, but are also responsible for indirectly acting on behalf of the learner by establishing and maintaining the learning environment, including managing time. Surgeons expressed that they feel responsible as teachers for protecting patients from any harm that may occur in the process of teaching, both directly in the OR and indirectly by teaching proper content, technique, and process. They also noted that surgical teachers must interact with others in the OR to advocate for surgical learning and to model appropriate collaboration and leadership. The surgeons recognised their intricate teaching responsibilities and noted that they strive for teaching excellence.

2. Management of the intraoperative learning environment

This sub-section is derived from the following conference proceeding:

Dath D, Szalay D, Matumoto E, Hoogenes J, Bhanji F, Frank J. Teaching in challenging environments: Choosing strategies that work. International Association for Medical Education, Prague, Czech Republic, 24-28 Aug. 2013.

Surgeon teachers provide training in the complex learning environment of the OR. Despite the challenge of treating their patients, which is their first priority, surgeon teachers must also collaborate with nurses and anesthesiologists, manage the flow of the operation, and cope with myriad distractions so that they can teach. However, effective teaching occurs best in an environment conducive to learning, and it is left to the surgeon teacher to manage this learning environment in the OR. We explored how surgeon teachers actively manipulate the learning environment to the advantage of their learners. From our qualitative data, twenty-four separate codes describing techniques for managing the learning environment were assembled into four themes: management of tasks and processes such as supervision; management of internal and external distractions such as interruptions; pacing and time management such as case booking time; and managing learner-related factors such as preparing the learner before the case (i.e., pre-briefing). Our data showed that surgeon teachers actively manipulate the teaching environment in the OR to optimize training for their learners, which is a process that begins even as they allot time for their cases, meaning that surgeon teachers must be mindful about intraoperative teaching long before a case begins. Surgeons in our sample reported that they constantly organize their activities to maximize teaching, and that they also make decisions on the fly to teach in ways that best suit their learners.

3. Feedback as an intraoperative teaching strategy

This sub-section is derived from the following two conference proceedings:

Dath D, Hoogenes J, Matsumoto ED, Szalay DA. Surgeon teachers' perceptions of and their efforts to provide feedback during intraoperative teaching. Association for Surgical Education Annual Surgical Education Week. Orlando, FL. April 22-25, 2013.

Dath D, Hoogenes J, Matsumoto E, Szalay D. How surgeon teachers use feedback to assess residents in the operating room. Association for Medical Education in Europe (AMEE): Transforming Healthcare through excellence, assessment, and evaluation. Ottawa, Ontario, Canada, April 25-29, 2014

Feedback is recognised as a teaching tool in many settings. During the focus groups study, we found that surgeon teachers agree that feedback is a core teaching strategy in the OR, akin to coaching in sports and other domains. However, recent literature finds that feedback is not well utilized in the OR and suggests several reasons. This qualitative study did not observe performance (how surgeon teachers gave feedback to residents based on observations) or outcomes (the results of providing feedback); instead, it examined how surgeon teachers use feedback as a teaching technique in an effort to provide a foundational understanding of how they perceive and give intraoperative feedback to residents. In this study, feedback was noted *a priori* as an important part of operative teaching and thus identified as a concept for exploration. Following qualitative content analysis, surgeon teachers discussed 17 concepts relating to intraoperative feedback. These concepts fell into 4 main themes: an understanding of feedback; the technique of giving feedback; the timing of feedback; and the affective component of giving feedback. However, discussion was not rich in specific techniques about how to give feedback. Many surgeons described feedback incompletely, and there was much variation in its use between participants, regardless of the specialty. Although surgeon teachers describe feedback and make it an intentional part of their intraoperative teaching strategy, their discussions demonstrated only a rudimentary understanding of the concepts and techniques of feedback. We considered that faculty development efforts that concentrate on the teaching and training of surgeons to give feedback appropriately when they teach in the OR may significantly raise the quality of teaching for surgical residents. The fact that the concept of feedback as a teaching tool varied so much within the focus groups study prompted further exploration of the literature in order to get a better understanding of feedback prior to introducing it into surgical faculty development courses. As it is used as a teaching technique during intraoperative teaching, it is important to further describe feedback in this thesis.

Although deemed critical to the success of surgical training, feedback is poorly understood and there is a paucity of literature on the effectiveness of its use by surgical instructors during the teaching of technical skills. Research on feedback in healthcare has primarily focused on multisource feedback (also referred to as 360˚ feedback) that assesses nontechnical competencies such as professionalism, communication skills, patient management, and overall performance, which are generally evaluated by colleagues, coworkers, and sometimes patients.[5] Although studies have suggested that educational feedback in the OR is essential, a gold-standard method for delivery and an optimal manner in which to disseminate feedback to surgical trainees has yet to be described.[6-10] The majority of residency programs require that supervisors provide summative feedback to residents to inform them of their progress, which is typically performed at prescribed times throughout residency. However, more informal, on-the-fly immediate feedback given during and after operative sessions are generally inadequate, which has led to reports of dissatisfaction among residents and medical students, especially with regard to feedback on technical skills proficiency and progression throughout their education, often leaving trainees wondering where they stand, not only as compared to their peers, but also on an individual level.[6,8,11]

Jensen et al. (2012) reported statistically significant differences in perceptions between faculty and residents with respect to a multitude of aspects surrounding feedback within the operative setting.[6] The authors concluded that perceptions of the importance of feedback in the OR did not differ between faculty and residents; however, faculty members' perceptions on the frequency and sufficiency of feedback were significantly higher than residents' perceptions of the intraoperative feedback they felt they received in seven specific areas of surgical competency. These domains included preoperative planning, intraoperative communication, respect for tissue, time and motion efficiency, instrument handling, knowledge of procedural steps, and knowledge of anatomy. In sum, residents in the Jensen et al. (2012) study were dissatisfied with all aspects of the feedback they received in the OR.[6]

Feedback is a construct that can be considerably influential in surgical skill acquisition and can serve as a catalyst for trainees to strive to improve and progress through the learning curve of procedural steps, with the ultimate goal of autonomously completing an entire operation with demonstrated competence. Frequent and timely formative feedback from instructors can serve as a strong motivator for trainees to independently practice in a surgical skills lab (or even with low-fidelity homemade bench models), accelerate the learning process, and prepare for actual OR cases. When providing training in a surgical skills centre (surgical simulation lab), instructors need to ensure that the assessment measures used are appropriate for what they intend to measure; for example, formative feedback needs to be provided by an instructor for learning purposes during training (e.g., while the trainee completes a specific step in a simulated procedure), and summative feedback ought to assess whether a certain level of competence has been attained for that procedure and that the level of proficiency is being maintained upon task repetition. Ideally, formative and summative feedback should be used jointly not only to ensure that the trainee knows his or her level of proficiency, but also for the instructor to determine whether the trainee needs to continue to practice the task or whether progression to the next procedural step is warranted. This type of feedback and subsequent assessment should carry over into the high stakes environment of the OR. The introduction of CBD and its milestones into surgical residency will eventually provide surgical educators with assessment methods to be used for each milestone (ideally measured that have been previously validated). These assessment measures may help to guide surgical educators on how and when to provide feedback along the residency training continuum.

4. Resident focus groups: how do surgical residents perceive the education they receive from surgeon teachers?

This sub-section is derived from the following conference proceeding:

Hoogenes J, Harlock JA, Vennettilli M, Gowing R, Rasheed F, Szalay D, Dath D, Matsumoto ED. A qualitative exploration of intraoperative teaching using surgical resident focus groups. American Urological Association (AUA) Annual Meeting, San Francisco, CA, May 29 – June 3, 2010. (Abstract published in The Journal of Urology, 2010;183(4), e514)

To obtain viewpoints of surgical residents in our institution with regards to how they perceive the intraoperative teaching they receive, our team conducted a separate study of ten focus groups consisting of 45 residents from various surgical residency programs at McMaster University. These were facilitated by resident investigators rather than staff surgeons so as to encourage open dialogue during focus groups. Participants were asked to identify and discuss various aspects of intraoperative teaching that they have been exposed to. A standardised discussion guide was developed to help direct each session. Discussion questions focused on five aspects of intraoperative teaching: 1) learning experiences in the OR; 2) residents' best and worst learning experiences; 3) how good educators involve and motivate learners; 4) how learners at different levels of training are treated by surgeons; and 5) how feedback is provided to learners in the OR.

Using qualitative content analysis, five primary themes emerged from the data. The first was positive teaching behaviours, which included participation and involvement of the learner (e.g., asking questions of the learner so they feel more involved in the OR case); awareness of the learners' knowledge and skills (e.g., surgical instructors should be aware of residents' level of surgical skill and knowledge related to a given case in the OR); defining roles and responsibilities of the learner, which was noted to help residents' build confidence, avoid conflicts with other participants, and allowed residents to focus on specific, level-appropriate task throughout a case.

The second primary theme was creating a positive learning environment. An example of this was described as when surgical educators create a sense of belonging in the OR, whereas the residents didn't feel they were being excluded from the operation at any point in the case. Furthermore, residents felt that encouraging participation in the case and maintaining a pleasant and collegial atmosphere in the OR contributed to a positive learning environment in the OR.

The third key theme was allowing a gradual increase in residents' responsibility (i.e., training level-appropriate involvement). This was termed as "graded responsibility", and as residents gained skills they felt more motivated and their confidence in their skills increased. Participants felt that this method of dividing tasks among residents in the OR benefited learners of multiple skill levels.

The fourth main theme was that of teaching constraints that create a negative learning environment. These included a lack of resources for learning (e.g., lack of OR time leads to fewer chances to participate and learn from cases), a lack of caring on behalf of the staff surgeon, and a lack of instruction during cases; all of which were felt to be a lack of commitment to teaching residents. Additionally, the issue of time constraints was pervasive among all focus groups. Time constraints were described as having a negative impact upon resident learning. A common complaint among the residents was the issue with booking times for cases performed by surgical learners. It was perceived that too little time was set aside for the residents so they do not to feel rushed, and that booking for the resident-type of cases (cases that were good learning opportunities) were left until the end of the day, where they have a chance of getting cancelled or taken over by the senior staff. This was not limited to the booking of cases, but also the manner in which operative time was managed within the OR by the surgeon teacher. Junior residents specifically perceived that they were not allowed to adequately participate in cases when time was a factor, or they were allowed to only perform a small part of the case, such as open the abdomen, and then watch and retract for hours. Consequently, time management in the OR was viewed as a constraint to operative learning.

The fifth and final theme that emerged from the resident focus groups was a consistent lack of feedback in the OR. Providing constructive feedback is often viewed as a basic tenet to the domain of teaching and learning; yet many surgical residents described that they often left the operating room feeling that their technical endeavours that day we either overlooked or unappreciated by their teacher. Participants also noted that any feedback, either positive or negative, would be better than no feedback at all.

With regard to study limitations, the focus groups were only attended by residents at a single centre. Their responses are thus based on the teaching and intraoperative experiences which may be common to their centre and lead to biases in their responses. They are also often exposed to the same surgical instructors who may utilise the same teaching behaviours while in the OR. Further, all residents at the institution did not participate in this study, thus a participant and reporting bias may exist among those that chose to participate. Combined, these biases may have resulted in the preferential reporting of specific common behaviours and a loss of some rare but important attributes of intraoperative teaching. By increasing the number of centres and thereby the number of teaching staff and learner experiences, additional or underreported attributes of intraoperative teaching may be identified, thereby constructing a more comprehensive inventory of themes related to teaching and learning in the OR. Direct observation of intraoperative teaching would also serve as an additional validation method.

2.2d Critical appraisal: Intraoperative teaching from the perspectives of surgical educators and surgical trainees

The studies discussed in this section describe efforts to improve the methods by which laparoscopic and robotic-assisted surgical training is conducted, with an emphasis on improving the teaching process and evaluation of surgical skills. As previously mentioned, the evaluation of surgical skills within a competency-based surgical residency curriculum is challenging, and the experts in the field are tasked with ensuring the evaluation of both surgical simulation-acquired skills and intraoperative skills meet or exceed the proficiency standards. Simulation and assessment are noted as among the major challenges and opportunities with the introduction of CanMEDS 2015 CBD:

> Around the world, medical educators are reconsidering the model of PGME (post-graduate medical education). Competency-based medical education, new teaching models, more direct observation, new assessment tools, greater use of portfolios, new teaching settings, greater emphasis on in-training assessment, and the rise of simulation are a few examples of major shifts in medical education.[34] (Harris KA, Frank JR; 2014)

As these are priorities within the CBD framework, surgical educators are faced not just with numerous challenges, but also with opportunities to develop and validate new assessment tools to add to the ever-changing landscape of surgical teaching in residency programs.

The themes that emerged from the work described in this chapter provide a great deal of insight into how surgical educators teach – their techniques and behaviours, and what is unique is that it is from their own point of view. Although this study was conducted with surgeons in just one institution, it provides insight into how surgical teachers actually teach (or perceive that they teach) and the techniques they use; and this further provides a starting point for additional research, such as workshops at international meetings, faculty development programs, and even distance learning modules for surgical educators, each of which can provide additional data about how surgical educators teach, with further investigation on how residents perceive this teaching – whether it is effective and which techniques are most helpful to learners at different stages of training.

The data acquired from the focus group studies (staff and residents) allowed for themes to emerge, which ended up aligning well with the CanMEDS competency roles. Many of the themes fit into multiple roles, particularly the communicator, scholar, and leader roles. Interestingly, the themes extracted from the resident focus groups aligned well with those of the surgical educators, providing some validation for both surgeons and residents and how surgical teaching is perceived at our institution. As leaders and researchers within the various surgical specialties begin to collaborate to develop the competency milestones for the CBD rollout within their respective specialties, it will be critical for curricula developers to consider the techniques surgeons use to teach and how residents respond to these techniques and what they feel are effective teaching techniques and strategies that will allow them to progress throughout their residency. Our research has been presented at multiple meetings both in Canada and abroad, and additional research is underway to further explore surgical teaching. This research will be described in the “current and future research” section of this thesis.

2.2e References for section 2.2

1. Bell RH, Jr., Biester TW, Tabuenca A, et al. Operative experience of residents in US general surgery programs: a gap between expectation and experience. *Ann Surg.* 2009;249(5):719-724.
2. Van Eaton EG, Tarpley JL, Solorzano CC, Cho CS, Weber SM, Termuhlen PM. Resident education in 2011: three key challenges on the road ahead. Surgery. 2011;149(4):465-473.
3. DaRosa DA, Skeff K, Friedland JA, et al. Barriers to effective teaching. Acad Med. 2011;86(4):453-459.
4. Cooke M, Irby DM, O'Brien BC. Educating physicians: a call for reform of medical school and residency. San Fransciso, C.A., U.S.A.: Jossey-Bass; 2010.
5. Al Khalifa K, Al Ansari A, Violato C, Donnon T. Multisource feedback to assess surgical practice: a systematic review. J Surg Educ. Jul-Aug 2013;70(4):475-486.
6. Jensen AR, Wright AS, Kim S, Horvath KD, Calhoun KE. Educational feedback in the operating room: a gap between resident and faculty perceptions. Am J Surg. Aug 2012;204(2):248-255.
7. Parmar S, Delaney CP. The role of proximate feedback in skills training. Surgeon. 2010;9 Suppl 1:S26-27.
8. Kannappan A, Yip DT, Lodhia NA, Morton J, Lau JN. The effect of positive and negative verbal feedback on surgical skills performance and motivation. J Surg Educ. Nov-Dec 2012;69(6):798-801.
9. Glarner CE, McDonald RJ, Smith AB, et al. Utilizing a novel tool for the comprehensive assessment of resident operative performance. J Surg Educ. Nov-Dec 2013;70(6):813-820.

10. Anderson CI, Gupta RN, Larson JR, et al. Impact of objectively assessing surgeons' teaching on effective perioperative instructional behaviors. JAMA Surg. Oct 1 2013;148(10):915-922.

11. Boehler ML, Rogers DA, Schwind CJ, et al. An investigation of medical student reactions to feedback: a randomised controlled trial. Med Educ. Aug 2006;40(8):746-749.

2.3 Exploring undergraduate surgical clerkship experiences within a competency-based curriculum – what are surgical clerks' experiences during surgical rotations?

2.3a Narrative

Undergraduate medical programs have also begun to adopt formal competency-based frameworks to guide their curricula, most with defined competency objectives that a medical student must meet within each year of medical school, similar to the CBME format of many current residency programs. As described in Published Work 1 (book chapter), various accreditation institutions use defined competencies to allow for progression through residency; however, similar guidelines are often used throughout medical school and the competencies are tailored to the level of training and usually to the specific year of training, dependent on the structure of the medical school curriculum (most often determined by the number of years required to complete before entering a residency program, which varies worldwide). These competencies generally include medical knowledge, interpersonal and communication skills, patient care, ethics and professionalism, practice-based learning and improvement, and systems-based practice, each of which are covered in the frameworks of CanMEDS, ACGME, the UK General Medical Council, and Institute of Medicine[1]. Just as with residency, defining these competencies in medical school curricula allows for structured assessment and progression through training.[2]

As medical students progress through training, they become less of a bystander, or observer, and assume a more hands-on clinical role. During this advancement, students develop relationships with their clinical instructors and mentors as they receive on-the-job training and become more involved in the care of patients. Due to this exposure, students are able to observe the behaviours of medical professionals in the workplace environment, in settings such as wards, intensive care units, emergency departments, and the surgical theatre. During this time, medical students begin to recognize what is commonly referred to as the "hidden curriculum". The hidden curriculum can be defined as a set of influences that pervade the organisational structure and culture during hands-on training and instruction, where the medical student begins to compare and contrast their instructors' and peers' behaviours with the professional standards they have previously been taught early on in the didactic setting.[3-6] It is essentially an unspoken code of conduct within the learning environment, which is not always congruent with the moral guidelines published by professional CBME frameworks such as CanMEDS.[6] Although it is not easily recognisable, the hidden curriculum often has a strong influence on medical students during their formative clerkship year(s), setting the stage for how they may behave in a professional capacity moving forward. Exploring how medical students navigate this hidden curriculum and how it affects them is vital, as it provides useful data for CBME curriculum developers and instructors on how medical students perceive and respond to their hands-on clinical training. These data are also valuable to residency program directors, as the hidden curriculum is something they, too, need to be aware of as recent medical school graduates begin their residency training.

In Canada, when medical students begin their clerkship, typically in their third or fourth year of medical school (medical schools in Canada are either three or four years in length), they become exposed to different specialties via elective placements. During this period, students are able to explore their interests, and they often travel to other academic centres and/or choose community-based elective rotations, all with the goal of determining which medical or surgical specialty they may wish to pursue moving forward into residency. For students interested in a surgical specialty, clerkship affords them the opportunity to choose surgical specialty and subspecialty-based electives; however, it is a requirement that all medical students receive mandated exposure to surgical specialties. If a student is seriously considering a surgical career, he or she may choose to forego some electives (e.g., internal medicine, radiology, family medicine) and instead attend multiple additional surgical placements.

At McMaster University, medical students follow a CBME curriculum modeled after the roles that comprise the CanMEDS framework, called the Professional Competencies curriculum, referred to as “ProComp”. It is mandatory for all students to complete a six-week surgical rotation during their clerkship year. This rotation consists of 4 weeks of general surgery, with an additional two weeks of a chosen surgical subspecialty. In addition to clinical and surgical placements, all clerks attend ongoing formal teaching sessions, devoted to professional competencies. During this rotation, students are required to write about a critical incident(s) involving one or more competencies. This reflective process brings out elements of the hidden curriculum, such as ethical and moral reasoning and clinical judgement. To determine the value of the ProComp curriculum during surgical clerkship, we embarked on a qualitative exploration of the hidden curriculum as it applies to surgical training. Our main outcome was to determine how clerks perceive and react to situations encountered during their surgical rotations, as these encounters can be influential in how medical students choose their residency specialty, be it medical or surgical.

Based on the data acquired from the intraoperative teaching and learning study in Published Work 2 and the supporting references that further described the data acquisition and findings, our team recognised a need to explore the surgical clerkship experiences of medical students, as the types of teaching they may have encountered could potentially have a profound effect on whether they choose to pursue a surgical residency, and further, a specific surgical specialty. We also recognised that positive and negative learning experiences on surgical rotations can potentially affect students' choices to pursue a surgical career at all. Examining clerks' written accounts of their experiences on surgical rotations proved to be very valuable in increasing our understanding of surgical education within a competency-based curriculum.

2.3b Published Work 3

Kittmer T, Hoogenes J, Pemberton J, Cameron B. Exploring the hidden curriculum: A qualitative analysis of clerks' reflections on professionalism in surgical clerkship. Am J Surg. 2013 Apr 205(4); 426-33.

Web link: ***https://www.ncbi.nlm.nih.gov/pubmed/23313441***

2.3c Critical Appraisal: Published Work 3

This study qualitatively explored elements of the undergraduate medical school hidden curriculum by evaluating critical incident reports (CIRs) reflectively written by McMaster University clerks (senior medical students) about their surgical rotations. The anonymous nature of the CIRs allowed clerks to express themselves without the fear of any impact on their status in medical school. With 85% of participants stating that they gained new insights from taking part in the exercise, this was encouraging, and has led to its continuation as a mandatory exercise within the ProComp surgical clerkship curriculum at McMaster University.

The data provided us with a unique perspective that we as non-clinician researchers are not privy to, which allowed us to take a more objective view with respect to the data. Each theme, or domain, that was extracted from the data (relationship of clerk with patients, healthcare team, healthcare system, and self) contained multiple accounts of incidents that are associated with the CanMEDS framework's roles, particularly with regard to communication, health advocacy, patient safety, and professionalism. Many of the CIRs overlapped themes, and some CIRs spoke of events where multiple competency roles were covered. One ubiquitous theme we observed was the clerk's undefined role in the hierarchy, which prevented them from addressing ethical, communication, patient safety, and professional situations on their own. The quote from the senior resident that, a clerk "is meant to be seen and not heard", speaks to this concept very well. The fact that clerks on surgical rotations most frequently cited issues with team communication, stress and emotions, responsibility (e.g., either having been given too much responsibility for their level of training, or being unclear as to what their responsibilities were), and the surgical hierarchy suggests that these are topics that ought to be addressed when developing, implementing, and evaluating a competency-based curriculum. Clerks who have a less than favourable experience while on a surgical rotation(s) may be turned off of pursing a surgical career altogether.

Team and interprofessional communication were cited frequently, suggesting communication as a general concept is a competency that poses a challenge for both junior and senior clerks. Communication is a vital professional competency, and addressing this challenge is important moving forward into residency. The data we evaluated showed that clerks are aware of professional competencies, as evidenced by their CIRs, and an exercise such as this may indeed encourage students to critically think more about the importance of being in a CBME curriculum throughout medical school, as it may better prepare them for entering a competency-driven residency program.

The hidden curriculum and the elements within may cause medical educators to question what else is going on during medical education that we may not necessarily be able to see, as well as what other types of teaching and learning are going on outside of the formal medical curriculum. These questions have been sought since as early as 1957 by Robert Merton and colleagues.[7]Their work was rooted in sociology and explored medical education in this context, yet they also focused on other types of education, including nursing and law, where the hidden curriculum was also prevalent. Through their research with medical programs, they introduced the concept of unintended consequences and delineation between the concepts of manifest and latent functions, while further describing the broader educational distinctions between deep/superficial and explicit/implicit learning.[8] Snyder (1971) focused on the space between a medical school's formal expectations and "real" requirements versus what was "actually" expected of the student. Snyder reported finding that the differences between the expected curriculum and its "real" requirements caused dissonance among students, which ultimately resulted in scorn, cynicism, and hypocrisy among members of the student body he studied. Additionally, Snyder found that the most successful students are not necessarily those who are the brightest, but those who learn what the system really wants of them.[9]

In 1961, an iconic book titled, "Boys in white: student culture in medical school", by Becker and colleagues, took a new approach to sociological research, at the time referred to as the "sociology of medical education".[10,11] The authors described the first known study of socialization in medical school, which also may have been the first discovery of the concepts that comprise the "hidden curriculum". The authors had a unique approach to their research, as they themselves were medical students; thus, they were immersed in their own research, taking an ethnographic approach to their qualitative analysis.[10,11]Their summary maintained that at medical school, their fellow students developed a set of dilemmas: idealism versus the demands of clinical work; fear and anxiety versus self-assurance; identifying oneself with the faculty versus taking medical responsibility and clinical experience, within their limits.[10,11] These findings provided a foundation for future researchers who explored the hidden curriculum within the medical education setting.

Following a lengthy hiatus in the literature on the hidden curriculum, in 1994 Hafferty and Franks published a landmark paper titled, “The hidden curriculum, ethics teaching, and the structure of medical education”.[12]This paper focused primarily on the inherent difficulty of formally teaching ethics in medical school and beyond to residency. The authors discuss whether medical ethics is best framed as an entire, separate body of knowledge and skills or whether it exists as part of one’s own professional identity. The authors concluded that “the content and possible impact of a hidden curriculum are best identified and addressed within a consortium of faulty, students, and expert outside observers (such as social scientists), whose goal it is to address the training process in its broadest sense. “Insiders” cannot do it alone” (p. 868). Furthermore, they stated that, the “fundamental nature of medicine’s culture is best reflected not in the *curriculum-formal* but in the *curriculum-hidden*” (p. 869). This insight can be observed within the current medical school curricula change movement to purely competency-based training and evaluation. Various types of experts are involved in this process, including those from the social sciences.

Following Hafferty and Franks’ 1994 paper, Douglas-Steele and Hundert (1996) carried out a large qualitative study where they thematically analysed hundreds of hours of recordings general surgery residents took both inside and outside of the classroom, virtually everywhere they went during their training. The authors found that professional and moral development was most likely to occur among medical trainees when faculty members were not present, and that informal curricula was in name only. They suggested further that there was an unwritten yet prominent code of behaviour that was passed along between peers on how to act while in surgical training – that of the hidden curriculum.[13]

O'Donnell (2014) provided a comprehensive summary of the findings-to-date (as of 2014) on hidden curriculum research in the medical school setting: 1) the hidden curriculum is "hidden" and will always be present, even as curricula continue to change and evolve; 2) the hidden curriculum is everywhere and touches everything, regardless of the location – from the hospital and clinics to the hallways and students' living spaces; 3) insiders often have a harder time "seeing" the hidden curriculum when compared to outsiders and newcomers to a program; 4) the hidden curriculum is extremely complex and solutions to understanding it are best approached as complex social constructs; 5) the things that happen within the hidden curriculum are not always bad – good learning can occur within it; 6) efforts by curricula developers to out the hidden curriculum may have untoward and/or unanticipated outcomes; 7) the hidden curriculum is difficult to address and change, as cultures within it are deep, wide, stable, and meant to be that way; 8) the greatest influence on the hidden curriculum may be to target and understand it on an organizational level, rather than only focusing on individuals within the organization (i.e., medical students); 9) ignoring the hidden curriculum while trying to revise curricula will risk reform without change; and 10) efforts to close the gap on what is supposed to be learned and what is actually being learned in medical school will be difficult and challenging, but will have a huge impact on how curricula are designed and how they evolve.[8] O'Donnell suggests that closing this gap may help to reduce the burnout, dissatisfaction, cynicism, and other ills that currently plague medical education and medicine as a profession.[8]

This summary of the findings of the historical research on the hidden curriculum can serve as a guide for curricula developers as they move forward with CBME initiatives such as CBD, as ignoring the existence of the hidden curriculum and its many complicated constructs may inhibit change and actually hinder the efforts to improve how medical students and residents are taught and evaluated.

Overall, our research showed that incorporating a CBME undergraduate medical school curriculum is advantageous, as it allows medical students to be taught different roles and competencies in a didactic manner while also providing opportunities for observing these roles in a tangible clinical setting. Recent work by Bacchus and colleagues (2017) supports this notion, as they, too found that when medical students were able to observe attending physicians in the workplace environment, the medical students noted direct links of the physicians' behaviours and practices to the CanMEDS 2015 competency roles, providing further evidence that it would be beneficial for a competency framework to become part of the standard medical school curriculum.[14]Lomis and colleagues (2017) adapted the ACGME competency framework for residency into an undergraduate medical school curriculum, with a primary focus on creating role-specific competency milestones and assessment measures to be used in the medical school environment.[15]They defined medical school-based milestones as those that "serve as a standardized articulation of expectations, providing clarity for both assessors and learners, and are useful to describe learner development across competency domains" (Lomis et al., 2017). The authors initially implemented their competency milestone framework curriculum over a two-year time period to determine its feasibility, practicability, and validity, and are currently (as of March 2017) determining the overall results. Their interim data show, however, that the program has generated enough confidence to include the evidence (competency milestone assessment results) in formal reviews of student progress.[15] In our study of the hidden curriculum, the roles mentioned by participants aligned well with those of the CanMEDS framework (and other frameworks, such as the ACGME's), thereby lending credence to the fact that the hidden curriculum plays a significant role in the experiences of medical students, and, along with considering the important role of the research to-date and its findings on the hidden curriculum, ought to be considered when developing, adopting, and evaluating a competency-based framework for undergraduate medical education, and even further into residency education.

2.3d References for section 2.3

1. Norcini JJ, Holmboe ES, Hawkins RE. Evaluation challenges in the era of outcomes-based education. In: Holboe ES, Hawikins RE, eds. *Practical guide to the evaluation of clinical competence*. Philadelphia, P.A., U.S.A.: Mosby Elsevier; 2008.
2. Holmboe ES, Sherbino J, Long DM, Swing SR, Frank JR. The role of assessment in competency-based medical education. *Med Teach.* 2010;32(8):676-682.
3. Epstein RM, Hundert EM. Defining and assessing professional competence. JAMA. 2002;287(2):226-235.
4. Hafferty FW. Beyond curriculum reform: confronting medicine's hidden curriculum. Acad Med. 1998;73(4):403-407.
5. Lempp H, Seale C. The hidden curriculum in undergraduate medical education: qualitative study of medical students' perceptions of teaching. BMJ. 2004;329(7469):770-773.
6. Kittmer T, Hoogenes J, Pemberton J, Cameron BH. Exploring the hidden curriculum: a qualitative analysis of clerks' reflections on professionalism in surgical clerkship. Am J Surg. 2013;205(4):426-433.
7. Merton RK, Reader G, Kendall P. The student physician: introductory studies in the sociology of medical education. Cambridge, MA: Harvard University Press; 1957.
8. O'Donnell JF. The hidden curriculum - a focus on learning and closing the gap. In: Hafferty FW and O'Donnell JF, eds. The hidden curriculum in health professional education. Hanover, NH: Dartmouth College Press; 2014.
9. Snyder BR. The hidden curriculum. New York: Knopf; 1971.

10. Becker HS, Geer BP, Hughes EC, and Strauss AL. Boys in white: student culture in medical school. Chicago: The University of Chicago Press; 1961.

11. Nunes ED, deBarros NF. Boys in white: a classic of qualitative research turns 50. Historia, Ciencias, Saude. 2013;21(4):1-18.

12. Hafferty FW, Franks R. The hidden curriculum, ethics teaching, and the structure of medical education. Acad Med. 1994;69(11):861-871.

13. Douglas-Steele D, Hundert EM. Accounting for context: future directions in bioethics theory and research. Theor Med. 1996;17(2):101-119.

14. Bacchus M, Ward DR, de Grood J, Lemaire JB. How evidence from observing attending physicians links to a competency-based framework. Med Educ. 2017.

15. Lomis KD, Russell RG, Davidson MA, et al. Competency milestones for medical students: Design, implementation, and analysis at one medical school. Med Teach. 2017:1-11.

2.4 Current tools for surgical teaching: the role of simulation in training and assessment

2.4a Narrative

This section serves as an introduction to surgical simulation and its role in surgical residency curricula. Simulation, in various forms, has become commonplace in many surgical residency programs, with the objective of providing additional education outside of the OR where trainees can deliberately practice surgical skills with and without instruction, and often on their own time (typically in a surgical skills laboratory). It has also begun to play a major role in the assessment of trainees' technical skill acquisition. The use of simulation depends on the availability of surgical simulation laboratories, simulation equipment (some of which can be very costly), administrators, and educators. As simulation is increasing in popularity, it is important to discuss as a valuable surgical education tool.

Surgical simulators have improved significantly with time, as improvements in technology have allowed for the development of high fidelity simulators, including those that use virtual reality (VR) with advanced software, enabling trainees to practice partial surgical tasks and even entire surgical procedures. VR simulators are primarily dedicated to minimally-invasive surgical procedures, such as those that use basic laparoscopic and robotic-assisted laparoscopic approaches, and many of these provide objective feedback to the user using sophisticated metrics. However, multiple options exist for performing more basic skills, such as suturing and knot tying, and those required for open surgical procedures. Simulation is also valuable for surgical team training for procedures such as kidney transplants, emergency/trauma surgery, and robotic surgery assistance.

With the aforementioned barriers to available OR time for residents, simulation affords trainees an alternative learning environment, where they can acquire surgical skills that can transfer to the live OR setting. Many centres hold regular formal training sessions for residents, which are designed for a particular level of training, where they can focus on the acquisition of surgical skills required for the specialty and for the level of training. Currently, there are no practice guidelines or curricula requirements for surgical simulation as part of surgical residency training programs. With CBD and other competency-based initiatives on the horizon, simulation can provide residents with the practice necessary to acquire the technical skills needed to competently perform a procedure and meet competency objectives. Published Work 4 is a book chapter (published in 2016) that provides a comprehensive background of surgical simulation, including the history and theory behind it, different types of simulators, assessment measures, and other considerations. As surgical simulation equipment can be costly, we conducted a systematic review and meta-analysis that evaluated any differences in fidelity and training outcomes between commercial video laparoscopic trainers and less expensive simple laparoscopic trainers (Published Work 5). Finally, Published Work 6 will describe a randomised controlled study we undertook to determine how raining on a novel, low-cost surgical simulator (a bench model) transfers to an animal model for the same surgical procedure.

2.4b Published Work 4 – A comprehensive background of current surgical simulation

<u>Hoogenes J</u> and Matsumoto ED. Simulation Surgical Models: Surgeon Perspectives. In: Bioengineering for Surgery: The Critical Engineer Surgeon Interface. Elsevier/Woodhead Publishing, Series in Biomedicine Number 84, Amsterdam. Eds. WA Farhat and J Drake. 2016 (Book chapter 10)

Web link to chapter: *https://doi.org/10.1016/B978-0-08-100123-3.00010-5*

Web link to book: *https://www.sciencedirect.com/science/book/9780081001233*

2.4c Are there differences in training outcomes between expensive, high fidelity simulators and low-cost, low fidelity simulators for laparoscopic surgical training?

2.4d Narrative

Surgical educators and the surgical training industry are making technological advancements that allow for higher fidelity simulators; yet, along with these enhanced technological abilities, such as VR with haptic capabilities, comes higher cost. Fidelity, similar to the concept of face validity, represents the likeness of the simulator to the real-life circumstances it was designed to duplicate. Simulations can achieve a high level of functional fidelity with relatively low technology methods. For example, low fidelity simulators such as simple bench models and box trainers can be very good at simulating a skill. Many simulators are out of the reach, financially, of many academic centres. Some laparoscopic box trainers, as described in Published Work 4, use little to no technology and can potentially teach a trainee the same types of fundamental and even advanced skills that a laparoscopic video box trainer, which uses cameras within a silicone torso to display the use of the instruments onto the laparoscopic screen (as seen in the image below [©McMaster University]):

Medical students and residents have become innovative and have published some of their prototypes to develop laparoscopic box trainers using homemade items such as plastic and cardboard boxes and baskets[9], to more advanced setups that include cameras (e.g., webcam) within the box that project the movement with the laparoscopic instruments onto a smartphone, laptop, or tablet screen.[10]Furthermore, there are several videos on the Internet that are posted to show others how to build inexpensive box trainers. Commercial laparoscopic box trainers are developed more for simulation laboratories and can range into the thousands of dollars ($CAD/$USD); however, some companies do have laparoscopic box trainers that are designed for “take-home” practice. After a quick online search of four companies, I found the average cost of their least expensive box trainers to be $1312.25 USD (£1023.84), and these costs did not include a tablet or camera that would need to be used with the systems. These costs may prohibit students from being able to have a “portable” laparoscopic trainer. Although many simulation labs have multiple laparoscopic trainers on which to practice, it would be convenient for students to be able to use a trainer outside of the lab.

Simple laparoscopic box trainers and other high-fidelity VR trainers are helpful for trainees in many ways, but particularly because of the Fundamentals of Laparoscopic Surgery (FLS) program, designed by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and the American College of Surgeons (ACS), and is a requirement of many surgical residency programs for certification and credentialing purposes.[10]The FLS is a self-paced program (wherein the use of laparoscopic simulation is imperative, as testing is completed using laparoscopic box trainers). Cognitive content (obtained via didactic training sessions and on-line modules) is supplemented with manual skills based on the five McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) tasks (previously described in Published Work 1).[11,12] The FLS program has been validated extensively, with performance and clinical skills closely correlated[13-15], and passing scores have been obtained using clinically relevant parameters.[16] The FLS certification program is used by residency programs for advancement purposes (e.g., from PGY1 to PGY2), and there is the potential that practicing surgeons might ultimately be required to become FLS certified for credentialing purposes.[11]With CBD and other competency initiatives that will eventually impact curricula (including life-long learning initiatives that may influence independent practice credentialing), the role of FLS and weight of its proficiency scoring may change; however, there is no note in any of the literature thus far to that effect.

As all surgical residents will at one time be required to train and/or test on laparoscopic skills via the use of laparoscopic training box and/or VR trainers. For those residents and fellows in the specialties of urology, general surgery, obstetrics and gynecology, and other specialties that are beginning to use more minimally-invasive techniques, they will be required to become adept at laparoscopic procedure-specific tasks (e.g., urethrovesical anastomosis [UVA]) before transferring their skills to the OR. It is of great benefit not only to the students who will be using them, but to surgical educators who will be teaching them, to know the differences between commercial video laparoscopic trainers and less expensive, simple laparoscopic trainers (i.e., those that can be made at home) to determine if they differ in terms of actually facilitating skill acquisition, despite the clear differences in fidelity. We conducted and published the first (to our knowledge) systematic review and meta-analysis of the available literature on this topic.

2.4e Published Work 5

Ngyuyen, T, Braga L, Hoogenes J, Matsumoto ED. Commercial video laparoscopic trainers versus less expensive, simple laparoscopic trainers: A systematic review and meta-analysis. J Urol. 2013 Sep; 190(3):894-9.

Web link: ***https://www.ncbi.nlm.nih.gov/pubmed/23567747***

2.4f Critical Appraisal: Published Work 5

The results found after carrying out the systematic review and meta-analysis for the study in Published Work 7 suggested that there was no real, statistically significant differences between simple, low cost laparoscopic box trainers (trainers that utilise mirrors or webcams to project the movement within the box – non-commercial) and commercial laparoscopic video trainers that are more sophisticated and thus more costly (as shown in the image earlier in this section). However, there were only five papers (all RCTs) that met our inclusion criteria for the review, as we did not include any kind of VR trainer, or those driven by computer programs and metrics. The quality of the evidence across all five studies was high, yet the only common outcome measures were suturing tasks and object transfers, with time to task completion as a comparison measure. As noted in the paper, there was quite a bit of variation between the studies' outcome measures (e.g., accuracy, motion, flow, instrument handling), as well as the difference in the participants' year of training, which were limitations of this study. However, we were able to independently analyse each study, and determined that both versions are equally as effective at teaching to the level of the user's training (no statistically significant differences). These findings suggest that some trainers that are low in cost and fidelity can still teach some surgical skills equally as well as some more expensive high fidelity trainers.

It is important to consider that this review only evaluated studies that examined simple laparoscopic training skill acquisition. More advanced laparoscopic training would indeed require simulators with VR capability, which allow trainees to complete partial surgical tasks and even full surgical procedures. However, some advanced training can also be accomplished by using a non-VR laparoscopic video trainers and a bench models, such as those previously discussed (e.g., latex kidney or bladder model). However, for simple skills such as suturing, knot tying, and transfer skills (many of those which are required for the FLS program), simple, homemade box trainers will provide the same level of training as more expensive video trainers that use laparoscopic scopes and silicon torsos with laparoscopic ports. The fact that webcams and smart phones have become more advanced and less expensive over time will allow for easier construction of simple laparoscopic trainers.

The very small sample size for this study is suggestive of a significant lack of research being conducted in the area of laparoscopic simulation at the time of data collection (2013), with regards to types of simulators available. It would certainly be useful to conduct this study again, as newer models have been commercially introduced to the market and also introduced by students on their own using their own materials, as evidenced by the literature and items posted online.[9,10] More recent data may assist students and researchers, as well as surgical educators whose purchase simulation materials for laboratories – with the ultimate goal of minimising spending without jeopardising the training and potential for effective skill acquisition by trainees. The growth of tools and modalities for simulation has been much more rapid than the development of evidence-based processes to integrate the most effective simulation into specific programs and curricula[17]; and although there is significant interest in doing so, there is very little guidance on how to actually incorporate it into training.[18-20]As surgical residency program directors reconsider curricula and the assessment methods that should accompany it in order to meet the new requirements of CBD and other competency-based frameworks, it will be necessary for them to consider the role of simulation in the program, along with the types and levels of fidelity of its simulators, and determine the best ways to evaluate the simulation-based competencies of its residents, as these competencies will provide a guide for when skills actually transfer to the high stakes environment of the OR.

2.4g Transfer of skills from the simulated environment to live surgical cases

2.4h Narrative

Published Work 4 presented an overview of surgical simulation, including the evolution of simulation into the surgical field, theoretical underpinnings that drive how trainees learn via simulation, types of surgical simulators, and some of the settings and types of research and projects where simulation can play a significant role. As noted previously, surgical simulation is used by learners of all levels, including medical student clerks up through the level of training hierarchy to include practicing surgeons who want to learn new skills (e.g., robotic surgical skill) and/or maintain their current level of surgical skill proficiency. Laparoscopic surgery, sometimes referred to as minimally-invasive, or MIS, surgery, has a steep learning curve, as described in Chapter 4. During intraoperative laparoscopic training, due to the OR arrangement, there is only room for one trainee, while other learners can only play an observational role, making it very difficult for trainees to log hands-on laparoscopic training hours. Because of this, it is imperative that surgical trainees not only get effective training intraoperatively, but that they also get *enough* training, which is why simulation is ideal for learning and practicing laparoscopic surgical techniques in a safe and controlled environment, as they prepare to transfer their acquired skills to the live OR.

The overall goal of surgical simulation is the proficient transfer of skills learned in the surgical simulation lab to the high-stakes environment of the OR. The transfer of skills from simulation to the OR has not been well-described in the literature. Of the few assessment tools that have been developed for rating skills acquired via simulation, such as the validated Objective

Structured Assessment of Laparoscopic Skills (OSATS)[1], the Global Operative Assessment of Laparoscopic Skills (GOALS)[2], and objective assessment metrics integrated into several high fidelity VR simulators (e.g., time to task completion, error rates, degree of bimanual dexterity[3]), none of these measures can truly rate how well a surgical skill will actually transfer to an real procedure in the OR, as there are numerous variables that can effect this transfer that are inherent to all live surgical cases. A recent literature review[3] on the topic of skills transfer from simulation to the OR found just 14 laparoscopic-based randomised controlled trials (RCTs) that observed one simple procedure each (one studied only holding the endoscopic camera), with the majority being assisting with laparoscopic cholecystectomies (n=6). The overall findings provided evidence that trainees who reached proficiency (defined by the authors as attaining an "expert" benchmark) in the task(s) for simulation-based training performed better in the patient-based setting than those with no simulation training. The authors support the use of a structured simulation program with predetermined proficiency levels in a laparoscopic residency curriculum.[3]This is an important consideration with competency frameworks such as CBD, regarding how to incorporate simulation into a curriculum and, importantly, *how* proficiency measures (such as, "novice", "intermediate", "expert") will be defined. As previously discussed, although technical skills are of utmost importance when transferring simulation-acquired skills to the OR, one must also consider the effects of non-technical skills and environmental variables that can affect this transfer.[4] Laparoscopic surgical procedures have replaced many types of surgeries that were once only possible via open approaches; and as such, they have substantially improved surgical outcomes and have become the standard of care for many surgical treatments.[5]As previously noted, laparoscopic surgery has its own unique challenges throughout its steep learning curve. Numerous laparoscopic tasks and techniques can be practiced in a simulation lab, yet many of these tasks are particularly difficult to learn, regardless of the setting.[3,5]

With the advent of the prostate-specific antigen (PSA) test, more cases of prostate cancer are being detected at a higher rate than ever before, and it is being diagnosed earlier in patients' lifetimes. It is estimated that in 2017 alone, 161,360 American men will be diagnosed with prostate cancer.[6]With this influx of prostate cancer diagnoses, up to 8 radical prostatectomies are done weekly between two surgeons at our institution. These are either done laparoscopically (laparoscopic-assisted radical prostatectomy, or LRP) or via robotic-assisted radical laparoscopic prostatectomy (RARP). The practice of urology has changed dramatically over the past decade, with numerous advances in technology leading the change. As with all technological advances come learning curves that must be overcome. Simulation has played a large part in the transfer of open surgical cases to more minimally-invasive techniques such as LRPs and RARPs, among other laparoscopic and robotic-assisted procedures. Our research team conducted a study to observe the transfer of simulation lab-based skill acquisition on a novel latex bladder model we developed to a live anaesthetized animal model (as a surrogate to a live human). This study is described in Published Work 6.

2.4i Published Work 6

Sabbagh R, Chatterjee S, Chawla A, Hoogenes J, Kapoor A, Matsumoto ED. Transfer of laparoscopic radical prostatectomy skills from bench model to animal model: a prospective, single-blind, randomized controlled study. J Urol. 2012 May;187(5):1861-6.

Web link: ***https://www.ncbi.nlm.nih.gov/pubmed/22425041***

2.4j Critical Appraisal: Published Work 6

Published Work 6 was the second study in a series[7] that has tested a novel, latex-based urethrovesical anastomosis model (UVM) (Figures 1-A and -B in the paper), which consists of an intact urethra and bladder for simulation training of a laparoscopic urethrovesical anastomosis (LUA). When performing a urethrovesical anastomosis (UVA) during radical prostatectomy, regardless of the surgical approach, the surgeon divides the urethra and bladder to allow for the dissection and removal of the prostate. After prostate removal, the urethra and bladder must be carefully and completely sewn together (anastomosed), watertight, so that the bladder will not leak and so it may heal intact and not lose functionality. The UVA is widely regarded as one of the most difficult, if not the most difficult, steps in a radical prostatectomy.[8]When the procedure is performed during the open approach, the visibility of the structures is superior to views through an endoscope during LRP and RARP, as it is via direct visualisation. In the previous simulation-only study with the silicone UVA model (Sabbagh et al. 2009), participants performed a simulated laparoscopic UVA with the model placed in a pelvic trainer (Figure 1-C in the paper). In that study, those who practiced laparoscopic-based tasks on a foam suture pad did not score as well as those using the latex UVM on a global rating scale (GRS). From these findings, we sought to determine whether the simulated LUA skills learned on the UVM would transfer to performing a LUA on live anaesthetized pigs.

The results of this single-blind, 2-group RCT were interesting in that, during the transfer of skills from simulation to the pig model, Group 1 (experimental – practiced on the UVM prior to the *in vivo* LUA) scored significantly higher on the task-specific checklist and GRS than Group 2 (control – practiced on only basic laparoscopic simulation tools prior to the *in vivo* LUA); however Group 2 completed the LUA quicker than Group 1. Overall, it was concluded that practice on the UVM did lead to better overall results on the pig model when compared to practice on just simulation tasks, suggesting the use of the UVM can be a valuable tool for preparing trainees to transfer LUA skills to a live patient. Despite the differences in levels of training and types of surgical backgrounds of the participants, the study shows promise for the UVM. Due to these promising results, we developed a study to examine this transfer task using now-available robotic simulation, with the transfer of robotic simulator-acquired skills to a new 3D-printed UVA model (which took the place of the latex model from the previous studies) to a simulated robotic surgical setting in the OR. This study is fully described in Section 2.5(j).

2.4k References for section 2.4

1. Vassiliou MC, Feldman LS, Andrew CG, et al. A global assessment tool for evaluation of intraoperative laparoscopic skills. Am J Surg. 2005;190(1):107-113.
2. Martin JA, Regehr G, Reznick R, et al. Objective structured assessment of technical skill (OSATS) for surgical residents. Br J Surg. 1997;84(2):273-278.
3. Dawe SR, Pena GN, Windsor JA, et al. Systematic review of skills transfer after surgical simulation-based training. Br J Surg. 2014;101(9):1063-1076.
4. Buckley CE, Kavanagh DO, Traynor O, Neary PC. Is the skillset obtained in surgical simulation transferable to the operating theatre? Am J Surg. 2014;207(1):146-157.
5. Al-Kadi AS, Donnon T, Oddone Paolucci E, Mitchell P, Debru E, Church N. The effect of simulation in improving students' performance in laparoscopic surgery: a meta-analysis. Surg Endosc. 2012;26(11):3215-3224.
6. Dunn MW. Prostate Cancer Screening. Semin Oncol Nurs. 2017. Epub March 23, 2017
7. Sabbagh R, Chatterjee S, Chawla A, Kapoor A, Matsumoto ED. Task-specific bench model training versus basic laparoscopic skills training for laparoscopic radical prostatectomy: a randomized controlled study. Can Urol Assoc J. 2009;3(1):22-30.
8. Raza SJ, Field E, Jay C, et al. Surgical competency for urethrovesical anastomosis during robot-assisted radical prostatectomy: development and validation of the robotic anastomosis competency evaluation. Urology. 2015;85(1):27-32.
9. Jaber N. The basket trainer: A homemade laparoscopic trainer attainable to every resident. J Minim Access Surg. 2010;6(1):3-5.

10. van Duren B, van Boxel G. Use your phone to build a simple laparoscopic trainer. J Minim Access Surg. 2014;10(4):219-220.
11. Scott DJ, Ritter EM, Tesfay ST, Pimentel EA, Nagji A, Fried GM. Certification pass rate of 100% for fundamentals of laparoscopic surgery skills after proficiency-based training. Surg Endosc. 2008;22(8):1887-1893.
12. Derossis AM, Bothwell J, Sigman HH, Fried GM. The effect of practice on performance in a laparoscopic simulator. Surg Endosc. 1998;12(9):1117-1120.
13. Fried GM, Derossis AM, Bothwell J, Sigman HH. Comparison of laparoscopic performance in vivo with performance measured in a laparoscopic simulator. Surg Endosc. 1999;13(11):1077-1081; discussion 1082.
14. Feldman LS, Sherman V, Fried GM. Using simulators to assess laparoscopic competence: ready for widespread use? Surgery. 2004;135(1):28-42.
15. Sherman V, Feldman LS, Stanbridge D, Kazmi R, Fried GM. Assessing the learning curve for the acquisition of laparoscopic skills on a virtual reality simulator. Surg Endosc. 2005;19(5):678-682.
16. Vassiliou M, Ghitulescu G, Feldman L et al (2006) The MISTELS program to measure technical skill in laparoscopic surgery: evidence for reliability. Surg Endosc 20:744–747
17. Cristancho SM, Moussa F, Dubrowski A. A framework-based approach to designing simulation-augmented surgical education and training programs. Am J Surg. Sep 2011;202(3):344-351.

18. Kolozsvari NO, Feldman LS, Vassiliou MC, Demyttenaere S, Hoover ML. Sim one, do one, teach one: considerations in designing training curricula for surgical simulation. J Surg Educ. Sep-Oct 2011;68(5):421-427.

19. Cannon-Bowers JA, Bowers C, Procci K. Optimizing learning in surgical simulations: guidelines from the science of learning and human performance. Surg Clin North Am. Jun 2010;90(3):583-603.

20. Palter VN, Grantcharov TP. Simulation in surgical education. Cmaj. Aug 10 2010;182(11):1191-1196.

2.5 Developing new tools for surgical education

2.5a Narrative – Observation of communication during live surgical cases and the development of a new tool to improve teaching during laparoscopic surgical cases

The development of new methods and tools for use during surgical training is critical to the advancement of the field and improving the education surgical trainees receive throughout their training. As there are no real guidelines for surgical education and curricula development, the design, study, and dissemination of study findings of novel tools aim to assist surgical educators in developing curricula specific to their surgical residency programs. Development of new surgical training tools and assessment metrics can be difficult, as it oftentimes involves conducting research in the live operating suite, which requires institutional ethics approval to allow intraoperative observation and evaluation and the introduction of newly-developed tools for training – not only with regards to the patient, but also with the surgical educator (often the lead surgeon), the trainees, and other staff members. However, trying new methods for surgical education and evaluating their utility cannot always be accomplished in the simulation lab.

The results of the focus groups study and the study that explored undergraduate clerkship experiences (described in sections 2.2 and 2.3, respectively) revealed that the nontechnical skill of communication (various types) pervaded nearly all of the themes brought about by the qualitative data. As such, because of the significant role communication plays in the surgical learning process, our team decided to conduct a study to observe and evaluate communication during live intraoperative teaching. We chose to focus on laparoscopic surgical teaching, as it is a form of minimally-invasive surgery that has a steep learning curve, requires a great deal of communication for its success, and is typically taught at all levels of residency and fellowship training, with graduated training based on PGY level. This study provided an account of how surgeons communicate during laparoscopic surgery within our institution. A background of the study, followed by its results and conclusions, will be described here. The findings of this observational study provided us with the idea of developing a new type of teaching tool that can be used during minimally-invasive surgery, with the overall goal of simplifying the communication process during intraoperative training. The development of this tool will be described in this section.

This research has been presented at several international conferences, and two of these references are as follows (additional research is currently being conducted on the new teaching tool, and a manuscript will be written once this research is completed):

Hoogenes J, Elias R, Kim S, Sonnadara R, Kim SK, Matsumoto ED. An exploration of communication between surgical instructors and trainees and the effect of standardized communication and a simulated on-screen frame of reference tool employed during urologic training. Society for Simulation in Healthcare, Vol 8(6), Dec. 2013, p. 541-542. (First Prize Student Paper, presented at the 2013 International Meeting for Simulation in Healthcare)

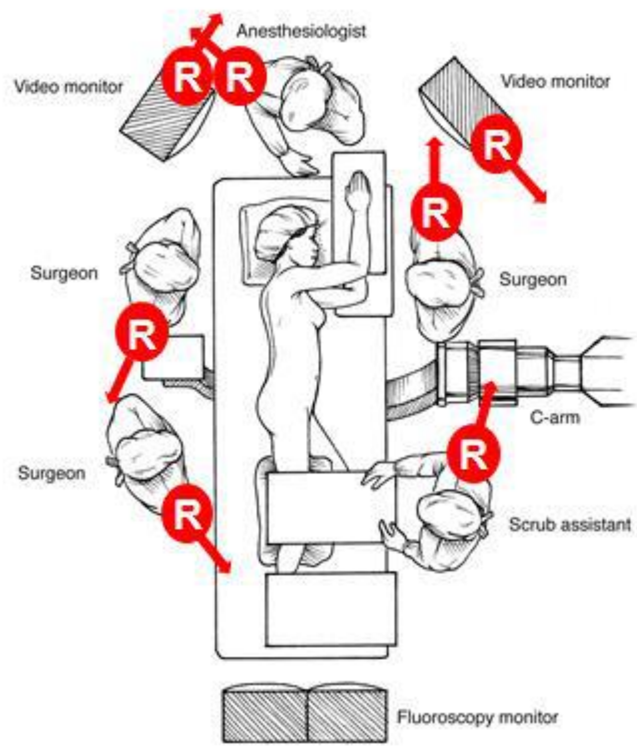
Hoogenes J, Elias R, Kim S, Shayegan B, Kim K, Piercey K, Kapoor A, Matsumoto ED. Utility of a novel on-screen overlay frame of reference system for orientation during intraoperative laparoscopic surgical education. J. Endourology 2015 Oct. 29(S1), p1-A457 (Presented at the 33rd World Congress of Endourology, 2015)

2.5b Communication issues unique to laparoscopic surgical teaching

As previously mentioned in this thesis, economic pressures, resident work hour restrictions, the complexity of surgical procedures (and the surgical environment), interruptions, unpredictability, elevated stress, physical challenges, scarce physical and personnel resources, and team communication issues are some of the barriers and challenges that can influence teaching and learning in the OR.[1-4] Surgeon teachers play vital roles in guiding the acquisition of knowledge, skills, and judgement of trainees in the OR[5], with the goal of preparing residents and fellows to achieve the required competencies set forth by governing agencies. Research has shown that clinical teachers rarely use the established teaching principles of encouraging dialogue, asking questions, and giving meaningful feedback.[5,6] As noted in the focus groups study in Section 2.2, surgical educators are not formally taught how to teach, and despite the fact that a large part of their job is to teach new surgeons, it is still unclear how they use communication techniques in the OR when teaching.[6]

Learning opportunities in the OR are frequently spontaneous and unorganized; and as a result, communication, which is a non-technical skill necessary for teaching, is often compromised. There is a steep learning curve associated with laparoscopic surgical techniques, making this type of surgery ideal for studying communication techniques. During laparoscopic surgery, effective communication between the instructor and trainee is vital to the success of the surgery, safety of the patient, patient outcomes, and to the learning process. Verbal communication is imperative during laparoscopic procedures since it is the primary mechanism the surgeon teacher has to convey instructions to the trainee. This differs in open surgery, where the instructor can directly demonstrate techniques, oftentimes by touching the open surgical field, which is not possible with the laparoscopic approach. Verbal communication is also frequently restricted by surgical masks worn during operations, and with laparoscopic surgery, communication between the instructor and trainee often relies heavily on pointing (primarily to the monitor) and verbal directing.

During a laparoscopic procedure, a common misunderstanding during surgeon-trainee communication relates to the spatial orientation of the targets.[7]Orientation typically differs with respect to the OR's endoscopic monitors and the patient, whereas the same image of the surgical site can be viewed from different vantage points with respect to the operative field (and most operating suites have multiple endoscopic screens). Part of the problem lays within the multiple frames of reference each individual (e.g., surgical instructor, trainee(s), nurses, anesthetist, etc.) hold. This is because the display space (screen) and workspace (surgical field) are separated; and as a result, individuals must perform mental rotations to match what they see on the screen to what they actually do at the site, mentally constructing a common frame of reference (see figures below for a graphical depiction of the different viewpoints individuals have during a laparoscopic case).



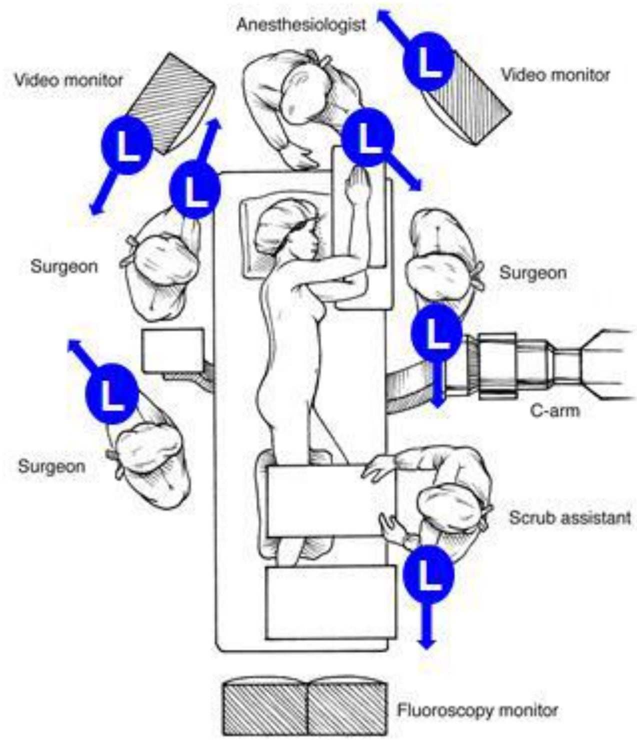


Figure: Multiple vantage points within the OR during a laparoscopic case

While performing laparoscopic procedures, especially when the trainee is at the beginning of the learning curve, this can create confusion and degradation of communication, which can actually lead to the attending surgeon taking over the case, either by portions or in its entirety, subsequently causing missed teaching opportunities. Misunderstandings slow procedures as the trainee has to double-check intentions and required actions, and the instructing surgeon may have to point to targets on the endoscopic screen with a finger or with the tip of an instrument directly in the operative field. Similar to navigation in the field of aviation[8], laparoscopic procedures involve more than one possible frame of reference: external (lateral, medial, etc.) and internal (left, right, etc.). Surgeons' vocabularies for frame of reference are often mixed as there is no standardisation. Several previous studies have assessed intraoperative teaching in terms of its learning environment, teaching behaviours, and trainees' experiences in a broad, general manner;[3,9-11] however, significant advancements in and increased utilisation with minimally invasive surgical approaches call for research that provides greater insight into both verbal and non-verbal communication. We set out to observe and qualitatively analyse the verbal and non-verbal teaching techniques that surgeons use to instruct trainees in the laparoscopic intraoperative setting.

2.5c Observation of laparoscopic teaching cases

Following the ethics approval process, we observed and videotaped twenty laparoscopic cases in the fields of urology and general surgery, as a large portion of cases conducted in these specialties are laparoscopic in nature, allowing us the most access to laparoscopic cases. Included in the sample were five different staff surgeons, fifteen residents, three fellows, and ten medical students, with a total of seven different types of surgical procedures (due to the nature of surgical rotations, some of the residents, fellows, and medical students overlapped during cases, but were never counted more than once with regard to the sample size). All participants were blinded to whether they were being videotaped, as only one in three were actually recorded. As an attempt to reduce multiple types of bias, we carried out every observation identically, regardless of whether it was actually being videotaped – we used a random number generator to choose which cases to record throughout the study, and kept a piece of black tape over the red “recording” light so that participants would not be able to discern whether the camcorder was actively recording. All videos were transcribed verbatim and thematically analysed by the study team using conventional qualitative content analysis. Handwritten notes were also taken during every case and were involved in the thematic analysis. Filming focused on the surgeons and trainees, surgical sites, and the endoscopic camera screens, never showing any of the patients’ identifying features, thereby maintaining their anonymity (each patient was prepped and draped in the same fashion, so there was no chance the face of a patient would be seen).

To avoid bias, analyses were carried out by non-clinician investigators. We reached conceptual saturation at fifteen cases, yet continued on to videotape a total of twenty cases to ensure that we had adequate data and that no new themes emerged. Our findings of the verbal communication used during teaching involved highly repetitive directional terms (e.g. “screen left/right”, “up/down”, “over”, “go back”, “lower/higher”, ”medial/distal/proximal”, “right angle”, ”superficial”). Trainees were often told to visualise a movement before it was completed. In addition to directional terminology, educators routinely quizzed trainees about anatomy and physiology related to the case, yet scarcely provided feedback. It is worth mentioning that the vast majority of the verbal communication was conducted by the surgical educator, and we noted that many of the trainees appeared intimidated to ask questions throughout procedures; however, this was more prevalent in junior resident trainees (PGY 1-3). These findings did not differ between cases. We also evaluated the non-verbal communication as observed on the videotapes. Techniques included the educator pointing to the screen, patient, and instruments (please see photo below for example); holding instruments to guide trainees' movements; displaying the type of hand and arm movement required of the task – this was done by the educator stepping out of the surgical field far enough to mimic the movement that was to be used with the surgical instrument; physically guiding a learner's hands; and at times taking over parts of a case or completely taking over the case (in which case the learner would end up either serving as a non-surgical assistant or as an observer). In all cases, we found that both verbal and non-verbal instructing was often found to be conducted concurrently (e.g., pointing while talking; displaying a hand movement while providing instruction, etc.).

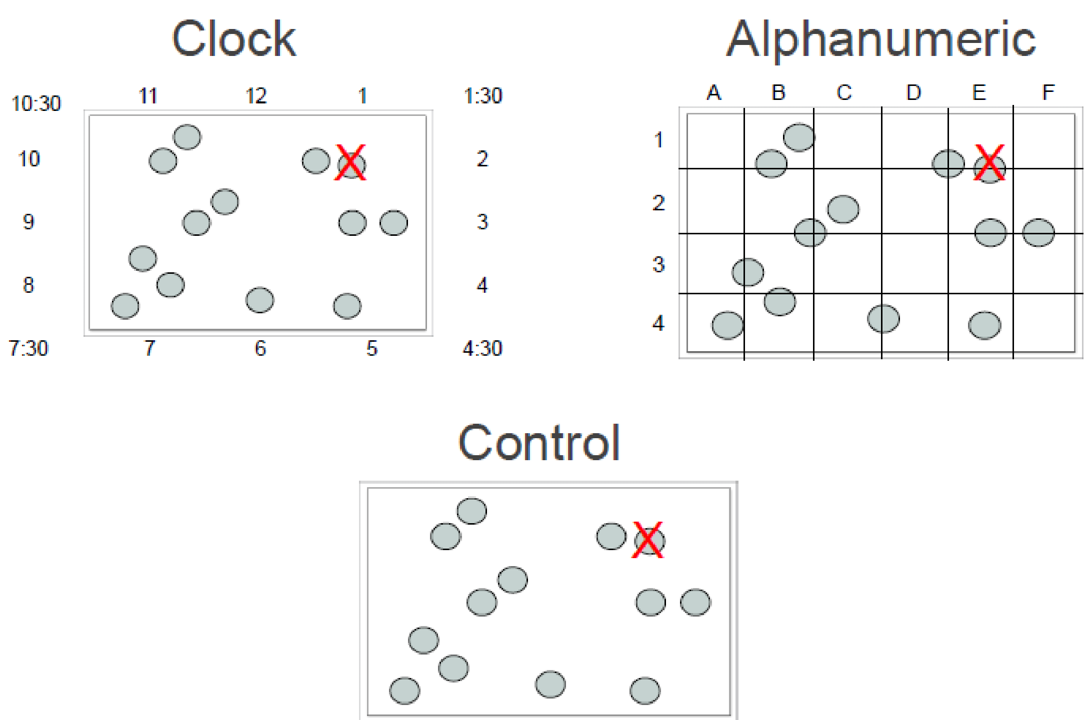
Surgical educator pointing to an endoscopic screen

2.5d Development and evaluation of an on-screen frame of reference tool for intraoperative laparoscopic teaching

Following our analysis of the observational study data, we set out to determine ways to improve the communication process during intraoperative laparoscopic teaching. We created two versions of a simulated on-screen directional system (screen: endoscopic camera video screen used in the OR for guidance during minimally invasive procedures): one with a clock design and x:y triangulation, and the other an alphanumeric coordinate grid. We created these using transparent overlays designed to cover the endoscopic video screens in laparoscopic OR suites. We decided to run a pilot study in a simulation lab using laparoscopic video trainers (figure below) prior to developing the study further for use in a live OR setting.

Laparoscopic video trainer used in the pilot study

We first developed a series of standardised verbal commands for each of the overlays. An example for the clock overlay included, “move to the 12:35 position”, and for the alphanumeric grid, “move to 2, C”. The figure below shows what the overlays looked like for the pilot study (the target is the “x”, so for example on the alphanumeric grid, the description for the target would be: “at the lower-right section of the ‘1, E’ quadrant, on the line between 1 and 2):



We recruited 63 medical students and randomised them into to three groups. At baseline, none of the participants had any laparoscopic simulation training. All subjects performed three trials of six simulated laparoscopic transfer tasks (moving a bean to six different pre-determined positions). Group 1 (control) performed tasks with no overlay or standardised communication. Group 2 performed tasks using the clock overlay, and Group 3 used the alphanumeric grid overlay. Groups 2 and 3 received standardised communication specific to their overlay. Urology and general surgery residents served as the instructors. Time to task completion and error scores were calculated (errors were based on incorrect placement during transfer).

Analyses showed that, between and within groups, Group 2 (clock) was significantly faster than both the Control Group and Group 3 (grid) (p<0.05) across all three trials.

Time to Completion (s)				
	Control	Clock	Grid	N
Trial I	86.6	69.7	92.0	21
Trial II	80.4	70.6	85.4	21
Trial III	71.0	56.4	68.4	21

Group 2 (clock) had fewer errors than the Control Group across trials 1 and 3 (p<0.05), but similar error scores to Group 3 (grid). Although Group 3 (grid) had similar time to task completion as the Control Group, Group 3 had significantly fewer errors (p<0.05).

Error Score (frequency)				
	Control	Clock	Grid	N
Trial I	1.43	0.94	0.68	21
Trial II	1.14	0.97	0.68	21
Trial III	0.81	0.26	0.23	21

The participants favoured the overlays, and found that the standardised communication scheme was easy to understand. With these data, we determined it was worth developing the overlays for the OR monitors and thus created a protocol to run the study during live laparoscopic teaching cases, observing in-person and videotaping for additional analysis, as we did for the observational communication study. We hypothesised that the overlays would improve intraoperative teaching and learning by decreasing the frequency of nonverbal communication such as gesturing and pointing, thus potentially making the learning process more efficient and result in fewer errors.

During the development of the endoscopic screen overlays, in addition to the alphanumeric grid overlay (Fig. 1 below) and the clock overlay (Fig. 2 below), we added a third type of overlay, which we called the “dartboard” style (Fig. 3 below). We worked with a graphic designer to develop the overlays and tested them in the OR to ensure that the gridlines didn’t obstruct the view, but could still be seen. The successful combination was black numbering and lettering with white gridlines. We briefed all surgeons on the study details and provided standardised instructions on how to use each overlay, and ensured that learners and others in the room were familiar with the study protocol. We obtained patient and participant consent (participants were the primary staff surgeon [instructor] and the resident or fellow assisting on the case). We videotaped consecutive laparoscopic cases in urology and general surgery, and conducted post-case interviews with all staff surgeons and trainees. Trainees also completed an exit survey on their experience being taught with the overlay in use. All cases were then transcribed verbatim and qualitatively analysed for common themes and teaching techniques. We arbitrarily chose to use the alphanumeric grid first, followed by the clock, and then the dartboard style. In an attempt to reduce bias, we utilised the same protocol as with the observational study where the participants were blinded as to whether the session was actually being recorded.

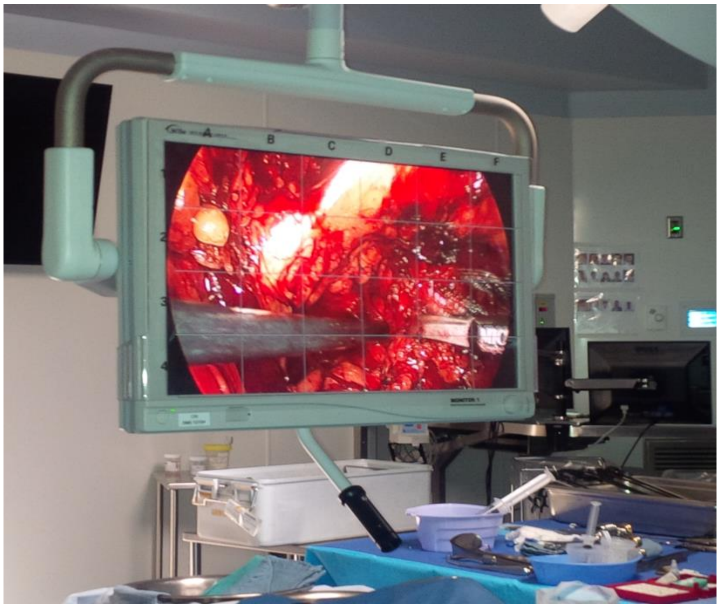


Figure 1. Alphanumeric grid overlay in the OR

Figure 2. Clock overlay in the OR

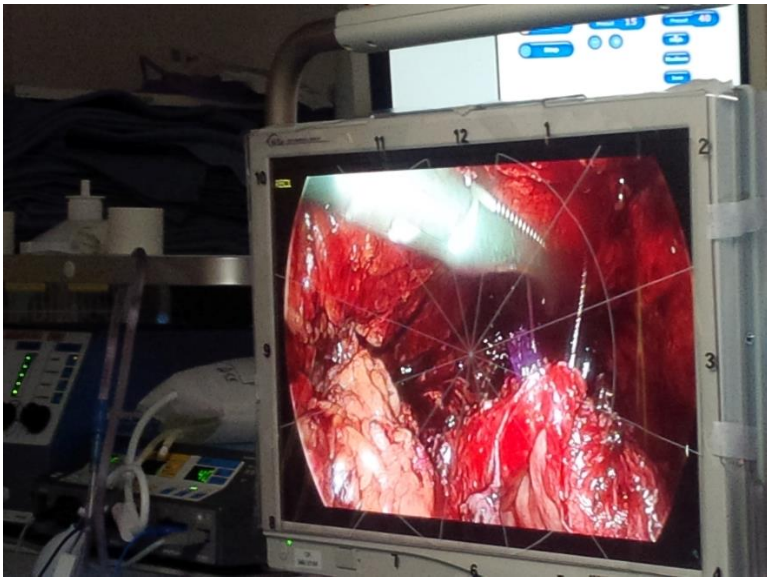


Figure 3. Dartboard overlay in the OR

We completed observations of 40 overlay cases: 30 alphanumeric, 7 clock, and 3 of the dartboard. During these cases, participants included 7 staff surgeons (instructors) from either urology or general surgery, with a total of 55 participants (learners): 12 PGY 1-3; 14 PGY 4-5; 4 fellows; and 18 medical students (in observer-only roles). The alphanumeric grid was found to be very precise, and participants felt that this format allowed the learner to move more quickly and directly to a target, which eliminated the need to point to the screen, being noted as extremely helpful in cases where there are no “free hands” for pointing. We also found that there was less uncertainty with the movements, with decisions being made more quickly, reducing the “second-guessing” of where the laparoscopic instrument(s) should go. We noted that fewer directional terms (e.g., “up”, “down”, “left”, “right”) were used when compared to our baseline observations without an overlay. Surgeons and trainees also stated that the grid overlay helped during the identification of anatomical structures and did not obstruct the view.

It was clear that the more junior the resident learner, the more frequently the staff used the alphanumeric grid. There were several cases with senior residents and fellows where the grid wasn't used at all, as their familiarity with the types of cases and the operative field precluded the use of the grid. Frequency of grid use also depended on the type of case; for example, cases with a smaller surface area where fewer movements were required used the grid less frequently. Although some non-verbal communication was still observed, they were used far fewer than with those cases we observed at baseline.

Neither the clock nor the dartboard overlay were found to be helpful – instead, they were both found to be a hindrance to the teaching process and at times were removed during the case. The clock overlay was found to be confusing by many of the staff and trainees, which contradicted our pilot study findings. The dartboard overlay was found to obstruct the endoscopic camera's view, and was removed immediately in each case due to patient safety (we tried it three times in different types of surgical cases and it obstructed the view for each type of case). As such, we stopped the use of the clock and dartboard overlays prior to reaching the target number of 30 cases for observation.

Overall, the results of this study showed that the alphanumeric grid with standardised commands improved the teaching and learning experience during urologic and general surgery laparoscopic surgical cases, especially for junior resident training. Surgical instructors were impressed by the simplicity of the alphanumeric grid design and its ease of use during teaching, especially with residents who were more inexperienced in a particular type of surgical case.

Residents overwhelmingly agreed that the alphanumeric grid allowed them to be more precise with where they moved the laparoscopic instruments, making the whole process more efficient. Residents also stated that they felt more confident in their ability to perform their part(s) of the cases, and found using the grid coordinates were helpful when asking directional questions. We are currently in the process of determining the best product to use to make the alphanumeric grid overlay sturdy enough to be re-used for multiple cases. It is currently printed on plastic that can cling to the screen, but it still requires adhesive to make it safe for use in the surgical theatre. We have discussed the possibility of creating a heads-up digital display, which will be further evaluated. We are currently conducting research using the alphanumeric grid for additional types of cases, and a manuscript will be written for publication following completion of the analyses.

2.5e Considerations regarding the observational communication and overlay development studies

The intraoperative teaching techniques observed during the observational study included the use of multiple non-technical skills such as multiple types of communication, motivation of the trainee, leadership, resource management in the OR, decision-making, teamwork, and situational awareness, and the provision of feedback, each of which have been found to play significant roles in surgeons' and trainees' overall performance during surgery.[12-14] Each of the themes that arose during the analysis of the observational communication study aligned with one or more competency roles that are designated in the CanMEDS framework and other frameworks such as the ACGME. The importance of the intraoperative instruction trainees receive is paramount when considering whether trainees will meet and/or exceed critical demonstrable competencies as they progress through training. A breakdown in one or more non-technical skills during surgical procedures can lead to medical errors, thereby compromising patient safety and outcomes while hindering the educational process. Thus far, the development, use, and evaluation of the alphanumeric overlay as a teaching tool for laparoscopic cases is promising, especially for teaching junior-level residents and other trainees learning a new surgical procedure. This overlay has the potential to improve efficiency of laparoscopic teaching cases and ultimately reduce the frequency of medical errors in the intraoperative teaching environment.

The role that non-technical skills play during surgical training and in the acquisition and performance of technical surgical skills is still poorly understood and is deserving of further study. A systematic review of the impact of non-technical skills on technical performance in surgery found just 28 reports of studies designed to assess the impact of surgeons' non-technical skills on technical skill performance in either the simulated surgical setting and/or the OR.[15] The majority of the studies in the review examined the impact of just one non-technical skill on technical performance. These were assessed by tools ranging from those with demonstrated reliability and validity to scales designed specifically for the study that had no validity evidence. The review showed that, indeed, failures in non-technical skills appear to be associated with a higher rate of technical errors.

Three major taxonomies have been developed to evaluate non-technical skills: the Non-Technical Skills for Surgeons (NOTSS) tool[16], the Oxford NOTECHS (Non-TECHnical Skills)[17], and the Observational Teamwork Assessment for Surgery (OTAS).[18] Each of these tools' constructs are related to aspects of the entire OR team and do not focus specifically on the surgeon or learner, but instead provide comprehensive information related to system-wide actions and teamwork-associated behaviors. These tools are primarily designed to evaluate entire surgical procedures and are not task-specific; and although they are not inherently feasible for quick evaluation of individual surgical skills, these tools may still have an important role in evaluating what occurs during teaching throughout an entire case. Despite the lack of valid, reliable, and feasible tools designed for evaluating distinctive non-technical skills and behaviours (e.g., motivation, feedback, communication) in the intraoperative setting, it is critical that the non-technical skills surgical educators use during the teaching process be considered when developing and/or revising surgical training curricula, especially as the new competency-based frameworks become integrated into training programs.

Our research team is encouraged by the findings of these studies, and we hope to integrate the alphanumeric overlay within our institution so that it may eventually become a mainstay of the curriculum for minimally-invasive surgical training, with the potential for initial use in simulated laparoscopic training, followed by eventual regular use in the OR. Although our results are limited to a small sample size within a single centre, additional research, perhaps via a multicentre study, may allow us to begin to generalise our findings, with the potential of the overlay to be included in curricula, especially with the development of an assessment component, which is a future objective of this research. Furthermore, the alphanumeric grid overlay concept has the potential to be transferred to other types of minimally-invasive surgical training, such as robotics and other surgical approaches that involve the use of screens for visual guidance, such as endoscopic and arthroscopic surgery.

2.5f References for sections 2.5a-2.5e

1. Ferguson C M. Mandatory resident work hour limitations. J Am Coll Surg, 2005, 200(4):637-638.
2. Greenfield LJ. Limiting resident duty hours, Am J Surg, 2003, 185(1):10-12.
3. Svensson MS, Luff P, & Heath C. Embedding instruction in practice: contingency and collaboration during surgical training. Sociol Health Illn, 2009, 31(6):889-906.
4. Wetzel CM, Kneebone RL, Woloshynowych M, et al. The effects of stress on surgical performance. Am J Surg, 2006, 191(1):5-10.
5. Blom EM, Verdaasdonk EG, Stassen LP, et al. Analysis of verbal communication during teaching in the operating room and the potential for surgical training. Surg Endosc, 2007, 21(9):1560-1566.
6. Claridge JA, Calland JF, Chandrasekhara V, et al. Comparing resident measurements to attending surgeon self-perceptions of surgical educators. Am J Surg, 2003, 185(4):323-327.
7. Lingard L, Reznick R, Espin S, Regehr, G. & DeVito I. Team communications in the operating room: talk patterns, sites of tension, and implications for novices, Acad Med, 2002, 77(3):232-237.
8. Moore A, Butt D, Ellis-Clarke J & Cartmill, J. Linguistic analysis of verbal and non-verbal communication in the operating room. ANZ J Surg, 2010; 80: 925-929.
9. Horwitz I, Horwitz SJ, Brandt ML, et al. Assessment of communication skills of surgical residents using the Social Skills Inventory. Am J Surg, 2007,194: 401-405.

10. Lingard L, Espin S, Whyte S, et al. Communication failures in the operating room: an observational classification of recurrent types and effects. Qual Saf Health Care. 2004;13(5):330-334.
11. Yule S, Flin R, Paterson-Brown S & Maran N. Non-technical skills for surgeons in the operating room: A review of the literature. Surgery, 2005, 139(2): 140-149.
12. Hull L, Arora S, Aggarwal R, Darzi A, Vincent C, Sevdalis N. The impact of nontechnical skills on technical performance in surgery: a systematic review. J Am Coll Surg. Feb 2012;214(2):214-230.
13. Sharma B, Mishra A, Aggarwal R, Grantcharov TP. Non-technical skills assessment in surgery. Surg Oncol. Sep 2010;20(3):169-177.
14. Beard JD, Marriott J, Purdie H, Crossley J. Assessing the surgical skills of trainees in the operating theatre: a prospective observational study of the methodology. Health Technol Assess. Jan 2011;15(1):i-xxi, 1-162.
15. Wetzel CM, Black SA, Hanna GB, et al. The effects of stress and coping on surgical performance during simulations. Ann Surg. Jan 2010;251(1):171-176.
16. Yule S, Flin R, Paterson-Brown S, Maran N, Rowley D. Development of a rating system for surgeons' non-technical skills. Med Educ. Nov 2006;40(11):1098-1104.
17. Sevdalis N, Davis R, Koutantji M, Undre S, Darzi A, Vincent CA. Reliability of a revised NOTECHS scale for use in surgical teams. Am J Surg. Aug 2008;196(2):184-190.
18. Hull L, Arora S, Kassab E, Kneebone R, Sevdalis N. Observational teamwork assessment for surgery: content validation and tool refinement. J Am Coll Surg. Feb 2011;212(2):234-243 e231-235.

2.5g Narrative – Development and evaluation of new tools for robotic surgical education and assessment (Published Work 7 and supplemental robotic surgical education research)

In addition to laparoscopic surgical education tools like the bladder model and the on-screen overlays, our research team has developed and evaluated a 3D-printed bench model for robotic surgical simulation training (based off of our original bladder model described in Published Work 6). Additionally, we have rigourously developed a competency assessment tool for evaluation of trainees as they learn how to perform a robotic-assisted radical prostatectomy (RARP), which is currently the most commonly performed robotic surgical procedure worldwide. Although some information on robotic simulation was provided in the simulation book chapter (Published Work 4), before describing these new tools and metrics, it is necessary to first provide a more thorough background of robotic surgical training to orient the reader to this relatively new type of minimally-invasive surgical approach.

Background of robotic surgical training

Robotic-assisted surgery has gained widespread popularity and adoption across multiple surgical disciplines worldwide, and is now currently used for facilitating complex surgical procedures with a minimally-invasive approach in cardiac, colorectal, general surgery, gynecologic, head and neck (otolaryngology), thoracic, and urologic surgery. Despite the widespread use of the da Vinci Robotic Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA), relatively little attention has been paid to robotic curricula and evaluation metrics for training.[1-9] With the trend of the increased use of robotic-assisted surgery comes the responsibility of training increasing numbers of residents, fellows, and established surgeons to perform robotic surgical cases.

Although brief (typically three-day) instructional workshops for new robotic surgeons exist in several centres operated by Intuitive Surgical, Inc., these courses are not a requirement to perform robotic surgery, and there are no guidelines for measurement of the proficiency of the trainees who complete these courses.[10]Despite a thorough search of the academic literature and commercially-available reports (from industry) there are no accessible data that describe the transferability of these simulated training sessions to the live OR setting. According to Intuitive Surgical, Inc.'s da Vinci website (www.davincisurgerycommunity.com), expert robotic surgeons will often serve as mentors and/or proctors for new robotic surgeons at different centres, typically at the new surgeon's own hospital. Although this is likely a beneficial option for new robotic surgeons as they progress through the learning curve, it is not always feasible and can be very costly. Without standardised training curricula and pre-determined benchmarks for progressing through training, assessment of robotic surgical skills is challenging, and to date has primarily been achieved only through informal intraoperative evaluation and postoperative patient outcomes. The use of robotic VR simulators and their sophisticated software may play a valuable role in the assessment of trainees as they prepare to transfer simulation-acquired skills to the OR.[1]

In an effort to develop and standardise a robotic curriculum that would include high-stakes testing for certification, in 2013, members of fourteen international surgical societies attended three consensus conferences to develop a Fundaments of Robotic Surgery (FRS) program.[10] This would be modeled closely on the Society of American Gastrointestinal and Endoscopic Surgeons' (SAGES) validated and widely utilized Fundamentals of Laparoscopy (FLS) program. As previously noted in this thesis, in 2004, the American College of Surgeons (ACS) made the FLS a minimum standard before a surgeon can be permitted to perform laparoscopic procedures independently[11], and it is now used worldwide for laparoscopic and endoscopic training and credentialing. These conferences took on a modified Delphi approach to determine the most effective means to develop a curriculum that would encompass the cognitive, psychomotor, and team training skills required to safely *operate* a surgical robotic system and perform the most basic skills necessary to safely perform *any* robotic surgery procedure.[10] Smith and colleagues (2014) reported that the first consensus conference resulted in a list of 25 outcome measures for pre-, intra- and post-operative skills. The second and third conferences focused on the development of the curriculum based on the outcome measures. The proposed curriculum would include cognitive (taught in a didactic format), psychomotor (taught via simulation and assessed via direct observation or VR simulator metrics), and team training skills (to teach pre-, intra-, and post-operative tasks that would be assessed via checklists). The authors recommend that this curriculum, once fully developed, should focus not on a time-based course but rather in a competency-based fashion until the student's learning curve has reached the benchmark values (as set by the program). This is similar to the CBD approach by the RCPSC. It is unclear when the FRS curriculum will be validated and made available, but it will likely provide a means by which to certify new robotic surgeons via high-stakes testing and evaluation.[10] Metrics developed for the FRS program will allow for evaluation of newly-certified robotic surgeons as they transfer their skills to the high-stakes OR environment. Until the FRS program is available, however, it is up to individual institutions to develop and implement their own robotic training curricula – and determine when trainees are deemed “competent” enough to practice robotic surgery independently.

Robotic simulation is becoming more prevalent with the advent, increased availability, and validation of robotic simulators. Despite multiple reports in the literature on validation of robotic simulators[12-18] there is still a paucity of research that describes the transfer of robotic surgical simulation skills to the OR setting. As with other types of surgical simulation, the use of robotic simulation can provide a risk-free environment for trainees to practice and acquire the technical skills necessary to proficiently perform live cases in the OR, especially with the available sophisticated VR robotic simulators that can be used in surgical skills labs. The most commonly used robotic simulators are the bench-top dV-Trainer (Mimic Technologies, Inc., Seattle, USA), and the da Vinci Surgical Skills Simulator (dVSSS) (Intuitive Surgical, Inc., Sunnyvale, CA, USA). The da Vinci robotic system itself can be used in a simulated dry lab format in an OR setting, using training tools designed by Intuitive Surgical, Inc. for the da Vinci platform.

The use of robotic-assisted surgery at McMaster University

With the more recent acquisition of the da Vinci Robotic Surgical System by multiple academic medical centres across Canada, it is expected that robotic surgery will increase significantly with time and will be used by multiple specialties, as it has in the United States for over 15 years. McMaster University acquired the da Vinci *Si* Surgical System® (the newest available model) in

2012 and has primarily been used for urologic procedures, with the most common being the robotic-assisted laparoscopic radical prostatectomy (RARP). To date, over 800 RARP cases have been performed between two urologic robotic surgeons. Over the past two years, thoracic surgeons have begun introducing robotic surgery into their practice, and the Divisions of General Surgery and Otolaryngology have plans to begin using the da Vinci within the next year.

McMaster University also has the da Vinci robotic dual-console arrangement in the OR, which allows for mentoring trainees during live operations. Additionally, McMaster has acquired the da Vinci Surgical Skills Simulator® (dVSSS), which is an apparatus that attaches to the secondary console, allowing it to become a VR simulator with three-dimensional viewing similar to the actual images through the robotic viewfinder. McMaster also owns the benchtop dV-Trainer VR robotic simulator located in the simulation lab. Both simulators use the identical VR software (Mimic, Inc.). Access to these simulators means that McMaster residency programs can include robotic simulation in their training curricula. However, to date, the simulators are not part of a formal curriculum and are used voluntarily by trainees at times suitable for their schedule. Incorporating these simulators into the residency programs would allow educators to evaluate trainees' proficiency of certain robotic skills as they move through the learning curve, thereby assessing their readiness to transfer these skills to the OR. The availability of both the da Vinci robot and the dVSSS allows us as researchers to conduct studies that will assist surgical educators with determining what content belongs in a robotic surgical skills curriculum, and how it should be implemented, especially with the timing of CBD. A primary concern is the evaluation of residents and fellows as they move through the learning curve. Given that the

RARP procedure is the most commonly performed robotic procedure, not just at McMaster but worldwide, our first focus, locally, on working towards evaluation measures for robotic training was to develop a step-wise assessment tool for intraoperative use with residents and fellows as they begin and progress through the RARP learning curve. Thus far, there has been nothing in the literature that describes any sort of consensus for how learners should be evaluated during RARP procedures. To our knowledge, this is the first study of its kind to be published, and the first assessment tool of its kind to be developed.

2.5h Published Work 7

Morris CM, Hoogenes J, Shayegan B, Matsumoto ED. Toward development and validation of an intraoperative assessment tool for robot-assisted radical prostatectomy training: Results of a Delphi study. Intl Braz J Urol. 43(x):2017 March 1[Ahead of print]. doi: 10.1590/S1677-5538.IBJU.2016.0420

Web link: ***https://www.ncbi.nlm.nih.gov/pubmed/28379668***

2.5i Critical Appraisal: Published Work 7

The use of a modified Delphi process with expert RARP surgeons to reach consensus of the major steps and sub-steps that comprise a RARP procedure allowed us to publish the first (to our knowledge) inventory of these steps. The paper has been published online ahead of print, as of March 1, 2017. Now that we have the inventory, we have begun the process of validating it for its use as an assessment tool (as described in the Discussion section of Published Work 7). Although this will be a lengthy process, validation of this as an assessment tool will allow for its use in new robotic curricula. As previously described, the FRS has been put forth as a generic robotic surgical curriculum that does not focus on any particular robotic procedure. With CBD, each of the expert working groups for specialties that utilise robotic surgery will be tasked with developing valid and reliable assessment tools that can be used for each of the robotic surgical procedures conducted within each specialty. This will be a monumental process moving forward to ensure competency milestones are valid; and with robotic surgery still in its infancy, there currently are no specific rating scales that have been validated for use to assess competencies. We believe our Delphi study is a step in the right direction for competency assessment, and can provide a template for gaining consensus among experts on how surgical procedures are completed via a step-wise approach. We believe the process of developing the inventory of steps and the eventual development of an assessment tool is transferable to other robotic and non-robotic surgical procedures, one that can be employed as CBD is rolled out in Canadian residency programs, and for other competency-based curricula.

2.5j Additional robotic surgical education research

The availability of our robotic simulators has afforded us the opportunity to conduct experiments to better learn how trainees at all levels of training acquire robotic surgical skills. Our research team set out to perform a study that would compare the dVSSS with the dV-Trainer and determine whether skills acquired on one transferred better than the other to a simulated task in the robotic surgical OR setting. This paper has been presented at the 34th World Congress of Endourology in November, 2016 in Cape Town, South Africa. It has been published in abstract form, yet has not been submitted for publication in any journals. I felt that in order to describe further research related to robotic surgical education and simulation and its transfer to the OR, this study should be included in the thesis. The citation is as follows, and the study description will follow:

J. Hoogenes, N.C. Wong, B. Al-Harbi, K. Kim, S. Vij, E. Bolognone, B. Shayegan, M. Quantz, E.D. Matsumoto. Robotic surgical skill acquisition in trainees: a randomized comparison of two robotic trainers and trainees' skills transfer to a 3D printed simulated surgical task in the operating room. J Endourology, Volume 30, Suppl 2, Nov.2016, DOI: 10.1089/end.2016.29020.abstracts

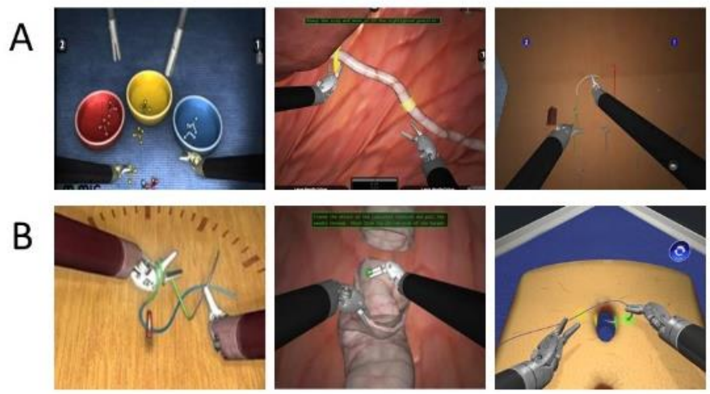
As previously noted, the two most cited virtual reality (VR) robotic simulators for the daVinci Surgical System currently available are the dV-Trainer (dV-T) (Mimic Technologies, Inc., Seattle, WA) and the da Vinci Surgical Skills Simulator (dVSSS).[19,20] The dV-T is a portable tabletop simulator that uses similar foot pedals and hand controls as the da Vinci console. The dVSSS is a simulator software package integrated into the da Vinci console and three-dimensional (3D) display. Despite the differences in their hardware, both simulators use the same VR software and scoring algorithms for objective performance metrics, making the two simulators comparable. Both have been shown to possess good content and construct validity, and can be used for assessing surgeon proficiency and robotic skills training with self-assessment feedback.[21-24] However, minimal research has been conducted to assess the proficiency of robotic simulation-acquired skills when transferred to the OR. A recent systematic review of 38 studies concluded that there is an urgent need for large, well-designed RCTs to study the efficacy of VR simulation for the acquisition of technical skills to improve competency and safe execution of robotic surgery.[21]

A better understanding of how surgical skills acquired on simulators transfer to robotic practice will allow surgical educators to develop curricula that can be integrated into residency programs and guide the assessment of learners' competency with specific surgical skills. To study this, we developed a training curriculum using the dV-T and dVSSS. We randomised trainees to each simulator to compare how well skills obtained on the assigned simulator transfer to performing a urethrovesical anastomosis (UVA) on a novel 3D printed bladder model using the da Vinci robot in the OR (the UVA procedure was described in Published Work 6).

McMaster University medical students (at the clerkship level), surgical residents, and surgical fellows were recruited via email sent by program directors for the medical school and for multiple surgical subspecialties: urology, general surgery, obstetrics and gynecology, otolaryngology, thoracic surgery, and vascular surgery (these specialties were chosen based on their use of minimally-invasive surgical procedures). Participants were separated into two groups based on their level of training; Group 1 (G1) consisted of junior trainees (medical students and junior residents [PGY1-2]), and Group 2 (G2) included experienced trainees (senior residents [PGY3-5] and fellows). Using 1:1 block randomisation, participants were allocated to either the dV-T or the dVSSS training and assigned a unique identification number for blinding purposes. After informed consent was obtained, participants completed a pre-training baseline questionnaire on previous simulator and OR experience. We aimed to recruit ten participants for each level of training, with distribution as equal as possible to the assigned simulator. Our intended sample size was 30 participants, where simulator scores between levels of training would range from 65% (novice) and 85% (advanced-expert). Considering a 2-sided test at the 5% significance level ($\alpha = 0.05$), a sample size of at least 5 participants per group per level of training were needed to achieve 80% statistical power ($\beta = 0.2$). We intended to oversample to account for potential loss to follow-up between the simulator and OR sessions and to account for any increased variability.

Simulator tasks

Before the study began, participants were emailed a link to an online tutorial to familiarise them with the basic components and controls of the da Vinci robot. Participants in both groups completed the identical VR curriculum, as follows: warm-up exercises with “Pick and Place” and “Ring Walk 1”, followed by 3 attempts each of simulator tasks “Thread the Rings 1”, “Knot the Ring 1/Vertical Defect Suturing 1”, and “Tubes 1” (see figure below):

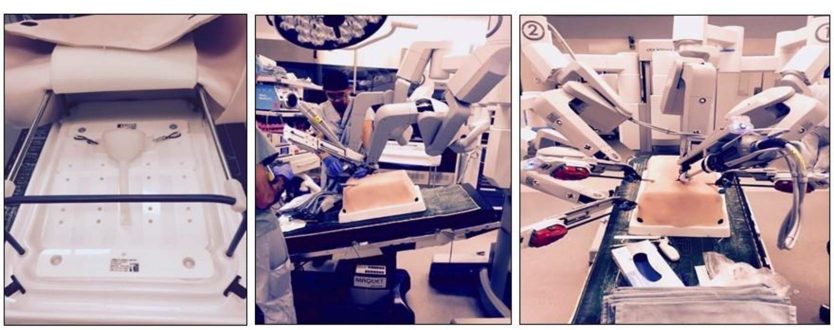


Curriculum development was optimized using input from three robotic surgeons at our centre for face validity. The initial warm-up exercises were designed to familiarise the user to the simulator and its controls. The simulator tasks comprise the specific steps and skills required to perform a UVA.[19,25] Task order was designed to be progressively more difficult. As “Knot the Ring 1” is exclusive to the dV-T, its equivalent exercise on the dVSSS, “Vertical Defect Suturing 1” was used. Each participant had his or her unique time slot in order to avoid contamination. The simulators have built-in metrics that provide an overall score and scores for each component of the task (e.g., time to completion). Participants’ scores were saved on their designated simulator and downloaded for analysis purposes.

Simulated UVA task with the da Vinci robot

All participants were scheduled for the UVA task within three weeks following their simulator session to ensure knowledge retention. Participants were sent a link to an *in vivo* UVA video to provide an example of the procedure they would be replicating during the simulated task. They were also sent a link to a video of one of our robotic surgeons performing a simulated UVA on a 3D-printed bladder model in the OR. Our novel 3D-printed model was developed through an iterative process, based on a silicone model developed and used in our previous research (Published Work 6).[25]The current model was developed using computer-aided design software with rapid prototyping using a Lulzbot Taz 4 3D printer (Loveland, Colorado). The model is composed of a unique polymer with characteristics similar to the human bladder and urethra with regards to size and handling for incising and cutting, needle penetration, and suture pull-through.

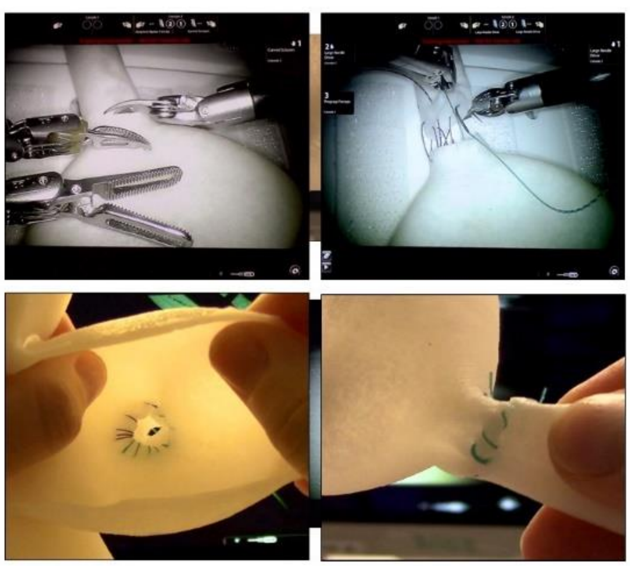
During the UVA task, the da Vinci training instruments were affixed and docked to a realistic silicone torso, simulating the human pelvis, with the bladder model fastened within the torso to obtain the similar view and mechanics as a RARP (see figure below):



Each session was videotaped via the endoscopic camera and separately on the OR monitor for backup. Following completion of the task, participants completed an exit questionnaire about their experience with the simulator, the UVA task, and the model itself.

Primary outcomes and evaluation

The primary outcomes for this study were the cumulative scores on the validated Global Evaluative Assessment of Robotic Skills (GEARS)[26](adapted from the previously described GOALS tool for basic laparoscopic assessment), the Robotic Anastomosis Competence Evaluation (RACE)[27](a new assessment tool specifically for evaluating intraoperative robotic UVA performance), time to task completion, and overall simulator score. Ratings were conducted by three expert urologic robotic surgeons at our centre. Raters were blinded to participant, level of training, and simulator allocation, and ratings were based on the videotapes of each participant's UVA task and final product (see figure below):



The GEARS rating tool consists of a 5-point anchored Likert scale across six domains that deconstruct the fundamental elements of robotic surgical procedures.[26]The overall score (out of 30) is obtained by summing the ratings in each domain. The RACE tool is scored identically to the GEARS tool.

Analysis

Descriptive statistics were performed for demographic data, and overall GEARS and RACE scores were compared within groups (Kruskal-Wallace analysis of variance) and between groups (Mann-Whitney U test). The intraclass correlation coefficient (ICC) was calculated for inter-rater reliability (IBM Statistics, SPSS v23®).

Results

Thirty-nine participants were recruited and randomised with no loss to follow-up. Demographic variables are displayed in Table 1. Residents were from multiple surgical specialties, with the majority (16) being from urology. At baseline, participants in G2 had significantly more laparoscopic simulation, robotic simulation, laparoscopic OR, and robotic OR experience compared to G1 ($p < 0.05$).

Table 1. Demographics

Variable	Value	
No.	33	
Mean age	28.0 ± 4.5	
Sex	23 M, 16 F	
Level of training	MS (10)	
	JR (16)	R1=8
		R2=5
		R3= 3
	SR (13)	R4=7
		R5=3
		R6=3
Previous laparoscopic experience (yes)	MS	2/10
	JR	13/16
	SR	12/13
Previous robotic experience (yes)	MS	0/10
	JR	2/16
	SR	9/13

RACE ICC = 0.864 [95% CI = 0.742 - 0.933] [F (26, 52) = 7.339, p<.001] High reliability

GEARS ICC = 0.845 [95% CI = 0.706 - 0.924] (F (26, 52) = 6.444, p<.001] High reliability

The “Thread the Rings” and “Tubes” simulator task results are shown in Tables 2 and 3, respectively.

Table 2. "Thread the rings" scores and time comparing dV-Trainer to dVSSS

Thread		Score (-/100)	p-value	Time (sec)	p-value
MS	dV-T	42.2		303.4	
	dVSSS	62.8	0.10	235.0	0.22
JR	dV-T	54.9		236.8	
	dVSSS	63.7	0.36	281.4	0.40
SR	dV-T	71.0		249.0	
	dVSSS	83.8	0.23	130.0	0.24

RACE ICC = 0.864 [95% CI = 0.742 - 0.933]
[F (26, 52) = 7.339, p<.001] High reliability

GEARS ICC = 0.845 [95% CI = 0.706 - 0.924]
(F (26, 52) = 6.444, p<.001] High reliability

Table 3. "Tubes" scores and time comparing dV-Trainer to dVSSS

Tubes		Score (-/100)	p-value	Time (sec)	p-value
MS	dV-T	21		682.2	
	dVSSS	47.8	**0.03**	386.8	0.07
JR	dV-T	10.4		808.9	
	dVSSS	60.1	**<0.01**	311.7	**<0.01**
SR	dV-T	44.6		292.0	
	dVSSS	73.4	**0.02**	207.0	0.10

RACE ICC = 0.864 [95% CI = 0.742 - 0.933]
[F (26, 52) = 7.339, *p*<.001] High reliability

GEARS ICC = 0.845 [95% CI = 0.706 - 0.924]
(F (26, 52) = 6.444, *p*<.001] High reliability

Results of the GEARS and RACE scores by level of training and simulator used are displayed in Table 4.

Table 4. GEARS and RACE scores for final UVA task on the 3-D printed bladder model in the OR comparing dV-Trainer to dVSSS

		GEARS (-/30)	p-value	RACE (-/30)	p-value
MS	dV-T	19.4		19.1±5.4	
	dVSSS	21.3	0.33	22.5±4.2	0.05
JR	dV-T	16.1		16.2±5.4	
	dVSSS	21.9	**<0.01**	22.5±5.3	**<0.01**
SR	dV-T	25.1		26.3±3.7	
	dVSSS	22.0	0.14	24.22±2.1	0.15

RACE ICC = 0.864 [95% CI = 0.742 - 0.933]
[F (26, 52) = 7.339, $p<.001$] High reliability

GEARS ICC = 0.845 [95% CI = 0.706 - 0.924]
(F (26, 52) = 6.444, $p<.001$] High reliability

Intraclass correlation coefficients for the GEARS and RACE scoring were 0.845 [95% CI = 0.706 - 0.924] [F (26, 52) = 6.444 p<0.001] and 0.864 [95% CI = 0.742 - 0.933] [F (26, 52) =7.339, p<0.001], respectively, demonstrating high interrater reliability. The exit questionnaire results showed that participants in both groups similarly reported that their respective simulators were useful in familiarizing themselves with the da Vinci robot controls, basic robotic skills, and the UVA task. However, those who were trained in the dVSSS group reported that their simulator provided a significantly greater realistic representation of the da Vinci robot (3.8 vs. 2.9, *p*=0.04).

Discussion of the robotic simulation study

We created a VR curriculum for the dV-T and dVSSS designed to teach trainees the steps to successful performance of a UVA, similar to that performed during a RARP. The UVA is considered a difficult RARP step[28] and requires robotic surgical techniques similar to other robotic procedures. It was therefore selected to explore how well training on the dV-T and dVSSS may transfer to a robotic surgical task in the OR.

Our curriculum used a stepwise approach with increasing difficulty that assumed minimal experience from the trainee, similar to a procedure-specific simulated UVA reported by Setty et al.[29] The first step was to orientate trainees to the da Vinci robot console and controls. Basic introduction to the EndoWrist® function, 3D vision, and pedal control was done via watching online videos and practicing with the warm-up exercises “Pick and Place” and “Ring Walk 1”. Success of performing a UVA requires mastery of needle handling at various angles, basic linear suturing, and knot tying, which was introduced with tasks “Thread the Rings 1” and “Knot the Ring 1/Vertical Defect Suturing 1”.[19] Finally, more advanced robotic suturing was taught with the use of “Tubes 1”. Trainees then used skills learned from the simulated exercises to perform an end to end anastomosis in a similar fashion as a UVA during a RARP. Use of the “Tubes 1” exercise has previously been shown to provide objective metrics that successfully determined proficiency with the da Vinci in the OR.[24]

All participants reported that the curriculum was useful in familiarising themselves with the da Vinci robot controls, basic robotic skills, and the UVA task. Although reported usefulness was statistically similar between groups, those in the dVSSS group reported that it provided a more realistic representation of the da Vinci robot. This is consistent with a comparison that validated the face and content validity of both VR trainers, which also showed that the dVSSS had a significantly higher face validity rating.[24] However, this increase in fidelity and realistic representation of simulation come with certain trade-offs. As a simulator software package integrated into the da Vinci robot, the dVSSS requires use of the actual robotics console, whose access may be limited as it may only be available after-hours in the OR, and that depends on whether the institution has the dVSSS. Conversely, although associated with lower fidelity, the dV-T is a stand-alone platform often located in easily accessible simulation labs.

It is intuitive that the more realistic representation and increased fidelity of the dVSSS may be the reason why it was shown to be superior to the dV-T. However, we showed that the benefits of training with the dVSSS over the dV-T appear to be only significant among junior trainees. In the senior trainee cohort, there was no significant difference between training on either simulator, based on the final UVA task scores. Senior trainees had significantly more previous robotic OR experience than their junior counterparts, therefore the familiarity with the da Vinci robot in the clinical setting may have minimized any benefit of the dVSSS in terms of the incremental improvement in fidelity over the dV-T.

A recent study concluded that practicing on the dVSSS was comparable to the standard da Vinci robot and both can be beneficial to residents in improving surgical skills.[30] An additional study of robotics-naïve participants concluded that dV-T curricula was comparable to training on the da Vinci robot in performing dry lab daVinci tasks.[31] Our study showed similar results, but offered stratification by level of training. Our findings support that the fidelity of the simulator ought to be targeted to the level of the trainee. The more realistic representation of the ergonomics interface of the dVSSS may have allowed for easier transfer of skills to the da Vinci robot. This is supported by our finding that GEARS and RACE scores of junior trainees that used the dVSSS were similar to those of the senior trainees, regardless of the simulator used in training.

We also evaluated the utility of the GEARS and RACE assessment tools previously used in other studies.[25,26,32] Performance of robotic simulated skills during fundamental inanimate robotic skills tasks and dVSSS tasks have been shown to be positively associated with clinical robotic surgical performances during RARP.[32] In our study, both tools were able to distinguish junior trainees from their senior counterparts. The blinded evaluation of the UVA task showed high interrater reliability for both GEARS and RACE tools, providing further evidence of their ability to provide consistent results, making them ideal for evaluation during robotic training.

One of our limitations is that the sample size restricted our ability to draw further conclusions on the specific impact of each simulator platform on each individual level of trainee. Further, we were unable to include a control group, as our sampling frame was not large enough. The benefits of a 5-week VR simulation curriculum over no simulation using the dVSSS has been shown to improve scores when suturing on a vaginal cuff model with the da Vinci robot.[33] Further research with a larger sample size will allow for additional evaluation of the effect of VR simulation training on the transfer of skills to a robotic UVA task.

This study was also limited to evaluation of a UVA, as the 3D printed model cannot replicate the multiple physiological factors experienced during an *in vivo* UVA. Validity of the study is increased, however, by the fact that all bladder models were identical and that our study can be replicated. While our previous bladder model has been demonstrated to be comparable to live animal models (Published Work 6)[25], further investigation is required to validate this new model. As previously described in Published Work 7, the UVA is also only one of many steps in performing a RARP. Although simulation allows us to deconstruct complicated procedures into more easily understood discrete tasks, a future challenge is to develop simulation (VR and/or bench models) that would include each of the critical steps to teach a complete procedure.[34] Although many generic skills simulator tasks have been created, only a limited number of procedure-specific models are available, and the VR models are costly.[34] Further studies are warranted to investigate training curricula and VR simulators for skills transfer to other RARP steps, as well as other robot-assisted surgical procedures. In summary, we found that, compared to the dV-T, the dVSSS training led to superior scores in performing the UVA task in junior, but not senior, trainees, possibly due to the higher fidelity of the dVSSS. Although both VR simulators allowed trainees to acquire robotic surgical skills that transferred to the da Vinci, for certain variables in our study, the dVSSS was superior to the dV-T. The dVSSS is a useful tool that can be used by surgical educators to enhance robotic surgical curricula in a safe and effective manner, especially when training less experienced surgical trainees. The use of a 3D-printed UVA model is promising and participants' feedback suggests potential face and content validity; and although future research on the model used in this study is required, it paves the way for the development of new 3D-printed models to train specific robotic surgical skills.

Recently (July 2017) a "techniques" paper that describes the development and use of the novel 3D-printed bladder model was published in the Canadian Urological Association Journal. The citation is as follows (the paper follows this citation):

Wong NC, Hoogenes J, Guo Y, Quantz MA, and Matsumoto ED. Techniques: Utility of a 3D printed bladder model for teaching minimally invasive urethrovesical anastomosis. Can Urol Assoc J 2017;11(7), E321-1.

Web link: ***https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5519395/***

It is also important to note that our 3D-printed bladder model has been face and construct validated for laparoscopic surgical simulation use. The following abstract was accepted for presentation at the World Congress of Endourology in September of 2017 in Vancouver, BC, Canada:

MP5-12 - Development and validation of a 3D-printed bladder model for laparoscopic simulated urethrovesical anastomosis training for radical prostatectomy. Guo Y, Hoogenes J, Wong NC, Quantz MA, and Matsumoto ED.

Web link:

https://www.eventscribe.com/2017/wce2017/searchbypresentation.asp?goToLetter=D&h=Browse%20By%20Title

2.5k References for section 2.5g-2.5k

1. Lee JY, Mucksavage P, Kerbl DC, Huynh VB, Etafy M, McDougall EM. Validation study of a virtual reality robotic simulator--role as an assessment tool? *J Urol.* 2012;187(3):998-1002.
2. Xylinas E, Poussard G, Durand X, de la Taille A. Robot-assisted extraperitoneal laparoscopic radical prostatectomy : A review of the current literature. Urol Onc : Article in press.
3. Lee JY, Mucksavage P, Sundaram CP, McDougall EM. Best practices for robotic surgery training and credentialing. J Urol 2011; 185(4):1191-1197.
4. Rashid HH, Leung YY, Rashid MJ, Oleyourryk G, Valvo JR and Eichel L: Robotic surgical education: a systematic approach to training urology residents to perform robotic-assisted laparoscopic radical prostatectomy. Urology. 68: 75-9, 2006.
5. Brinkman WM, Luursema J, Kengen B, et al. daVinci Skills Simulator for assessing learning curve and criterion-based training of robotic skills. J Urol 2013
6. Lerner MA, Ayalew M, Peine WJ and Sundaram CP: Does training on a virtual reality robotic simulator improve performance on the da Vinci surgical system? J Endourol. 24: 467-72, 2010.
7. Wittig K, Finnegan KT, Meraney AM, Shichman SJ. Mentored vs. non-mentored robotic simulator training. *J Urol.* 2012;187(4S):e609.
8. Dulan G, Rege RV, Hogg DC, et al. Developing a comprehensive, proficiency-based training program for robotic surgery. *Surgery.* Sep 2012;152(3):477-488.
9. Sweet RM, Hananel D and Lawrenz F: A unified approach to validation, reliability, and education study design for surgical technical skills training. Arch Surg. 145: 197-201, 2010.

10. Smith R, Patel V, Satava R. Fundamentals of robotic surgery: a course of basic robotic surgery skills based upon a 14-society consensus template of outcomes measures and curriculum development. *Int J Med Robot.* 2014;10(3):379-384.

11. Peters JH, Fried GM, Swanstrom LL, et al. Development and validation of a comprehensive program of education and assessment of the basic fundamentals of laparoscopic surgery. Surgery. 2004;135(1):21-27.

12. Kenney PA, Wszolek MF, Gould J, Libertino JA, Molnzadeh A. Face, content, and construct validity of dV-Trainer, a novel virtual reality simulator for robotic surgery. Urology 2009; 73: 1288-1292.

13. Lee JY, Mucksavage P, Kerbl DC, et al. Validation study of a virtual reality robotic simulator-role as an assessment tool. J Urol 2012; 187(3):998-1002.

14. Miller GE. The assessment of clinical skills/competence/performance. *Acad Med.* Sep 1990;65(9 Suppl):S63-67.

15. Hung AJ, Zehnder P, Patil MB, et al. Face, content and construct validity of a novel robotic surgery simulator. J Urol 2011; 186:1019-1024.

16. Hung AJ, Patil MB, Zehnder P, et al. Concurrent and predictive validation of a novel robotic surgery simulator: a prospective, randomised study. J Urol 2011; 187:630-637.

17. Liss MA, Abdelshehid C, Quach S, et al. Validation, correlation, and comparison of the da Vinci trainer and the daVinci surgical skills simulator using the Mimic software for urologic robotic surgical education. *J Endourol.* Dec 2012;26(12):1629-1634.

18. Abboudi H, Khan MS, Aboumarzouk O, et al. Current status of validation for robotic surgery simulators - a systematic review. *BJU Int.* Feb 2012;111(2):194-205.

19. Datta V, Chang A, Mackay S, et al. The relationship between motion analysis and surgical technical assessments. Am J Surg. Jul 2002;184(1):70-73.
20. Bric JD, Lumbard DC, Frelich MJ, et al. Current state of virtual reality simulation in robotic surgery training: a review. *Surg Endosc*. 2016;30(6):2169-2178.
21. Moglia A, Ferrari V, Morelli L, et al. A Systematic Review of Virtual Reality Simulators for Robot-assisted Surgery. *Eur Urol*. 2016;69(6):1065-1080.
22. Kelly DC, Margules AC, Kundavaram CR, et al. Face, content, and construct validation of the da Vinci Skills Simulator. *Urology*. 2012;79:1068-1072.
23. Kenney PA, Wszolek MF, Gould JJ, et al. Face, content, and construct validity of dV-trainer, a novel virtual reality simulator for robotic surgery. *Urology*. 2009;73:1288-1292.
24. Liss MA, Abdelshehid C, Quach S, et al. Validation, correlation, and comparison of the da Vinci Trainer and the da Vinci Surgical Skills Simulator using the Mimic Software for urologic robotic surgical education. *J Endourol* Dec 2012; 26(12):1629-1634.
25. Sabbagh R, Chatterjee S, Chawla A, et al. Transfer of laparoscopic radical prostatectomy skills from bench model to animal model: a prospective, single-blind, randomized, controlled study. *J Urol* 2012; 187(5):1861-6.
26. Goh AC, Goldfarb DW, Sander JC, et al. Global evaluative assessment of robotic skills: validation of a clinical assessment tool to measure robotic surgical skills. *J Urol*. Jan 2012;187(1):247-252.
27. Raza SJ, Field E, Jay C, et al. Surgical competency for urethrovesical anastomosis during robot-assisted radical prostatectomy: development and validation of the robotic anastomosis competency evaluation. *Urology*. 2015;85(1):27-32.

28. Tyritzis SI, Katafigiotis I, Constantinides CA. All you need to know about urethrovesical anastomotic urinary leakage following radical prostatectomy. *J Urol* 2012;188(2):369-376.

29. Setty Y, Salzman O. A methodological, task-based approach to procedure-specific simulations training. *Int J Comput Assist Radiol Surg*. 2016;11(12):2317-2324.

30. Brown K, Mosley N, Tierney J. Battle of the bots: a comparison of the standard da Vinci and the da Vinci Surgical Skills Simulator in surgical skills acquisition. *J Robot Surg*. April 2015;193(4):e269

31. Whitehurst SV, Lockrow EG, Lendvay TS, et al. Comparison of two simulation systems to support robotic-assisted surgical training: a pilot study (swine model). *J Minim Invasive Gynecol*. 2015;22(3):483-488.

32. Aghazadeh MA, Mercado MA, Pan MM, et al. Performance of robotic simulated skills tasks is positively associated with clinical robotic surgical performance. *BJU Int*. 2016;118(3):475-481.

33. Kiely DJ, Gotlieb WH, Lau S, et al. Virtual reality robotic surgery simulation curriculum to teach robotic suturing: a randomized controlled trial. *J Robot Surg*. 2015;9(3):179-186.

34. Harris KA, Frank JR. Competence by Design: Reshaping Canadian Medical Education. Canada: The Royal College of Physicians and Surgeons of Canada; 2014.

2.6 Designing new curricula and approaches for surgical training

2.6a Narrative

As previously discussed in this thesis, incorporating surgical simulation into a residency program is a challenging endeavour, and there exists no "guidebook" on how to successfully integrate simulation within existing surgical curricula. Although there has been discussion about the importance of doing so, it will indeed take time for surgical specialty-specific oversight committees and professional organizations to develop and publish a simulation curriculum that can be adopted by residency program developers. Until that time, it is worthwhile to develop, implement, and evaluate simulation curricula within willing (and able, as simulation equipment can be cost-prohibitive) residency programs, with the ultimate goals of disseminating the findings, addressing any challenges to make improvements, and potentially integrating it into a program's formal curriculum. Published Work 8 describes a study we conducted to test a new approach to teaching surgical skills via simulation within an existing residency curriculum, which we called "student-led learning". This novel approach was developed to qualitatively compare student-driven learning in a simulation teaching environment (which would be similar to how CBD will work) and compare it to the traditional time-based instructional format.

2.6b Published Work 8

Hoogenes J, Mironova P, Safir O, McQueen SA, Abdelbary H, Drexler M, Nousiainen M, Ferguson P, Kraemer W, Alman B, Reznick R, Sonnadara R, et al. Student-led learning: a new teaching paradigm for surgical skills. Am J Surg. 2015. 209: 107-14.2

Web link: ***https://www.ncbi.nlm.nih.gov/pubmed/25454965***

2.6c Critical Appraisal: Published Work 8

As described in Published Work 5, the increasing popularity and availability of surgical skills laboratories, oftentimes allowing for 24/7 access to all surgical trainees and staff, including medical students in their clerkship year, has brought about more self-guided, or independent, learning. We have coined this "student-led learning", or SLL (the opposite of traditional, instructor-led learning, or, as referred to in the paper as "IL"). The theoretical constructs noted in Published Work 4 align well with the types of training students may utilise on their own time in skills labs, especially with deliberate practice as they move through the learning curve of a given surgical task.[1] While it is agreed that formal skills lab courses are a critical component of simulation-based learning, especially due to the component of feedback[2], SLL is focused more on *what* learners do on their own time and *how* they use this time while in the skills lab – particularly, how they take the information learned from formal instruction (didactic and hands-on training) and then practice alone or with others. Understanding how trainees learn surgical skills on their own time via simulation will be an important consideration as competency-based frameworks become integrated into surgical residency programs.

Published Work 8 was a continuation of research work conducted within the Department of Surgery's Division of Orthopaedics at the University of Toronto, which has been described in detail in three previous papers.[3-5] The curriculum developers created an innovative competency-based pilot program that ran parallel to the traditional curriculum for a select number of first-year orthopaedic residents.[6] Half of the residents were allocated to the student-led (SL) paradigm, while the others continued in the program using the traditional IL curriculum (this was not random – those who participated volunteered to do so). The Toronto Orthopaedic Boot Camp (TOBC) was part of this curriculum, where the SL residents completed a month-long intense surgical skill acquisition course (this was conducted both didactically and hands-on in the simulation lab). Following the TOBC, the curriculum program was run for three consecutive years (and is still being implemented – there are no data, yet, on the residents who have completed this residency stream), and the investigators extensively evaluated surgical skill acquisition and proficiency levels between groups. The approach taken by the curriculum developers followed the stepwise guidelines set forth by Frank and colleagues[7], which include 1) a focus on curricular outcomes; 2) the use of competencies (abilities) as the organizational principle of curricula; 3) de-emphasis on time-based training; 4) promoting learner centredness throughout the curriculum. The curriculum used the competencies from CanMEDS 2005; but by taking the time-based approach out of it, the program actually foreshadowed the CanMEDS CBD framework that was published five years later. The competencies were achieved via the use of "modular-based training"[6](each module was devoted to a certain topic and skillset in which first-year orthopaedic residents should become proficient). Assessment measures were utilised during each module to ensure proficiency benchmarks were met. In addition to modular-based training, curriculum developers accelerated the pace of procedural skill acquisition, diminished wasted time (e.g., non-essential call), and frequent skills assessments that allowed for additional and consistent feedback. This program has been deemed very effective in surgical skills acquisition, and those who participated in the TOBC showed a significant improvement in technical skill performance compared to the regular IL cohort[3], and some junior-level residents were found to have technical skills comparable with those in the IL fifth-year residents.[4]

Although the curriculum developers' primary focus was on evaluating the surgical and technical skill acquisition over time, they had not yet observed how residents attained non-technical skills between groups. Results described in Published Work 8 qualitatively evaluated both cohorts of first-year residents during the previously-described TOBC, which took place during the first month of residency training. Our results allowed curriculum developers to observe how non-technical skills played a role in the technical skills training during the TOBC. The themes derived from the data included instructional style, feedback, peer and instructor collaboration, and self-efficacy. As there was a clear distinction in the training methods, as expected, our data lend credence to the potential value SLL may have over its counterpart of traditional instructional-based teaching. Despite the clear differences between groups, we found that it is still necessary and valuable to have easily-accessible experts available when needed, for trainees in both groups. As suggested in the paper, in order to meet certain competencies, elements of SLL integrated into a surgical residency program may be advantageous in light of the introduction of CBD and other competency-based frameworks. The University of Toronto model is the first of its kind to publish and introduce the type of curriculum surgical educators will be striving to develop, and its results hold promise for CBD curricula.

2.6d References for Section 2.6c

1. Ericsson KA, Nandagopal K, Roring RW. Toward a science of exceptional achievement: attaining superior performance through deliberate practice. *Ann N Y Acad Sci.* Aug 2009;1172:199-217.
2. Gallagher AG, Ritter EM, Champion H, et al. Virtual reality simulation for the operating room: proficiency-based training as a paradigm shift in surgical skills training. *Ann Surg*. 2005;241(2):364-72.
3. Sonnadara RR, Van Vliet A, Safir O, et al. Orthopedic boot camp: examining the effectiveness of an intensive surgical skills course. Surgery. 2011;149(6):745-749.
4. Sonnadara RR, Garbedian S, Safir O, et al. Orthopaedic Boot Camp II: examining the retention rates of an intensive surgical skills course. Surgery. 2012;151(6):803-807.
5. Sonnadara RR, Garbedian S, Safir O, et al. Toronto orthopaedic boot camp III: examining the efficacy of student-regulated learning during an intensive, laboratory-based surgical skills course. Surgery. 2013;154(1):29-33.
6. Ferguson PC, Kraemer W, Nousiainen M, et al. Three-year experience with an innovative, modular competency-based curriculum for orthopaedic training. J Bone Joint Surg Am. 2013;95(21):e166.
7. Frank JR, Snell LS, Cate OT, et al. Competency-based medical education: theory to practice. Med Teach. 2010;32(8):638-645.

2.6e Medical student-run lecture and simulation curriculum – supplemental work

An additional project that is worth noting in the development of new curriculum is described in the paper below:

Li JZ, Chan SCY, Au M, Hoogenes J, Chan T, Li K, Reid S. Review of a medical student-run lecture and simulation curriculum. Can J Surg 2014:57(3) 152-154

Web link: ***https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4035394/***

This project was initiated by senior medical students (clerks) as a result of a recent decreased interest among medical students across Canada and the United States in pursuing surgical residency, perhaps due to a lack of early exposure to surgery rotations during their pre-clerkship years. The authors designed a didactic lecture series along with a surgical simulation skills lab curriculum for pre-clerkship medical students to voluntarily attend. The content and setup of the lecture series was developed by the clerks, but the lectures were given by a research methodologist and surgical staff members at McMaster University. The surgical skills laboratory was also conducted with the assistance of staff surgeons, whereby each of the three simulation stations consisted of one instructor and five students, with a total of 15 minutes of instruction and 30 minutes of practice by the participants. The approach of having small groups for each simulation station allowed for more practice time and students felt more comfortable asking questions – which is similar to the SL group in the Hoogenes et al. study (Published Work

8). The program was well-received and is still continuing on today within the McMaster Medical School. This paper offers additional insight into how medical students and clerks view surgical exposure at the undergraduate level, which shows some comparisons with the students as described in Published Work 3.

Chapter 3

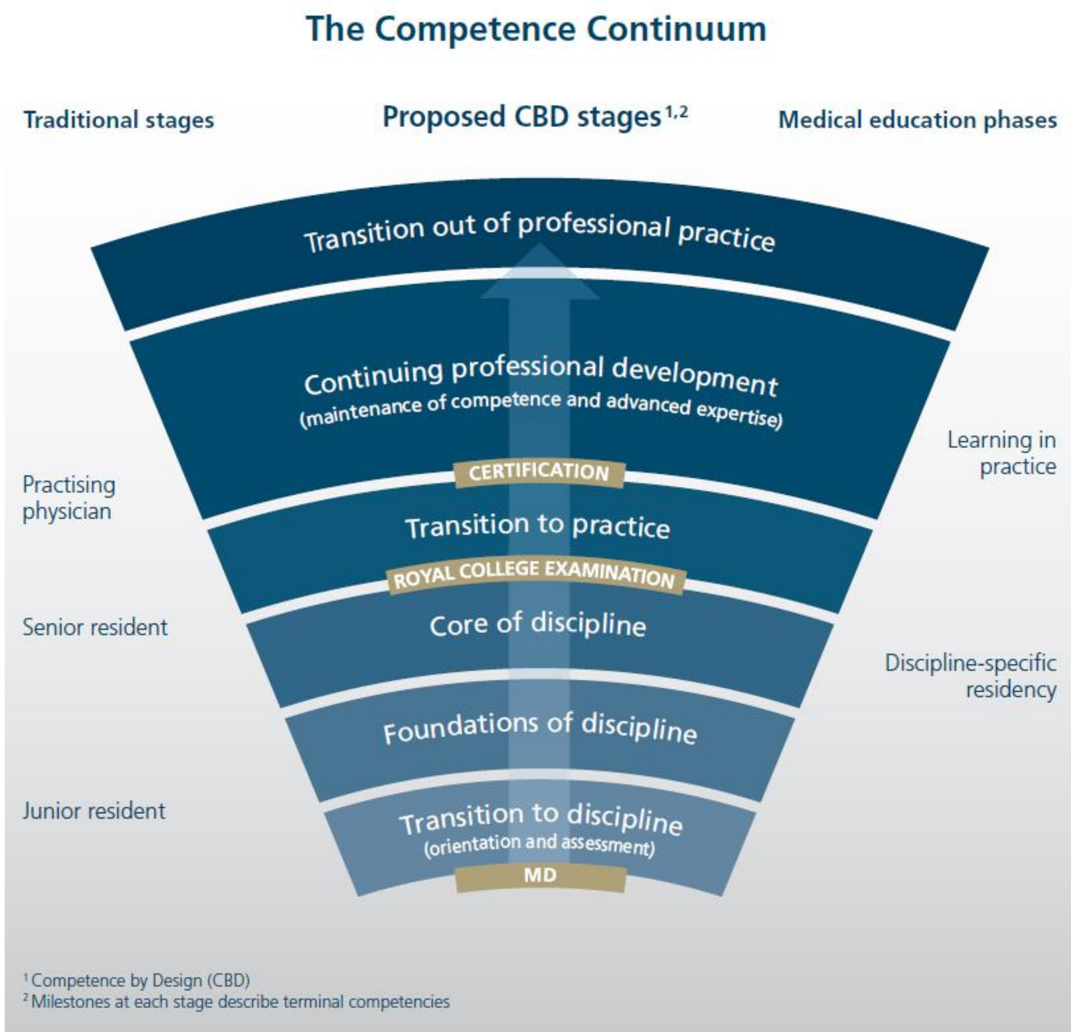
DISCUSSION OF THE THESIS

This thesis has brought together eight published works that have described timely issues and research work that have played a significant role in understanding and advancing surgical education during the time of a paradigm shift from a traditional time-based apprenticeship model of surgical training to one that is becoming purely competency-based. The introduction of the RCPSC's CBD initiative into medical and surgical residency curricula throughout Canada will represent significant changes in the approach to the development, delivery, and evaluation of new residency curricula. The RCPSC's CanMEDS competency framework has been in place since 1996 (with an update in 2005 and its most recent iteration released in 2015); thus, the appreciation of competency-guided physician specialist (residency) training has existed since the CanMEDS roles were first published. However, the new modifications to residency training being brought about by the implementation of CBD over the next two decades puts greater emphasis on competency, and will significantly change the face of surgical training as it eliminates the time-based approach, replacing time with competency initiatives, referred to as "milestones", which a trainee must meet to progress throughout the program. As surgical training has forever followed an apprenticeship approach developed by Sir William Halsted, the CBD approach will require surgical educators to develop entirely new approaches to training residents, and will have to adapt to an entirely new type of curricula.

My work with surgical education began in 2009 out of a need to learn more about how surgical educators teach trainees, as there had not been a standard curriculum for surgical education (even specialty-specific) in Canada. Our small research team (comprised of staff surgeons, residency program directors, and residents at different levels of training) set out to try to understand the surgical training process and to identify the techniques surgeon teachers use on a regular basis both intraoperatively and in the perioperative setting (e.g., didactic teaching, ward teaching, and training in other settings such as a simulation laboratory). Upon exploring the teaching styles and techniques of surgical educators, we aimed to determine how curricula are developed and how trainees are evaluated on their technical skills acquisition outside of the OR and their competency inside the OR. Throughout our research, our goals included learning how trainees perceive the surgical training they receive, as well as the developing new tools for surgical training and evaluation, and determining new ways to teach within surgical residency curricula. A unifying component of our research has been that of surgical competence. With a lack of standardised curriculum guidelines throughout Canada, even under the CanMEDS competency framework, we recognised that although surgical curricula development and implementation is the sole responsibility of the surgical faculty at each institution, our research has the ability to inform other programs and institutions. As we conducted our research, we made sure to try to disseminate our findings at national and international meetings whenever we got the opportunity, which allowed us to learn about other faculties' approaches and discuss and collaborate on new research initiatives and projects, such as faculty development workshops. Surgical education researchers comprise a relatively small and tight-knit international community, which fosters multicentre research and collaborative projects, some of with which we are currently involved, which will be described in the next section of this thesis.

It is important to note my roles in the research presented in this thesis. For the majority of the studies in this thesis, I have developed them from original ideas into grant proposals and securing funding. As the majority of the grants for which we apply require the principal investigator to be a staff surgeon, I am limited to being a co-investigator; but this does not limit my role in the research. I serve as the supervising and coordinating investigator on these studies, ensuring they are properly staffed by other surgeons and residents as required (the structure within our faculty at McMaster was described in the introduction), and carry out all study activities on a daily basis, including training residents, medical students, and undergraduate health science students, and sometimes even staff, on the study itself and the research process. I am involved in the entire process, which includes data collection, data analysis, the writing up of abstracts and manuscripts, and the dissemination of findings at annual meetings throughout the world. I absolutely love having these opportunities, as I am able to become immersed in the studies, which allows for a greater understanding of the methods and the data. I have found that being this involved in the research often sparks new ideas and next steps for a particular study (for example, the continued evolvement of the bladder model for UVA training, which is now being 3D-printed and used for both robotic and laparoscopic training and is serving as a prototype for additional 3D-printed bench models for simulation). As previously described, because of how each study's investigators are comprised in our department, where a resident is "assigned" a study in order to meet his or her research requirements during their training, my name in the author list generally comes second, as we offer authorship to students and residents who make a strong effort and contribution to the study to which they are assigned. They must also meet the International Committee of Medical Journal Editors' (ICMJE) authorship and contributor guidelines. As stated previously, I enjoy the opportunity to work with different residents and students and teach them the research process, and I believe it is mutually beneficial, as their input usually drives some of the methodology and types of analyses we run for given studies. However, I feel it is important to note that my contributions to the research presented in this thesis go far beyond where my name is placed in the authorship queue.

Throughout the published works, the supplemental works, the narratives, and the critical appraisals for each section of this thesis, I have provided a thorough background of clinical competency and its past, present, and future role in the development, implementation, and evaluation of curricula for surgical residency training, including curricula at the medical student level due to the exposure surgical clerks receive on rotations. Furthermore, I have provided a description of the current paradigm shift from the traditional time-based model of surgical training to a competency approach whereby residents will be required to meet "milestones" of progress as defined by the RCPSC. According to the RCPSC, the milestones with the CBD initiative will undergo continuous revisions as they are modified by educators for each discipline.[1,2] It is currently unclear as to how competency will be assessed when the milestones themselves will be revised over time, as they serve to measure trainees' competency levels in a given area or task (as defined by the milestone). One of the CanMEDS 2015's CBD central tenets is that of a competence continuum (please see graphic below); a model of continued professional education throughout one's career, with the professional responsibility to maintain a high level of competence as one progresses from undergraduate medical training to independent practice. The CBD continuum focuses on addressing societal health needs; achieving a balance within specialisation; diversified learning contexts; the resident's (trainee's) dual role as a learner and service provider; professionalism; fostering a culture of patient safety; assessment; faculty development; and continuing medical education.[1] As described by Frank et al., the milestones "define the specific abilities expected at certain points within a physician's career", and that by "focusing on learning rather than time, the CBD approach is helping the Royal College align medical education with the realities of today's practice and thus ensure that physicians have the competencies they need at every stage of their career. (p. 12).[1] The published works that comprise this thesis each have unique elements that contribute to the enhancement of CBME, from recognising professional competencies that are well-defined in multiple competency-based frameworks, to the role of teaching surgical skills intraoperatively and the formal assessment of acquired surgical skills.



Each of the CanMEDS roles (redefined for the 2015 iteration) are designed to guide the trainee throughout the training process, on the competence continuum. The current framework's roles include; Medical Expert; Communicator; Collaborator; Leader; Health Advocate; Scholar; and Professional.[2] As these align well with competency frameworks such as the ACGME and the UK Foundation Programme, there appears to be a general consensus, regardless of geographical location, of what comprises a competent, professional doctor. In the currently-used CanMEDS framework, the roles help to guide trainees as they progress through their programs, and within each role, trainees are expected to meet specific competencies at different parts of their training. However, these are professional roles within the framework, and are in addition to the medical or residency programs' pre-defined competency requirements in the time-spent model of medical and surgical education. As training moves away from the current Halstedian apprenticeship model, post-graduate year level of training will no longer define a resident or fellow; instead, with the introduction of CBD in the CanMEDS framework, learners will instead train under a model of achievement and progression based on attained milestones of competence.[2]As previously described, expert working groups (i.e., specialty-specific program developers) will be charged with the monumental task of developing and defining these milestones. It is expected that this will be a lengthy process, many years, even, for this new training paradigm to take hold in Canada, and as such, it presents a formidable time for medical and surgical educators to conduct work that will build new competency-based, specialised curricula that will eventually train future doctors, with that cycle repeating as medical and surgical education evolves.

Within this thesis, I have also described the work our team has conducted to explore how surgical educators teach residents and how residents perceive the teaching they receive from their staff. Although this study was limited to just our institution, the qualitative approach and the large number of focus group participants provided us with rich data on the teaching techniques and behaviours noted by both the educators and residents, themselves. This information was vital to the progression of our research, which went on to develop new tools for teaching, including those for simulation, and for evaluation of competency, such as the

RARP assessment tool development, which is currently in the validation stage and will hopefully be ready for use in practice within the coming year. Finally, this thesis described research we conducted to create new curricula development, specifically within a program designed for didactic and simulation-based surgical training. Curriculum development is one of the primary objectives we have made for future research endeavours, especially as CBD becomes integrated into the existing surgical residency curriculum at McMaster University.

The work that comprises this thesis has added its own new knowledge to the literature, so that others may use the findings and hopefully improve future surgical education. At McMaster University, we are currently in the process

References for Chapter 3

1. Harris KA, Frank JR. Competence by Design: Reshaping Canadian Medical Education. Canada: The Royal College of Physicians and Surgeons of Canada; 2014.
2. Frank JR, Snell L, Sherbino J, editors. *CanMEDS 2015 Physician Competency Framework*. Ottawa: Royal College of Physicians and Surgeons of Canada; 2015.

Chapter 4

CURRENT AND FUTURE RESEARCH PROJECTS

4.1 The development of three-dimensional printed anatomical urology models for surgical training and preoperative planning

Three-dimensional (3D) printing (also known as rapid prototyping) is a technology that has been utilized in the manufacturing, engineering, and aerospace fields for decades[1],but has only recently begun to be applied to medical and surgical education. As with many new technologies, cost is often prohibitive for its use; however, over the past few years, 3D printing has gained momentum in the medical field to assist with surgical planning, prostheses, implanted structures, and medical education, among others.[2]With this demand, the cost for 3D printers and its hardware and software has decreased considerably (some software is open-sourced and free), even to the point that a small laboratory can afford to own and operate a high quality printer.[3] The availability of this technology, along with significant reductions in the cost of 3D printers and its accessories could mean that our team can create novel 3D-printed anatomical models for surgical education and planning. Using these models, proposed workshops would include didactic and skills laboratory curricula that are conducted in-house, such as at the Centre for Minimal Access Surgery (CMAS) skills laboratory at St. Joseph's Healthcare Hamilton (SJHH), part of McMaster University. Using 3D models can teach learners at different levels of training about basic anatomical structure and general medical education with lifelike reusable models, simple surgical simulation, and even create models for preoperative planning. Images such as those of a human kidney can be 3D-printed based off of contrast-enhanced imaging such as computed tomography (CT) scans to provide a virtual 3D model of the kidney. Importantly, for this proposal, 3D- printed models of diseased structures, such as a kidney with multiple tumours, can be created from CT scans and be used to teach learners how to identify certain disease processes, how to plan for surgical intervention, and even use the model to surgically simulate the "treatment" of the disease (i.e., simulated surgical resection of tumours). Our team intends to create several urological educational 3D-printed models and incorporate them into with didactic and simulation workshops for medical students and surgical learners at all levels of training, and we feel that these workshops can serve as templates for educational programs for other surgical specialties.

Recent technological advances have contributed to the increased access and probability that 3D printing anatomical replicas of organs and organ structures, including those that are diseased, can be used by surgical educators to teach trainee basic anatomy, disease processes, and even preoperative planning. This is taught outside of the operating room (OR), allowing for adequate time spent on teaching and learning, which can have a significant impact on how trainees may apply what they have learned to actual OR cases. As learning anatomy requires spacial visualization, students need to not only learn about the anatomical structures, but also the spatial relationships to surrounding structures.[4] While anatomy textbooks can only provide two dimensional (2D) static illustrations, learners may find it challenging to visualize 2D images as 3D structures, while trying to understand the dynamic aspects of functional anatomy.[5,6] This becomes more complicated when trying to visualize certain planes of a structure, for example, when visualizing the renal lobe of a kidney, or even the structures of the kidney as would be seen in a cross-sectional plane. 3D printing can provide visually detailed anatomy and can be created in ways that show different planes of organ structures, allowing for a new method of learning, perhaps one that can be incorporated into medical school and residency curricula and surgical boot camps.

When surgical residents begin their training, they must narrow their focus to the specialty-specific structures they will be operating on and treating in clinical practice. 3D-printed models are beneficial to surgical residency education in that they can be developed for surgical simulations that more accurately represent the anatomic pathology encountered, the tactile feedback of actually operating, and rare surgical pathology that may not always be seen in cadaveric samples.[7] Surgical simulation with 3D-printed models can be conducted in a risk-free environment with no time pressures and often in the presence of surgical educators who can provide valuable feedback on disease process and surgical technique. With a 3D printer available, multiple identical models can be (inexpensively) produced to allow for learners to repetitively practice on a duplicate model, if desired. This method can also allow for standardization of models to be used for training workshops. With the recent decrease in resident working hours and the introduction of the Competence by Design (CBD) initiative by the Royal College of Physicians and Surgeons of Canada[8], having readily available specialty-specific 3D-printed models (including those printed on a custom, case-by-case basis from CT scans) may improve competency in learners at all levels of training, including staff surgeons.

3D printing can also play a major role in preoperative planning, especially in difficult cases. Printing a model of a diseased kidney with multiple and/or large tumours, for example, can permit a surgical team to simulate the surgery prior to actually performing it. While reviewing a CT or MRI scan prior to a complicated renal surgery may delineate the structures and demarcate disease (tumours), allowing for the formulation of a preoperative plan, these images cannot imitate a physical anatomical 3D model that can be used to measure the size of the kidney and its structures and actually gauge the depth and dimensions of a tumour. Having this knowledge prior to a kidney case, for example, can aid in determining whether a radical versus a partial nephrectomy should be conducted, and can prepare surgeons for potential complications ahead of time. The surgical and clinical significance of such a tool is invaluable to both the surgical team and the patient, as it can lead to improved outcomes. Furthermore, a 3D-printed model can be used to compare it to the final specimen derived from a surgery, which can be used to determine the validity of the 3D-printed model and for postoperative evaluation. For an example, please see Figure 1, of a CT-derived 3D-printed kidney with a tumour, with the actual tumour specimen shown side by side.[9]

Figure 1: Silberstein, et al., 2014

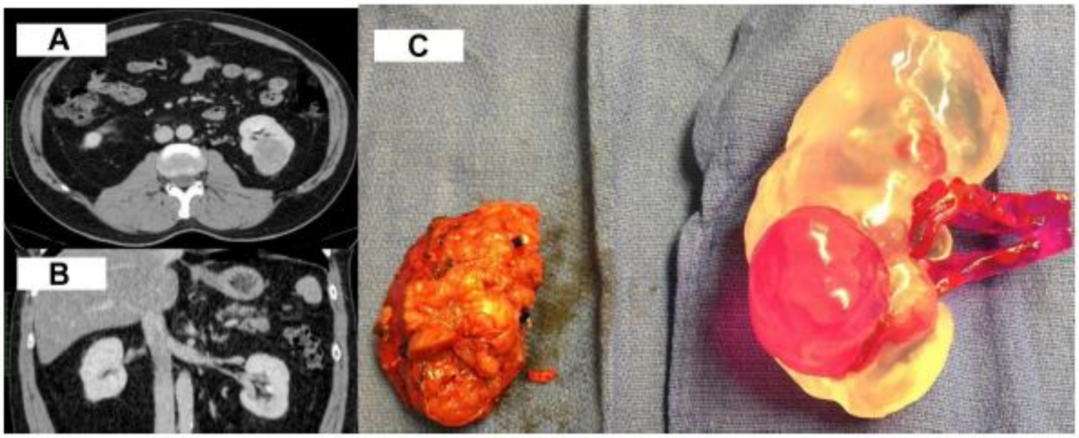


Figure 2. (A,B) Select transverse and sagittal CT images of a 57-year-old man (patient 3) with a left lower pole posterior enhancing renal mass. **(C)** Resected left renal mass next to 3-dimensional physical model of left kidney (turned posterior) including major renal vasculature constructed from CT scan. CT, computed tomography.

The value of 3D printing for surgical education is supported in the available literature. With the reduction in the cost of purchasing and operating a 3D printer, obtaining one would be incredibly helpful for teaching medical students, residents, and staff surgeons on various surgical education topics. A 3D printer will allow our group to create a series of urology-based workshops for learners at different levels of training. These workshops will use several 3D-printed models and will focus on basic anatomy and disease processes (of healthy and diseased structures), simulation training, preoperative surgical planning, and postoperative evaluation. In the future, 3D printing may serve as a patient education tool, to visually help them understand their own disease process and how a planned operation will conducted. Furthermore, 3D printing may become a useful fixture for our annual PGY1 Urology Boot Camp. Based on workshop (program) evaluation, we can improve our teaching techniques and approaches over time and develop a template for other divisions with the Department of Surgery to adopt 3D printing and integrate it into training curricula.

Three systematic reviews have been published on 3D printing that are most closely related to the type of 3D printing we propose to use in our workshops. Azer and Azer (2016) reviewed 3D anatomy models and their impact of learning using a scoping review approach. Most of the authors' emphasis was on the quality of the existing literature. In addition to 3D-printed models, the authors included digital 3D models. Thirty articles met their inclusion criteria. The authors concluded that a number of factors require further study: students' learning needs; students' learning style; educational design on 3D models; digital versus physical models; and effect of training prior to using 3D models.[6] Secondly Hoang and colleagues (2016) published a review of the current literature on surgical applications of 3D printing, including 168 articles. The focus of this review was not solely on education, but also on the technology of 3D printing and printing of surgical instruments, implants, prosthesis, splints, and external fixators, with skull and facial structure models being substantially more reported than other anatomical models. The authors concluded that that 3D printing in surgery has increased exponentially as evidenced by the increased number of publications in the past ten years, owing to the impressive utility and large array of potential applications for 3D printing, but also due to the decreasing cost.[7] The third review was by AliAli et al. (2015), which looked at 3D printing's surgical applications. They limited their review to publications less than ten years old, and included 23 in their review, not all of which were focused on surgical education with 3D-printed models, similar to the two aforementioned reviews. The authors concluded that there are promising data for the use of 3D printing in surgical planning, and medical school and resident education, yet there is a need for further study to determine how best to us 3D printing in surgical education.[10]

Each of our planned workshops will provide us with detailed information related to the feasibility and utility of 3D printing in surgical education, specifically in urology. Data will be collected on the fidelity of the 3D-printed models and the ability to be used for anatomical and disease process education, surgical simulation, preoperative planning, and postoperative evaluation. These data will help us to determine whether and how 3D printing can be introduced into the urology residency and fellowship curricula, including the potential for its use in the now-annual Urology Boot Camp for incoming PGY1 residents. Furthermore, the format of the workshops can be modified over time to become more suitable to the needs of the learners; and if successful, it can be used as a template for other surgical specialties. A we were able to successfully validate the 3D-printed bladder model for robotic and laparoscopic surgical simulation use, the potential exists to conduct additional surgical education studies using the variety of 3D-printed urological models we propose to create. In the future, we may be able to incorporate 3D printing into patient education, as it is possible to 3D print a patient's actual organ and evidence of disease, as seen on a CT scan.

We plan to purchase a 3D printer and accessories to create three models: a "diseased" kidney model (one with tumours); a bladder and both ureters with a stone(s) inside the ureter(s); and a prostate model with the outline of the location of the carcinoma (organ-confined). These would be the three initial models proposed for use in the workshops – however, the type and number of models will likely increase if the 3D printing is a success. For example, a 3D-printed staghorn kidney stone with all of the branches that could help plan for percutaneous kidney stone surgery; a 3D-printed bladder with a mass; a horseshoe kidney; and multiple other structures with various disease pathologies. Since the 3D models are CT-rendered, the 3D printing applications are numerous.

The image processing software we propose to use is open-source (free) Slicer 4 (https://www.slicer.org/), which is used solely for medical image processing and was created by the US National Institutes of Health. This software also works with the two types of GE CT scanners used at our institution. Each CT scan is in a DICOM format, and the software takes the information from the (anonymous) CT scan to the 3D printer and the model is created using the additive filament slice by slice (as per the CT). The filament for the models we propose to create and use is silicone-based (0.2mm thickness), and the colours for each structure can be chosen manually to make the diseased part stand out. Depending on the size, the models can cost between $2.00-$20.00 CDN.

We plan to have a single workshop for each level of training (for the urology residency program): junior residents (PGY1-2); senior residents (PGY3-5); fellows; and staff urologists. The workshops will likely run one full day per group on a weekend, and will include didactic training on the each of the models (each participant will have their own models) to include anatomy and pathology (with the CT scans available for reference). Participants will then be talked through the surgical planning, followed by surgical simulation (e.g., sharp dissection, ureteroscopy, etc.). Urology fellows and staff may assist with the resident courses, as the fellows and staff workshops will be more advanced and will provide education on creating their own models as desired. Program evaluation will focus on didactic feedback, fidelity of the models, ease of surgical simulation, and overall impressions of the workshop, including suggestions for potential future use of 3D-printed models in urology (e.g., curriculum, boot camp, additional workshops, and future study ideas).

References for section 4.1

1. Malik HH, Darwood AR, Shaunak S, et al. Three-dimensional printing in surgery: J Surgical Res. 2015;199(2):512–522.

2. Hoy MB. 3D printing: making things at the library. Med Ref Serv Q. 2013;32(1):94-9,

3. Soliman, Youssef, et al. 3D printing and its urologic applications. Reviews in Urology. 2015;24(17):1.

4. Berney S, Betrancourt M, Molinari G, Hoyek N. How spatial abilities and dynamic visualizations interplay when learning functional anatomy with 3D anatomical models. Anat Sci Educ. 2015;8(5):452-462.

5. Langlois J, Wells GA, Lecourtois M, Bergeron G, Yetisir E, Martin M. Spatial abilities in an elective course of applied anatomy after a problem-based learning curriculum. Anat Sci Educ. 2009;2(3):107-112.

6. Azer SA, Azer S. 3D anatomy models and impact on learning: a review on the quality of the literature. Health Prof Educ. 2016;2:80-98

7. Hoang D, Perrault D, Stevanovic M, Ghiassi A. Surgical applications of three-dimensional printing: a review of the current literature & how to get started. Ann Transl Med. 2016;4(23):456.

8. Frank JR, Snell LS, Sherbino J, editors. Draft CanMEDS 2015 Physician Competency Framework – Series III. Ottawa: The Royal College of Physicians and Surgeons of Canada; 2014 September.

9. Silberstein JL, Maddox MM, Dorsey P, Feibus A, Thomas R, Lee BR. Physical models of renal malignancies using standard cross-sectional imaging and 3-dimensional printers: a pilot study. Urology. 2014;84(2):268-272.

10. AliAli AB, Griffin M, Butler PE. Three-dimensional printing surgical applications. Eplasty.2014:352-367

4.2 Urology Boot Camp program

Our research group has successfully implemented the first competency-based Urology Boot Camp for incoming PGY1 urology residents at McMaster University and the University of Western Ontario. This collaborative project was completed at the beginning of the residency year (first week of July). The boot camp was designed to prospectively observe the cohort of incoming urology residents as they participate in and complete a mandatory didactic and technical skills-based simulation curriculum (boot camp). This boot camp model loosely followed that of the TOBC described in Published Work 8, yet on a smaller scale, as urology residency programs are generally smaller in numbers than orthopaedic programs. The boot camp trained these new residents from two different universities (all together) in an attempt to give them a “jump-start” on the skills and didactic information they will need to know as they begin residency and throughout their first year. We, as program developers, want to know whether, in a group of incoming PGY1 urology residents, the implementation of a competency-based didactic and technical skills-based simulation curriculum (boot camp) during the first four weeks of residency lead to higher global rating scale and checklist scores on a 7- station objective structured clinical examination (OSCE) (each of a simulated task taught in the boot camp) at the end of boot camp when compared to scores of the same OSCE taken by PGY2 urology residents who did not have the advantage of boot camp during their first year of residency (historical controls). Furthermore, we will evaluate pre- and post- boot camp MCQ exams for the didactic training, and entry and exit surveys of demographic information (including previous experiences) and feedback about the boot camp. The PGY2 residents will take the same OSCE during the first week of August 2017, and as they will serve as historical controls, their OSCE results will be extremely vital to our evaluation of the boot camp. Although they serve as controls, it will still be difficult to control for any exposure bias, such as tasks they were given and performed at different centres on different rotations.

Thus far, we had received excellent feedback and will continue to seek out feedback on the program's effectiveness by maintaining contact with the participants throughout their first year of residency. Each participant received a bound notebook with all 11 lectures with notes and slides. Some feedback was given that we should develop a smartphone app for the boot camp, which would serve as a quick reference tool for residents as needed. To our knowledge, there is only one existing urology boot camp, at the University of Leeds in the UK; however, its primary focus is simulation and is an elective program for trainees at all levels and a fee is associated with it. Our boot camp is different in that it not only provides a great deal of didactic information, but new residents were able to learn and repeatedly practice the simulation tasks in the McMaster Centre for Minimal Access Surgery (CMAS), which is a renowned simulation centre.

Over the next couple of years, this will be used as a pilot program to further develop, implement, evaluate, and refine the boot camp curriculum. The utility and feasibility of its use will be an important factor to determine whether this course will become a permanent part of the urology residency curriculum at McMaster University, and how it may fit with the upcoming CBD initiative. Further, it will provide a blueprint for the development of urology boot camps that can be integrated into programs at other centres. It will also provide data that will help to fill in the gaps in the literature on urologic surgical education using simulation. We hope that this program will help to get residents thinking in the manner of competency-based education that will be present throughout their education. As program developers and surgical educators, it is imperative that we develop and evaluate these types of programs now, to allow for a smoother transition into pure competency-based undergraduate, residency, and fellowship training.

4.3 Faculty development project based on intraoperative teaching data (from Section 2.2)

As mentioned in Section 2.2, surgeons have little to no formal training in adult education and teaching, and therefore often rely on teaching methods based on how they were taught as residents and fellows. Because of this lack of formal teaching, faculty development sessions can help to bridge this gap by providing staff surgeons in the academic environment some tools for intraoperative teaching. Based on the data that were described in Section 2.2, we have developed a series of video vignettes, known as "trigger videos" to supplement faculty development sessions.

Trigger videos are short (3-5 minutes in length) vignettes that can be used to simulate a challenging scenario (e.g., unprepared resident showing up in the OR under time constraints) to stimulate discussion and reflection among learners. As an active learning tool, in faculty development sessions, trigger videos can be used to simulate a scenario and then oblige the participants to reflect upon their experiences relative to those displayed in the video.

Thus far, we have created six trigger videos, each of which depicts a challenging intraoperative teaching/learning scenario. These will be used during surgical faculty development sessions. The videos will be shown to the audience, and small groups of participants will discuss each video in the context of their own experiences, if relevant, and will be asked to come up with means by which to solve the intraoperative issues shown in the videos, which will then become part of the broader discussion in the sessions. From each faculty development workshop, we intend to collect feedback on the trigger videos themselves and data on the teaching styles that participants would likely adopt or discard based on each video's scenario. We then intend to qualitatively analyse the responses to highlight teaching techniques that could enhance intraoperative learning. We hypothesise that the discussions surrounding the trigger videos will provide rich data that can be used to categorise surgical teaching techniques and potential solutions to everyday issues that arise in the teaching environment in the OR. We anticipate that, similar to the focus groups study, we will obtain data that will align with each CanMEDS role, providing us with information that can be useful in the development of surgical curricula within the CBD teaching environment.

4.4 Development and evaluation of objective assessment tools for use in intraoperative and simulation-based trainee evaluation

As previously discussed in multiple sections of this thesis, our team has planned to develop, evaluate, validate, and assess the utility and reliability of intraoperative assessment tools that can be used for the objective evaluation of learners, specifically with regard to technical skills acquisition and assessment during and after a surgical case. Developing and utilising objective assessment metrics is a challenging endeavour, as it is critical to control for the inherent bias often associated with subjective assessment. By breaking down tools into checklists (i.e., partial/full task completed: yes/no) and using adaptations of the validated objective structured assessment of technical skills (OSATS) and objective structured clinical examination (OSCE), as well as incorporating additional existing validated tools such as the global evaluative assessment of robotic skills (GEARS), we aim to control for raters' subjective influence on the evaluation of trainees. It is important to briefly note how we intend to utilise these tools in our future research and the rationale for the use of objective evaluation.

With the Competence by Design (CBD) initiative rolling out Canada-wide soon, this is an ideal time to develop and test objective assessment tools for use in the operating room (OR) and in the surgical simulation setting (e.g., planned evaluations during surgical simulation as part of the PGY1 boot camp program; additional robotic simulation studies; further research to evaluate surgical tasks conducted on 3D-printed models). Intraoperatively, assessment of residents' surgical skills is based on frequent evaluations of performance in the OR. However, very little is known as to how individual raters (surgical educators) in the OR make these assessment decisions. The OR is a demanding and complex environment with many competing priorities placed on the primary surgeon, only one of which is the assessment of residents.[1] It is known that rater performance decreases with increased demand on rater cogntion.[2,3] Surgical educators face challenges such as procedure complexity, peer evaluation, time pressures, multitasking, and multiple types of distractions, all of which can raise levels of intraoperative stress.[4,5] Intraoperative assessment is a cognitively taxing exercise, and in the OR, unlike other clinical assessment environments, the stakes of the patient and resident interaction are high and are often limited by a time-sensitive nature of the case.[6,7] Simple mistakes in judgement can have catastrophic and irreversible results.

Recent studies using large population-based patient outcome databases have shown resident involvement to be an independent predictor of increased operative times and increased complication rates.[6,7] Although association does not necessarily imply causation, these results confer with anecdotal experience that resident involvement carries increased risk and requires close monitoring by the attending surgeon. Understanding the influence of the intraoperative environment on rater performance can inform the validity and reliability of intraoperative assessment and identify means for improvement. This understanding can bridge a critical gap in the literature centred on the rater and the limits of his or her cognition under conditions with substantial cognitive workload.

Based on a model of physician professionalism put forth by Ginsburg et al.,[8] Leung and colleagues (2012) found that teaching and assessment become secondary to factors such as time pressure, consideration of colleagues, and patient pressures, and even disavowed factors such as the surgeon's personal ego.[1] Additionally, interviews with surgeons regarding their intraoperative decisions revealed a theme of "tension in balancing" between these competing factors.[1] Further exploration of this construct can provide data on its influence on intraoperative assessment and whether these assessments are reliable and valid when considering the environment in which they are completed. Gaining this information is particularly important as renewed focus is placed on daily workplace assessments which are in turn used to inform on high stakes decisions such as those involving a resident's ability to advance through training (as will be the case with CBD).

Potential solutions to decrease the mental workload of the rater, including separating the "rater" from the "clinician" and decreasing the complexity of the assessment, such as decreasing the number of items being assessed.[9] One way to do this is through video assessment, which has been reported to be a feasible, reliable, and valid evaluation technique in the OR setting.[10] However, there is still a paucity of research that examines the correlation between video-based assessment of residents by external raters and the assessment given by the surgical educator at the end of a case. Despite some potential limitations, such as the Hawthorne Effect and often the inability to perform blinded rater assessments, video assessment can offer several potential advantages, as they may be assessed whenever convenient and frees the surgeon to concentrate on the skill being evaluated away from extraneous distractions of being the case surgeon. Further, the videotaped procedures can serve as a training tool for the resident and surgeon, and can be reviewed on more than one occasion by multiple assessors which may increase the validity and reliability of assessments.

One of our planned studies will explore intraoperative assessment by surgical educators of surgical residents at all levels of training (PGY1-5). The primary objective will be to explore the role that cognitive load plays on the formal intraoperative assessment process via the use of a validated, objective, entrustment-based assessment tool, the Ottawa Surgical Competency Operating Room Evaluation (O-SCORE).[11] Comparisons will be made between video-captured and live intraoperative assessment based on interrater reliability on the O-SCORE. Assessment will be completed by the surgical educator immediately following the case and then three independent expert surgeon raters will evaluate the case via video, using the O- SCORE and the validated objective Surgery-specific Task Load Index (SURG-TLX).[12] Importantly, this work will help inform and identify potential areas of deficiency for intraoperative objective assessments that may be improved. This work can be applicable across multiple medical/surgical specialities as we begin to better understand the influences of rater cognition on assessment.

Furthermore, as was discussed in Published Work 7, the results of the Delphi study provided us with an expert consensus-based inventory of critical main steps and sub-steps of performing a robot-assisted radical prostatectomy (RARP). With this inventory, we intend to develop an objective rating tool for each step in the RARP, and evaluate the utility and reliability of this method via assessment by the case surgeon immediately following the case, as well as validate it via assessments from blinded (to level of training and resident identity) expert surgeons based on intraoperative videotape of each step. This approach may provide a template for producing the same type of inventory and assessment metrics for other surgical specialties.

As noted previously, we also intend to develop new objective metrics for future simulation-based research, as well as for other types of surgical procedures. The RARP Delphi study proved to be methodologically sound and is certainly a process we plan to incorporate into future research with other surgical specialties, especially those that are highly technical, including robot-assisted, laparoscopic, and other minimally-invasive surgical approaches. Additionally, as our Urology Boot Camp program evolves, we plan to develop program-specific objective metrics for evaluation using modified OSATS and OSCE assessments for the PGY1 group and the PGY2 residents who serve as historical controls. In planning for the development and validation of objective metrics for surgical education, although we recognize that the development of assessment tools is a lengthy process, we anticipate that we will significantly add to the literature on the objective measurement of surgical skills both in the OR and for the simulation setting, provide evidence of the utility and feasibility of using video-based assessments by blinded raters, as well as provide options for use within the CBD initiative. We also anticipate collaborating with other institutions to improve the reach and generalisability of this research.

References for section 4.4

1. Leung A, Luu S, Regehr G, Murnaghan ML, Gallinger S and Moulton CA: "First, do no harm": balancing competing priorities in surgical practice. Acad Med. 87: 1368-74. (2012).
2. Tavares, Walter, and Kevin W. Eva. "Impact of rating demands on rater-based assessments of clinical competence." *Education for Primary Care* 25.6 (2014): 308-318.
3. Vu, Nu Viet., Marcy, M., Colliver, J.A., Verhulst, S.J., Travis, T.A., & Barrows, H.S. (1992). Standardized (simulated) patients' accuracy in recording clinical performance check-list items. *Medical Education, 26*(2), 99-104.
4. Arora S, Sevdalis N, Nestel D, Woloshynowych M, Darzi A and Kneebone R: The impact of stress on surgical performance: a systematic review of the literature. Surgery. 147: 318-30, 330 e1-6.
5. Wetzel CM, Kneebone RL, Woloshynowych M, Nestel D, Moorthy K, Kidd J and Darzi A: The effects of stress on surgical performance. Am J Surg. 191: 5-10, 2006.
6. Tseng, Warren H., et al. "Surgical resident involvement is safe for common elective general surgery procedures." *Journal of the American College of Surgeons* 213.1 (2011): 19-26.
7. Kiran, Ravi Pokala, et al. "Impact of resident participation in surgical operations on postoperative outcomes: National Surgical Quality Improvement Program." *Annals of surgery* 256.3 (2012): 469-475.
8. Ginsburg S, Regehr G and Lingard L: Basing the evaluation of professionalism on observable behaviors: a cautionary tale. Acad Med. 79: S1-4, 2004.
9. Tavares W and Eva KW: Impact of rating demands on rater-based assessments of clinical competence. Educ Prim Care. 25: 308-18, 2013.

10. Habuchi T, Terachi T, Mimata H, Kondo Y, Kanayama H, Ichikawa T, Nutahara K, Miki T, Ono Y, Baba S et al.: Evaluation of 2,590 urological laparoscopic surgeries undertaken by urological surgeons accredited by an endoscopic surgical skill qualification system in urological laparoscopy in Japan. Surg Endosc. 26: 1656-63.
11. Gofton WT, Dudek NL, Wood TJ, Balaa F and Hamstra SJ: The Ottawa Surgical Competency Operating Room Evaluation (O-SCORE): a tool to assess surgical competence. Acad Med. 87: 1401-7.
12. Wilson MR, Poolton JM, Malhotra N, Ngo K, Bright E and Masters RS: Development and validation of a surgical workload measure: the surgery task load index (SURG-TLX). World J Surg. 35: 1961-9.

Chapter 5

CONCLUSIONS

This thesis has described much of my research work from 2009-2017 that surrounds surgical education within competency-based educational frameworks and means by which to optimise curricula for surgical training. The published works have served to tell the "story" of the research, which was initiated due to the problem surgical educators were (and still are) facing due to a lack of standardised guidelines and evaluation metrics for surgical training in residency programs in Canada. My research began with the exploratory work around how surgical educators teach and how trainees perceive they are taught, along with an exploration of the hidden curriculum in medical training. This was followed by a description of simulation and the development of new tools for surgical simulation and training, and then a narrative describing the development of new curricula that are focused on competency-based initiatives, which can be used within the development process of residency curricula for CBD. As previously noted, this research is timely, as many accrediting bodies worldwide are currently in the process of adopting and developing and competency-based curricula at the undergraduate medical school, residency, and fellowship levels, and especially with the approaching integration of CBD into Canadian residency programs. As the RCPSC's CanMEDS framework has been adopted and adapted worldwide, it is possible that the CBD initiative may follow suit and eventually be adopted by medical educators throughout the world. The research presented in this thesis contributes significantly to the existing body of surgical education research, and future work will focus on expanding the reach of our research initiatives via collaborative efforts with other surgical residency programs within Canada and abroad.

Appendix. Declaration of contributions to publications

Total as of August 6, 2017:

529 reads and 67 citations on Research Gate
h-index= 5 (Scopus and Google Scholar)

Published Work 1:

Matsumoto ED and Hoogenes J. Assessment of competence. In: Urolithiasis – basic science and clinical practice. Talati, JJ, Tiselius H-G, Albala DM, Ye Z (Eds). Springer. Dec 2012. (Book chapter)

From publisher's website (Springer): 111 chapter downloads; 31 readers

Research and Knowledge Exchange

Graduate School

Form **RDPUB (ROUTE 1 AND 2)**

Manchester Metropolitan University

PhD BY PUBLISHED WORK (ROUTE 1/2): CONTRIBUTION TO PUBLICATIONS

This form is to accompany an application for registration for PhD where the PhD is by Published Work. A separate form should be completed for each publication that is submitted with the proposal and should accompany the RD1 form.

1. The Candidate

First Name(s):	Jennifer	Preferred Title:	
Surname:	Hoogenes		
MMU e-mail address:	JENNIFER.HOOGENES@stu.mmu.ac.uk	Contact Number:	+15192426294
Personal e-mail address:	REAMJA@MCMASTER.CA	Student ID Number:	15500398

2. Title of PhD Proposal

MEDICAL AND SURGICAL EDUCTION: EXPLORATION OF CURRUICULA TO OPTIMISE TRAINING AND ASSESS COMPETENCY

Title of Research Output

Matsumoto ED and Hoogenes J. Assessment of competence. In: Urolithiasis – basic science and clinical practice. Talati, JJ, Tiselius H-G, Albala DM, Ye Z (Eds). Springer. Dec 2012.

3. Candidate's contribution to the research output

(State nature and approximate percentage contribution of each author)

Literature search and review, writing and editing of book chapter for publication
70% Hoogenes J; 30% Matsumoto ED

4. Co author(s):

I confirm that the contribution indicated above is an accurate assessment of the contribution by the candidate to the research output named in section 3.

Name	Signature	Current e-mail address
Edward Matsumoto	Please see email attachment for role confirmation	matsumo@mcmaster.ca

5. Statement by Director of Studies/Advisor

I confirm that I have read the above publication and am satisfied that the extent and nature of the candidate's contribution is as indicated in section 4 above.

Signature:		Date:	
	(Director of Studies/Advisor)		

6. Signature of Faculty Research Degrees Administrator

Signature:		Date:	
	(Faculty Research Degrees Administrator)		

CONTRIBUTION EMAIL REGARDING PUBLICATION:
Matsumoto ED and Hoogenes J. Assessment of competence. In: Urolithiasis – basic science and clinical practice. Talati, JJ, Tiselius H-G, Albala DM, Ye Z (Eds). Springer. Dec 2012.

Confirmation of roles in book chapter

Hoogenes, Jennifer

Actions
To:
Matsumoto, Edward
Sent Items
Sunday, October 30, 2016 12:47 PM

This message was sent with High importance.
Hi Eddie,

Can you please confirm my role in writing up this book chapter?

1. Matsumoto ED and Hoogenes J. Assessment of competence. In: Urolithiasis – basic science and clinical practice. Talati, JJ, Tiselius H-G, Albala DM, Ye Z (Eds). Springer. Dec 2012.

ROLES:
Literature search/review
Writing and editing chapter for publication

Matsumoto, Edward

Sunday, October 30, 2016 1:38 PM
I confirm your role.

Edward Matsumoto

Sent on the fly. Please excuse brevity and typos.

Published Work 2:

Dath D, Hoogenes J, Matsumoto ED, Szalay DA. Exploring how surgeon teachers motivate residents in the operating room. Am J Surg. 2013 Feb, 205(2):151-5.

63 reads and 4 citations on Research Gate
10 downloads on Academia.edu
Cited 5 times (Scopus and Google Scholar)

Research and Knowledge Exchange

Graduate School

Form **RDPUB (ROUTE 1 AND 2)**

Manchester Metropolitan University

PhD BY PUBLISHED WORK (ROUTE 1/2): CONTRIBUTION TO PUBLICATIONS

This form is to accompany an application for registration for PhD where the PhD is by Published Work. A separate form should be completed for each publication that is submitted with the proposal and should accompany the RD1 form.

1. The Candidate

First Name(s):	Jennifer	Preferred Title:	
Surname:	Hoogenes		
MMU e-mail address:	JENNIFER.HOOGENES@stu.mmu.ac.uk	Contact Number:	+15192426294
Personal e-mail address:	REAMJA@MCMASTER.CA	Student ID Number:	15500398

2. Title of PhD Proposal

MEDICAL AND SURGICAL EDUCTION: EXPLORATION OF CURRUICULA TO OPTIMISE TRAINING AND ASSESS COMPETENCY

Title of Research Output

Dath D, Hoogenes J, Matsumoto ED, Szalay DA. Exploring how surgeon teachers motivate residents in the operating room. Am J Surg. 2013 Feb, 205(2):151-5.

3. Candidate's contribution to the research output

(State nature and approximate percentage contribution of each author)

Literature search and review, methodology, data entry and analysis, writing and editing of manuscript for publication, presentation of results

40% Dath D; 35% Hoogenes J; 15% Matsumoto ED; 10% Szalay DA

4. Co author(s):

I confirm that the contribution indicated above is an accurate assessment of the contribution by the candidate to the research output named in section 3.

Name	Signature	Current e-mail address
Deepak Dath	Please see email attachment for role confirmation	dathd@mcmaster.ca
Edward Matsumoto	Please see email attachment for role confirmation	matsumo@mcmaster.ca
David Szalay	Please see email attachment for role confirmation	szalayd@HHSC.ca

5. Statement by Director of Studies/Advisor

I confirm that I have read the above publication and am satisfied that the extent and nature of the candidate's contribution is as indicated in section 4 above.

Signature:		Date:	
	(Director of Studies/Advisor)		

6. Signature of Faculty Research Degrees Administrator

Signature:		Date:	
	(Faculty Research Degrees Administrator)		

CONTRIBUTION EMAIL REGARDING PUBLICATION:
Dath D, Hoogenes J, Matsumoto ED, Szalay DA. Exploring how surgeon teachers motivate residents in the operating room. Am J Surg. 2013 Feb, 205(2):151-5.

Confirmation of role in study/paper

Hoogenes, Jennifer

Actions
To:
Matsumoto, Edward; szalayd@hhsc.ca; Dath, Deepak
Sent Items
Sunday, October 30, 2016 1:26 PM

This message was sent with High importance.
Hi all,

I hope all is well! I am taking some courses abroad and the university requires confirmation of my role(s) in all of the studies/papers with which I have been involved. If you could reply to this email with your confirmation of the roles below, it would be much appreciated. The emails will be sent to the university.

1. Dath D, Hoogenes J, Matsumoto ED, Szalay DA. Exploring how surgeon teachers motivate residents in the operating room. Am J Surg. 2013 Feb, 205(2):151-5.

ROLES (Assisted with):
Literature search/review
Methodology
Data entry and analysis
Manuscript writing and editing for publication
Presentation of results

Thanks so much!

All the best,
Jen

Matsumoto, Edward

Sunday, October 30, 2016 1:39 PM
I confirm your role.

Edward Matsumoto

Sent on the fly. Please excuse brevity and typos.

Dath, Deepak

Sunday, October 30, 2016 3:26 PM
Confirm.

Deepak Dath, MD MEd FRCSC FACS
Professor of Surgery, McMaster University

Laparoscopic Hepatobiliary Surgery,
Juravinski Hospital and Cancer Centre

Clinician Educator, CanMEDS, RCPSC

-----Original Message-----
From: Matsumoto, Edward [matsumo@mcmaster.ca]
Received: Sunday, 30 Oct 2016, 1:39PM
To: Hoogenes, Jennifer [reamja@mcmaster.ca]; szalayd@hhsc.ca [szalayd@hhsc.ca]; Dath, Deepak [dathd@mcmaster.ca]
Subject: Re: Confirmation of role in study/paper

Szalay David Dr. [szalayd@HHSC.CA]

Tuesday, November 01, 2016 10:59 PM
Sorry for the delay - confirm all
David Szalay

Sent from my BlackBerry 10 smartphone on the Bell network.
From: Hoogenes, Jennifer
Sent: Sunday, October 30, 2016 1:23 PM
To: Matsumoto, Edward; Szalay David Dr.; Dath Deepak (McMaster)
Subject: Confirmation of role in study/paper

Published Work 3:

Kittmer T, Hoogenes J, Pemberton J, Cameron B. Exploring the hidden curriculum: A qualitative analysis of clerks' reflections on professionalism in surgical clerkship. Am J Surg. 2013 Apr 205(4); 426-33.

37 reads and 8 citations on Research Gate
Cited 15 times on Google Scholar
Cited 9 times on Scopus

Research and Knowledge Exchange

Graduate School

Form **RDPUB (ROUTE 1 AND 2)**

PhD BY PUBLISHED WORK (ROUTE 1/2): CONTRIBUTION TO PUBLICATIONS

This form is to accompany an application for registration for PhD where the PhD is by Published Work. A separate form should be completed for each publication that is submitted with the proposal and should accompany the RD1 form.

1. The Candidate

First Name(s):	Jennifer	Preferred Title:	
Surname:	Hoogenes		
MMU e-mail address:	JENNIFER.HOOGENES@stu.mmu.ac.uk	Contact Number:	+15192426294
Personal e-mail address:	REAMJA@MCMASTER.CA	Student ID Number:	15500398

2. Title of PhD Proposal

MEDICAL AND SURGICAL EDUCTION: EXPLORATION OF CURRUICULA TO OPTIMISE TRAINING AND ASSESS COMPETENCY

Title of Research Output

Kittmer T, Hoogenes J, Pemberton J, Cameron B. Exploring the hidden curriculum: A qualitative analysis of clerks' reflections on professionalism in surgical clerkship. Am J Surg. 2013 Apr 205(4); 426-33.

3. Candidate's contribution to the research output
(State nature and approximate percentage contribution of each author)

Literature search and review, methodology, data analysis, writing and editing of manuscript for publication

35% Kittmer T; 32% Hoogenes J; 16.5% Pemberton J; 16.5% Cameron B

4. Co author(s):

I confirm that the contribution indicated above is an accurate assessment of the contribution by the candidate to the research output named in section 3.

Name	Signature	Current e-mail address
Tiffaney Kittmer	Please see email attachment for role confirmation	tiffany.kittmer@medportal.ca
Julia Pemberton	Please see email attachment for role confirmation	pemberj@mcmaster.ca
Brian Cameron	Please see email attachment for role confirmation	cameronb@mcmaster.ca

5. Statement by Director of Studies/Advisor

I confirm that I have read the above publication and am satisfied that the extent and nature of the candidate's contribution is as indicated in section 4 above.			
Signature:		Date:	
	(Director of Studies/Advisor)		

6. Signature of Faculty Research Degrees Administrator

Signature:		Date:	
	(Faculty Research Degrees Administrator)		

CONTRIBUTION EMAIL REGARDING PUBLICATION:
Kittmer T, Hoogenes J, Pemberton J, Cameron B. Exploring the hidden curriculum: A qualitative analysis of clerks' reflections on professionalism in surgical clerkship. Am J Surg. 2013 Apr 205(4); 426-33.

Confirmation of role in hidden curriculum study/paper

Hoogenes, Jennifer

Sent Items
Sunday, October 30, 2016 1:22 PM
Hello all!

I hope all is well! I am taking some courses abroad and the university requires confirmation of my role(s) in all of the studies/papers with which I have been involved. If you could reply to this email with your confirmation of the roles below, it would be much appreciated. The emails will be sent to the university.

1. Kittmer T, Hoogenes J, Pemberton J, Cameron B. Exploring the hidden curriculum: A qualitative analysis of clerks' reflections on professionalism in surgical clerkship. Am J Surg. 2013 Apr 205(4); 426-33.

ROLES (Assisted with):
Literature search/review
Methodology
Data analysis
Writing and editing of manuscript for publication/presentation

Many thanks, and again I hope you're all doing well!

All the best,
Jen

Tiffaney Kittmer [tiffaney.kittmer@medportal.ca]

Actions
To:
Hoogenes, Jennifer
Cc:
Cameron, Brian; pemberton.julia@gmail.com

Sunday, October 30, 2016 4:41 PM

Flag for follow up
I can attest to the fact that Jen Hoogenes took on all of the roles listed below for that paper.

Sincerely,

Tiffaney Kittmer, MD FRCSC
General Surgeon
Alexandra & Marine General Hospital
120 Napier Street
Goderich, ON N7A 1W5
Tel 519-524-8323 x5208
Fax 519-524-8527

Julia Pemberton [pemberton.julia@gmail.com]

Sunday, October 30, 2016 4:49 PM
Hi Jen,

I confirm. Hope you are well.

Best,

Julia

On Oct 30, 2016, at 4:41 PM, Tiffaney Kittmer <tiffaney.kittmer@medportal.ca> wrote:

I can attest to the fact that Jen Hoogenes took on all of the roles listed below for that paper.

Sincerely,

Tiffaney Kittmer, MD FRCSC
General Surgeon
Alexandra & Marine General Hospital
120 Napier Street
Goderich, ON N7A 1W5
Tel 519-524-8323 x5208
Fax 519-524-8527

On Sun, Oct 30, 2016 at 1:22 PM, Hoogenes, Jennifer <reamja@mcmaster.ca> wrote:
Hello all!

I hope all is well! I am taking some courses abroad and the university requires confirmation of my role(s) in all of the studies/papers with which I have been involved. If you could reply to this email with your confirmation of the roles below, it would be much appreciated. The emails will be sent to the university.

1. Kittmer T, Hoogenes J, Pemberton J, Cameron B. Exploring the hidden curriculum: A qualitative analysis of clerks' reflections on professionalism in surgical clerkship. Am J Surg. 2013 Apr 205(4); 426-33.

ROLES (Assisted with):
Literature search/review
Methodology
Data analysis
Writing and editing of manuscript for publication/presentation

Many thanks, and again I hope you're all doing well!

All the best,
Jen

Cameron, Brian

Monday, October 31, 2016 9:48 AM
Hi Jen,
Yes I can confirm your involvement in the research work as listed below.
All the best!
Brian

Brian H. Cameron, MD, DipMedEd, FRCSC
Professor and Academic Division Head, Pediatric Surgery,
Director, International Surgery Desk,
McMaster University, Hamilton

Published Work 4:

Hoogenes J and Matsumoto ED. Simulation Surgical Models: Surgeon Perspectives. In: Bioengineering for Surgery: The Critical Engineer Surgeon Interface. Elsevier/Woodhead Publishing, Series in Biomedicine Number 84, Amsterdam. Eds. WA Farhat and J Drake. 2016. (Book chapter)

Unable to find citation data on this book chapter.

Research and Knowledge Exchange

Graduate School

Form **RDPUB (ROUTE 1 AND 2)**

PhD BY PUBLISHED WORK (ROUTE 1/2): CONTRIBUTION TO PUBLICATIONS

This form is to accompany an application for registration for PhD where the PhD is by Published Work. A separate form should be completed for each publication that is submitted with the proposal and should accompany the RD1 form.

1. The Candidate

First Name(s):	Jennifer	Preferred Title:	
Surname:	Hoogenes		
MMU e-mail address:	JENNIFER.HOOGENES@stu.mmu.ac.uk	Contact Number:	+15192426294
Personal e-mail address:	REAMJA@MCMASTER.CA	Student ID Number:	15500398

2. Title of PhD Proposal

MEDICAL AND SURGICAL EDUCTION: EXPLORATION OF CURRUICULA TO OPTIMISE TRAINING AND ASSESS COMPETENCY

Title of Research Output

Hoogenes J and Matsumoto ED. Simulation Surgical Models: Surgeon Perspectives. In: Bioengineering for Surgery: The Critical Engineer Surgeon Interface. Elsevier/Woodhead Publishing, Series in Biomedicine Number 84, Amsterdam. Eds. W.A. Farhat and J. Drake.© 2016

3. Candidate's contribution to the research output

(State nature and approximate percentage contribution of each author)

Literature search and review, writing and editing chapter for publication
80%: J Hoogenes; 20% ED Matsumoto

4. Co author(s):

I confirm that the contribution indicated above is an accurate assessment of the contribution by the candidate to the research output named in section 3.

Name	Signature	Current e-mail address
Edward D. Matsumoto	Please see email attachment for role confirmation	matsumo@mcmaster.ca

5. Statement by Director of Studies/Advisor

I confirm that I have read the above publication and am satisfied that the extent and nature of the candidate's contribution is as indicated in section 4 above.

Signature:		Date:	
	(Director of Studies/Advisor)		
6. Signature of Faculty Research Degrees Administrator			
Signature:		Date:	
	(Faculty Research Degrees Administrator)		

<u>CONTRIBUTION EMAIL REGARDING PUBLICATION:</u>

Hoogenes J and Matsumoto ED. Simulation Surgical Models: Surgeon Perspectives. In: Bioengineering for Surgery: The Critical Engineer Surgeon Interface. Elsevier/Woodhead Publishing, Series in Biomedicine Number 84, Amsterdam. Eds. W.A. Farhat and J. Drake. Available September, 2015, © 2016

Confirmation of role in book chapter

Hoogenes, Jennifer

Actions
To:
Matsumoto, Edward
Sent Items
Sunday, October 30, 2016 12:44 PM

This message was sent with High importance.
Hi Eddie,

Can you please confirm my role in this chapter? This is required for the PhD, and will be emailed to my supervisor.

1. <u>Hoogenes J</u> and Matsumoto ED. Simulation Surgical Models: Surgeon Perspectives. In: Bioengineering for Surgery: The Critical Engineer Surgeon Interface. Elsevier/Woodhead Publishing, Series in Biomedicine Number 84, Amsterdam. Eds. W.A. Farhat and J. Drake. Available September, 2015, © 2016

ROLES:
Literature search/review
Writing and editing of chapter for publication

Many thanks!
Jen

Matsumoto, Edward

Sunday, October 30, 2016 1:35 PM
I confirm your role.

Edward Matsumoto

Sent on the fly. Please excuse brevity and typos.

Published Work 5:

Ngyuyen, T, Braga L, Hoogenes J, Matsumoto ED. Commercial video laparoscopic trainers versus less expensive, simple laparoscopic trainers: A systematic review and meta-analysis. J Urol. 2013 Sep; 190(3):894-9.

5 reads and 6 citations on Research Gate
Cited 9 times on Google Scholar
Cited 4 times on Scopus

Research and Knowledge Exchange

Graduate School

Form **RDPUB (ROUTE 1 AND 2)**

Manchester Metropolitan University

PhD BY PUBLISHED WORK (ROUTE 1/2): CONTRIBUTION TO PUBLICATIONS

This form is to accompany an application for registration for PhD where the PhD is by Published Work. A separate form should be completed for each publication that is submitted with the proposal and should accompany the RD1 form.

1. The Candidate

First Name(s):	Jennifer	Preferred Title:	
Surname:	Hoogenes		
MMU e-mail address:	JENNIFER.HOOGENES@stu.mmu.ac.uk	Contact Number:	+15192426294
Personal e-mail address:	REAMJA@MCMASTER.CA	Student ID Number:	15500398

2. Title of PhD Proposal

MEDICAL AND SURGICAL EDUCTION: EXPLORATION OF CURRUICULA TO OPTIMISE TRAINING AND ASSESS COMPETENCY

Title of Research Output

Ngyuyen T, Braga L, Hoogenes J, Matsumoto ED. Commercial video laparoscopic trainers versus less expensive, simple laparoscopic trainers: A systematic review and meta-analysis. J Urol. 2013 Sep; 190(3):894-9.

3. Candidate's contribution to the research output

(State nature and approximate percentage contribution of each author)

Literature search and review, data entry and analysis, writing and editing paper for publication
35% NgyuyenT; 15.5% Braga L, 34% Hoogenes J; 15.5% Matsumoto ED

4. Co author(s):

I confirm that the contribution indicated above is an accurate assessment of the contribution by the candidate to the research output named in section 3.

Name	Signature	Current e-mail address
Edward D. Matsumoto	Please see email attachment for role confirmation	matsumo@mcmaster.ca
Luis Braga	Please see email attachment for role confirmation	braga@mcmaster.ca
Please note: the co-author T Ngyuyen was a medical student at the time of the study and we currently cannot locate him.		

5. Statement by Director of Studies/Advisor			
I confirm that I have read the above publication and am satisfied that the extent and nature of the candidate's contribution is as indicated in section 4 above.			
Signature:		Date:	
	(Director of Studies/Advisor)		

6. Signature of Faculty Research Degrees Administrator			
Signature:		Date:	
	(Faculty Research Degrees Administrator)		

CONTRIBUTION EMAIL REGARDING PUBLICATION:
Ngyuyen, T, Braga L, Hoogenes J, Matsumoto ED. Commercial video laparoscopic trainers versus less expensive, simple laparoscopic trainers: A systematic review and meta-analysis. J Urol. 2013 Sep; 190(3):894-9.

Confirmation of role in study/paper

Hoogenes, Jennifer

Sent Items
Sunday, October 30, 2016 1:11 PM
Hi Eddie and Luis,

I am taking courses abroad and the university requires confirmation of all of the studies and papers I have been involved with - If you could please confirm the roles (below) for this paper via email, it would be much appreciated. I will be sending the email directly to the university.

1.Ngyuyen, T, Braga L, Hoogenes J, Matsumoto ED. Commercial video laparoscopic trainers versus less expensive, simple laparoscopic trainers: A systematic review and meta-analysis. J Urol. 2013 Sep; 190(3):894-9.

ROLES (assisted in):
Literature search/review
Data entry/analysis
Writing and editing of manuscript for publication

Thank you kindly!
Jen

Matsumoto, Edward

Actions
To:
Hoogenes, Jennifer; Braga, Luis

Sunday, October 30, 2016 1:38 PM

Flag for follow up

This message was sent with High importance.
I confirm your role.

Edward Matsumoto

Sent on the fly. Please excuse brevity and typos.

Braga, Luis

Sunday, October 30, 2016 8:26 PM
I also confirm your role as stated
Thanks, Jen
Luis

Sent from my iPhone

Published Work 6:

Sabbagh R, Chatterjee S, Chawla A, Hoogenes J, Kapoor A, Matsumoto ED. Transfer of laparoscopic radical prostatectomy skills from bench model to animal model: a prospective, single-blind, randomized controlled study. J Urol. 2012 May;187(5):1861-6.

34 reads and 13 citations on Research Gate
15 citations noted on both Google Scholar and Scopus

Research and Knowledge Exchange

Graduate School

Form **RDPUB (ROUTE 1 AND 2)**

PhD BY PUBLISHED WORK (ROUTE 1/2): CONTRIBUTION TO PUBLICATIONS

This form is to accompany an application for registration for PhD where the PhD is by Published Work. A separate form should be completed for each publication that is submitted with the proposal and should accompany the RD1 form.

1. The Candidate

First Name(s):	Jennifer	Preferred Title:	
Surname:	Hoogenes		
MMU e-mail address:	JENNIFER.HOOGENES@stu.mmu.ac.uk	Contact Number:	+15192426294
Personal e-mail address:	REAMJA@MCMASTER.CA	Student ID Number:	15500398

2. Title of PhD Proposal

MEDICAL AND SURGICAL EDUCTION: EXPLORATION OF CURRUICULA TO OPTIMISE TRAINING AND ASSESS COMPETENCY

Title of Research Output

Sabbagh R, Chatterjee S, Chawla A, Hoogenes J, Kapoor A, Matsumoto ED. Transfer of laparoscopic radical prostatectomy skills from bench model to animal model: a prospective, single-blind, randomized controlled study. J Urol. 2012 May;187(5):1861-6.

3. Candidate's contribution to the research output

(State nature and approximate percentage contribution of each author)

Literature search and review, methodology development, writing and editing of manuscript for publication

21% Sabbagh R; 15% Chatterjee S; 12% Chawla A; 17% Hoogenes J; 15% Kapoor A; 20% Matsumoto ED

4. Co author(s):

I confirm that the contribution indicated above is an accurate assessment of the contribution by the candidate to the research output named in section 3.

Name	Signature	Current e-mail address
Edward Matsumoto	Please see email attachment for role confirmation	matsumo@mcmaster.ca
Anil Kapoor	Please see email attachment for role confirmation	akapoor@mcmaster.ca
The remaining co-authors could not be located and thus could not be contacted. This study was conducted with medical students, residents,		

and fellows who are with our department for a very short time, so we unfortunately lose contact with many of them (many move abroad). The two senior authors have provided their approval of my roles in this study.		

5. Statement by Director of Studies/Advisor

I confirm that I have read the above publication and am satisfied that the extent and nature of the candidate's contribution is as indicated in section 4 above.

Signature:		Date:	
	(Director of Studies/Advisor)		

6. Signature of Faculty Research Degrees Administrator

Signature:		Date:	
	(Faculty Research Degrees Administrator)		

CONTRIBUTION EMAIL REGARDING PUBLICATION:
Sabbagh R, Chatterjee S, Chawla A, Hoogenes J, Kapoor A, Matsumoto ED. Transfer of laparoscopic radical prostatectomy skills from bench model to animal model: a prospective, single-blind, randomized controlled study. J Urol. 2012 May;187(5):1861-6.

Contribution email for PhD - publication -need ASAP please

Hoogenes, Jennifer

Sent Items
Tuesday, December 06, 2016 4:10 PM
Hi Eddie and Anil,

I am putting together the publications I will be using for my PhD dissertation, and one of them is the following:

Sabbagh R, Chatterjee S, Chawla A, Hoogenes J, Kapoor A, Matsumoto ED. Transfer of laparoscopic radical prostatectomy skills from bench model to animal model: a prospective, single-blind, randomized controlled study. J Urol. 2012 May;187(5):1861-6.

I would like to describe the evolution of the new 3-D printed bladder model and use this paper as a starting point.

I will need to have you each briefly email me back to say that you agree or disagree about the role I played in this study/paper. The email will be sent to the administrator of the PhD program (they will be copied, not forwarded, so no worries about getting emails or anything).

My role(s):
Literature review
Methodology development and write-up
Writing and editing of the manuscript

Thanks very much in advance, I appreciate it! Please hit "reply all" so the email stays together as one.
-Jen

Kapoor, Anil

Actions
To:
Hoogenes, Jennifer
Cc:
Matsumoto, Edward

Tuesday, December 06, 2016 4:16 PM

Flag for follow up

You replied on 12/6/2016 5:38 PM.
Agree

Anil Kapoor, MD, FRCSC
Professor of Surgery (Urology)
McMaster University
Hamilton, Ontario, Canada
akapoor@mcmaster.ca

Hoogenes, Jennifer
Thanks, Anil.
Tue 5:38 PM

Matsumoto, Edward

Wednesday, December 07, 2016 9:40 PM
Agree with your role in this study.

Eddie

Published Work 7:

Morris CM, Hoogenes J, Shayegan B, Matsumoto ED. Toward development and validation of an intraoperative assessment tool for robot-assisted radical prostatectomy training: Results of a Delphi study. Intl Braz J Urol. 2017. 43(1).

9 reads on Research Gate
No citation data available yet.

Research and Knowledge Exchange

Graduate School

Form **RDPUB (ROUTE 1 AND 2)**

PhD BY PUBLISHED WORK (ROUTE 1/2): CONTRIBUTION TO PUBLICATIONS

This form is to accompany an application for registration for PhD where the PhD is by Published Work. A separate form should be completed for each publication that is submitted with the proposal and should accompany the RD1 form.

1. The Candidate

First Name(s):	Jennifer	Preferred Title:	
Surname:	Hoogenes		
MMU e-mail address:	JENNIFER.HOOGENES@stu.mmu.ac.uk	Contact Number:	+15192426294
Personal e-mail address:	REAMJA@MCMASTER.CA	Student ID Number:	15500398

2. Title of PhD Proposal

MEDICAL AND SURGICAL EDUCTION: EXPLORATION OF CURRUICULA TO OPTIMISE TRAINING AND ASSESS COMPETENCY

Title of Research Output

Morris CM, Hoogenes J, Shayegan B, Matsumoto ED. Toward development and validation of an intraoperative assessment tool for robot-assisted radical prostatectomy training: Results of a Delphi study. Intl Braz J Urol *in press*

3. Candidate's contribution to the research output

(State nature and approximate percentage contribution of each author)

Study development, proposal and grant writing, data collection, entry, and analysis, dissemination of results (presentations at conferences), writing and editing manuscript for publication.

36% Morris CM; 34% Hoogenes J; 10% Shayegan B; 20% Matsumoto ED

4. Co author(s):

I confirm that the contribution indicated above is an accurate assessment of the contribution by the candidate to the research output named in section 3.

Name	Signature	Current e-mail address
Christopher Morris	Please see email attachment for role confirmation	christopher.morris@medportal.ca
Edward Matsumoto	Please see email attachment for role confirmation	matsumo@mcmaster.ca
Bobby Shayegan	Please see email attachment for role confirmation	shayeb@mcmaster.ca

5. Statement by Director of Studies/Advisor

I confirm that I have read the above publication and am satisfied that the extent and nature of the candidate's contribution is as indicated in section 4 above.

Signature:		Date:	
	(Director of Studies/Advisor)		

6. Signature of Faculty Research Degrees Administrator

Signature:		Date:	
	(Faculty Research Degrees Administrator)		

CONTRIBUTION EMAIL REGARDING PUBLICATION:
Morris CM, Hoogenes J, Shayegan B, Matsumoto ED. Toward development and validation of an intraoperative assessment tool for robot-assisted radical prostatectomy training: Results of a Delphi study. Intl Braz J Urol (in press)

Confirmation of role in Delphi paper

Hoogenes, Jennifer

Sent Items
Sunday, October 30, 2016 12:53 PM
Hi guys,

For the PhD program I am in, they require confirmation of the my role(s) in all papers/studies. If you can please confirm these roles, I would appreciate it! The email will be forwarded to the program.

Morris CM, Hoogenes J, Shayegan B, Matsumoto ED. Toward development and validation of an intraoperative assessment tool for robot-assisted radical prostatectomy training: Results of a Delphi study. Accepted, Intl Braz J Urol (in press)

ROLES (Assisted in):
Study development/proposal/grant writing
Data collection/entry
Data analysis
Dissemination of study (conferences, etc.)
Writing up and editing the paper for publication

Thanks so much!
Jen

Shayegan, Bobby

Sunday, October 30, 2016 12:59 PM
No problem.

Sent from my iPhone

Shayegan, Bobby

Sunday, October 30, 2016 1:01 PM
I confirm.

B Shayegan

Sent from my iPhone

Matsumoto, Edward

Sunday, October 30, 2016 1:38 PM
I confirm your role.

Edward Matsumoto

Sent on the fly. Please excuse brevity and typos.

Hoogenes, Jennifer

Sent Items
Wednesday, December 07, 2016 2:10 PM
Hi Topher,

Below is the email information I was talking about.

Thanks!
Jen

Christopher Morris [christopher.morris@medportal.ca]

Actions
To:
Hoogenes, Jennifer

Wednesday, December 07, 2016 2:29 PM
I confirm your roles.

Topher Morris
Uro-Oncology Fellow
The Ottawa Hospital

Sent from my iPhone

Published Work 8:

Hoogenes J, Mironova P, Safir O, McQueen SA, Abdelbary H, Drexler M, Nousiainen M, Ferguson P, Kraemer W, Alman B, Reznick R, Sonnadara R, et al. Student-led learning: a new teaching paradigm for surgical skills. Am J Surg. 2015. 209: 107-14.2.

137 reads and 3 citations on Research Gate
Cited 8 times on Google Scholar
Cited 3 times on Scopus
40 all-time views and 14 all-time downloads on Academia.edu

Research and Knowledge Exchange

Graduate School

Form **RDPUB (ROUTE 1 AND 2)**

PhD BY PUBLISHED WORK (ROUTE 1/2): CONTRIBUTION TO PUBLICATIONS

This form is to accompany an application for registration for PhD where the PhD is by Published Work. A separate form should be completed for each publication that is submitted with the proposal and should accompany the RD1 form.

1. The Candidate

First Name(s):	Jennifer	Preferred Title:	
Surname:	Hoogenes		
MMU e-mail address:	JENNIFER.HOOGENES@stu.mmu.ac.uk	Contact Number:	+15192426294
Personal e-mail address:	REAMJA@MCMASTER.CA	Student ID Number:	15500398

2. Title of PhD Proposal

MEDICAL AND SURGICAL EDUCTION: EXPLORATION OF CURRUICULA TO OPTIMISE TRAINING AND ASSESS COMPETENCY

Title of Research Output

Hoogenes J, Mironova P, Safir O, McQueen SA, Abdelbary H, Drexler M, Nousiainen M, Ferguson P, Kraemer W, Alman B, Reznick R, Sonnadara R, et al. Student-led learning: a new teaching paradigm for surgical skills. Am J Surg. 2015. 209: 107-14.2.

3. Candidate's contribution to the research output

(State nature and approximate percentage contribution of each author)

Literature search and review, data entry and analysis, writing and editing paper for publication

54% Hoogenes J; 10% Mironova P; 2% Safir O; 10% McQueen SA; 2% Abdelbary H; 2% Drexler M; 2% Nousiainen M; 2% Ferguson P; 2% Kraemer W; 2% Alman B; 2% Reznick R; 10% Sonnadara R

4. Co author(s):

I confirm that the contribution indicated above is an accurate assessment of the contribution by the candidate to the research output named in section 3.

Name	Signature	Current e-mail address
Polina Mironova	Please see email attachment for role confirmation	polinka.mironova@gmail.com
Sydney McQueen	Please see email attachment for role confirmation	sydney.mcqueen@mail.utoronto.ca
Ranil Sonnadara	Please see email attachment for role confirmation	ranil@skillslab.ca

The remaining co-authors could not be located and thus could not be contacted. This study was conducted with medical students and residents, who are with our department for a very short time (and often move abroad), so we unfortunately lose contact with many of them. The senior author has provided his approval of my roles in this study.		

5. Statement by Director of Studies/Advisor

I confirm that I have read the above publication and am satisfied that the extent and nature of the candidate's contribution is as indicated in section 4 above.

Signature:		Date:	
	(Director of Studies/Advisor)		

6. Signature of Faculty Research Degrees Administrator

Signature:		Date:	
	(Faculty Research Degrees Administrator)		

<u>CONTRIBUTION EMAIL REGARDING PUBLICATION:</u>

<u>Hoogenes J</u>, Mironova P, Safir O, McQueen SA, Abdelbary H, Drexler M, Nousiainen M, Ferguson P, Kraemer W, Alman B,, Reznick RK, Sonnadara RR. Student-led learning: a new teaching paradigm for surgical skills. Am J Surg. 2015. 209: 107-14.2.

Confirmation of role in study/paper

Hoogenes, Jennifer

Sent Items
Sunday, October 30, 2016 1:05 PM
Hi all,

Hope all is well! I am taking some courses abroad, and they require confirmation of my role(s) in all studies and papers. Can you please send back an email to me that says "I confirm" or something along those lines, as I am required to pass them along to the university.

<u>Hoogenes J</u>, Mironova P, Safir O, McQueen SA, Abdelbary H, Drexler M, Nousiainen M, Ferguson P, Kraemer W, Alman B et al. Student-led learning: a new teaching paradigm for surgical skills. Am J Surg. 2015. 209: 107-14.2.

ROLES:
Literature search/review
Data entry/analysis
Writing and editing of paper for publication

Thanks very much in advance!
-Jen

Ranil Sonnadara [ranil@skillslab.ca]

Sunday, October 30, 2016 1:12 PM
I confirm the roles listed below.

--
Ranil Sonnadara, Ph.D.
Director, Education Science
Department of Surgery
A.N. Bourns Science Building Room 131
McMaster University
Hamilton, Ontario, L8S 4K1

Sydney McQueen [sydney.mcqueen@mail.utoronto.ca]

Actions
To:
Ranil Sonnadara [ranil@skillslab.ca]
Cc:
Hoogenes, Jennifer; polinka.mironova@gmail.com

Sunday, October 30, 2016 2:25 PM

Flag for follow up
I can also confirm.

Sydney

On Oct 30, 2016, at 1:12 PM, Ranil Sonnadara <ranil@skillslab.ca> wrote:

I confirm the roles listed below.

--
Ranil Sonnadara, Ph.D.
Director, Education Science
Department of Surgery
A.N. Bourns Science Building Room 131
McMaster University
Hamilton, Ontario, L8S 4K1

From: Hoogenes, Jennifer [mailto:reamja@mcmaster.ca]
Sent: October 30, 2016 1:06 PM
To: sydney.mcqueen@mail.utoronto.ca; ranil@rhpcs.mcmaster.ca; polinka.mironova@gmail.com
Subject: Confirmation of role in study/paper
Importance: High

Hi all,

Hope all is well! I am taking some courses abroad, and they require confirmation of my role(s) in all studies and papers. Can you please send back an email to me that says "I confirm" or something along those lines, as I am required to pass them along to the university.

Hoogenes J, Mironova P, Safir O, McQueen SA, Abdelbary H, Drexler M, Nousiainen M, Ferguson P, Kraemer W, Alman B et al. Student-led learning: a new teaching paradigm for surgical skills. Am J Surg. 2015. 209: 107-14.2.

ROLES:
Literature search/review

Data entry/analysis
Writing and editing of paper for publication

Thanks very much in advance!
-Jen

Polina Mironova [polinka.mironova@gmail.com]

Monday, October 31, 2016 9:58 AM
I confirm.

Kind regards,
Polina Mironova