What Is a ‘Good’ Surgical Video?

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

In

Surgical Education

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Abstract

Video is widely used in modern surgical education and may have advantages over other ways of learning surgery. However, less is known about the purposes and needs of surgical learners who use videos, as well as what learners consider to be the attributes of a 'good' surgical video. Qualitative research methods were used to answer these research questions. In-depth semi-structured interviews were conducted with nine medical students, eight surgical residents, and eight surgeons. The data were analyzed using a Thematic Analysis approach. Two frameworks were developed to structure the findings. Framework 1 explained that how learners used video was not simply associated with their designation but was related to the proficiency of an individual learner on a continuum of growing surgical proficiency from 'seeing' to 'doing' to 'perfecting'. Framework 2 identified seven key attributes that learners associated with a 'good' surgical video: intelligible, concise, clear, interactive, reliable, accessible, and suitable. This study showed that a surgical video created for education requires to be tailored to the level of the surgical proficiency of the intended audience. The attributes of a 'good' surgical video need to be considered when deciding how to record, edit, and disseminate video-based educational materials in order to advance their value.

Preface

This thesis is an original work by Dr. Murodbek Akhrorov. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, “The Use of Video in Surgical Education”, ID Pro00091584, July 26, 2019. No part of this thesis has been previously published.

Acknowledgements

First and foremost, I would like to acknowledge my supervisor, Dr. Jonathan White. Thank you for agreeing to supervise such an unusual student. Thank you for believing in me, for supporting and inspiring me. I greatly appreciate all your time and effort that you spent to teach, guide, and help me. It was a big honor and pleasure for me to be your student.

I would like to acknowledge my supervisory committee, Dr. Bin Zheng and Dr. Simon Turner. Thank you for journeying with me through this project from start to end and sharing your valuable thoughts and insights. I very much appreciate your mentorship, kindness, and supportiveness.

I would like to acknowledge all of the participants of the study, for agreeing to participate and finding time to discuss and share with me their perspectives.

I would like to acknowledge the Government of the Republic of Uzbekistan, the Foundation 'El-Yurt Umidi', and Tashkent Pediatric Medical Institute, for believing in me and giving me a chance to study in one of the prominent universities in the world.

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Chapter I. Introduction

My Personal Position Regarding the Topic of the Study

One day, as a medical student, I found myself wasting my time in the operating room. I was not alone: there was a company of other medical students, my groupmates. We were standing for several hours, attempting to observe a surgical case over the shoulders of each other and trying to puzzle out what was going on at an operation site. It was crowded, hot, silent, and slightly awkward to be there. Asking questions was not an option - our professor was not talkative while he is operating. After the case, I went on the internet seeking answers to my questions. That was the first time when I saw great potential for learning in surgical videos.

Later, as a surgical trainee, I have been watching surgical videos very often, to have a better visual representation of operational approaches and steps, to perform better in the operating room and to gain the most contemporary knowledge from outstanding surgeons all over the world. But it was so hard to find what I needed on the internet: it would take a long time sorting out and finding a good surgical video. Some of the videos were too shallow, giving a short overview of a procedure without going into the details that I was looking for. Other videos were too long and required countless scrolling through to find something relevant. That was when I comprehend that a great teaching medium was not being used on its full capability.

After my surgical training in Uzbekistan, I had a great chance of coming to Canada, enrolling into a graduate program in the field of surgical education. Guided by my supervisors, I reviewed literature behind using video for surgical education and this made me wonder:

- What do surgical learners use video for, how do they use it?
- What are the attributes of a ‘good’ surgical video?

With these research questions in mind, I started my journey in this study.

The Role of Video in Surgical Education

Sir William Halsted is remembered as the founder of surgical training in North America (Carter, 1952). After his reform in 1889, surgical training converted from the apprenticeship model to a structured and standardized form. During the 20th century, this model was the dominant type of upbringing for young surgeons, and it remains familiar today as the surgical residency training program (Mayberry, 2003). Typically, this involves five years of clinical training in the hospital environment, with daily exposure to the operating room and surgical decision-making, with a graduated increase in responsibility throughout the period of training until independence is achieved. However, during the past few decades, surgical education has been profoundly transformed. Financial considerations (Bridges & Diamond, 1999), restriction of work hours (DaRosa, Bell, & Dunnington, 2003), and patient safety concerns (Barone, Tucker, & Bull, 2003) have raised discussions about the quality of modern surgical training, and there has been an increasing focus on simulation-based and technology-based education (Elfenbein, 2016; Snyder, Terhune, & Williams, 2014). In addition, lessons taught by the COVID-19 pandemic also emphasize the importance of technologies in surgical education and raise future demand for distance learning (Chick et al., 2020; Zingaretti et al., 2020).

In recent years, watching surgical videos has become a common way of learning for trainees and surgeons. For example, Rapp et al. (2016) found that 90% of students, residents and faculty members watched videos when prepared to take part in a surgery. Learning by watching a video would be anticipated to have various advantages over learning through direct observation in the operating room or participating in the surgery as an assistant. Considerations about operative time, sterility and patient safety may restrict surgeons in explaining a surgical procedure to learners. A video recording can be watched at a time and place of the learner's

choosing, and can also be paused, re-winded and re-watched in a way that live experience cannot. Video also allows the learner to watch the procedure from another point of view other than their own, such as surgeon's point of view or the point of view of other members of the surgical team. Online learning resources can also be accessed by learners from developing countries who do not have access to up-to-date surgical education. For example, a study on the 'Surgery 101" podcast showed that there was a high worldwide demand for online surgical learning content (White, Sharma, & Boora, 2011).

A number of studies have demonstrated the effectiveness of surgical videos in learning. For example, a study conducted among 6 residents at the University of Alberta showed that use of a video teaching modules decreased the occurrence of errors in neck dissection by 55% (Mendez, Seikaly, Ansari, Murphy, & Cote, 2014). Another experimental study among 70 surgical trainees, tested the effectiveness of learning resources combining surgical video with text, audio, and animation (Pape-Koehler et al., 2013). Researchers concluded that this type of multimedia-based training significantly improved surgical performance. Various authors have compared video-based learning to the traditional methods of surgical learning. For example, Lwin et al. (2018) compared self-directed Interactive Video-Based Instruction (IVBI) versus instructor-led teaching for learning basic surgical skills among 50 medical students. Researchers concluded that self-directed IVBI facilitated similar levels of acquisition of surgical skills with instructor-led teaching. Another study compared video versus text for teaching laparoscopic skills. A randomized controlled trial, including 80 medical students, showed that video was better to develop conceptual understanding compared to text (Yeung, Justice, & Pasic, 2009).

Acknowledging the aspects discussed above, I concluded that video-based learning may have an important role in surgical education.

What Is a 'Good' Surgical Video?

Video have become a valuable part of modern surgical education and have the potential to improve surgical performance. However, there are also problems associated with its use, including concerns around its quality, reliability, accessibility, and effectiveness (Cassidy et al., 2018; Rodriguez, Young, Jackson, Oelschlager, & Wright, 2018).

Certainly, the internet has some excellent quality sources of surgical videos. Such websites and educational platforms as the 'American College of Surgeons', 'Royal College of Surgeons of England', 'www.neurosurgicalatlas.com' are good examples of these. The strong side of these websites is they contain peer-reviewed materials, created by acknowledged experts in the field. However, many of surgical learners tend to watch surgical videos on unofficial websites, such as YouTube, Facebook, and Instagram. This was demonstrated in the studies conducted by Rapp et al. (2016) and Mota et al. (2018): 100 % of junior residents, 93.8 % of senior residents, and 73 % of surgeons watched YouTube to prepare for surgery. With many surgical learners using YouTube to meet their education needs, it is problematic that many surgical videos found there were quite low in quality and reliability. (Cassidy et al., 2018; Rodriguez, Young, Jackson, Oelschlager, & Wright, 2018).

During my own practice of using surgical videos on YouTube, I found a broad variety of their quality. Some of the videos were truly 'bad' in quality, mainly because of poor videography, absence of any editing afterwards, or lack of supporting information (to watch sample video scan QR-Code 1). Even excluding those 'truly bad' surgical videos from this discussion and considering only the relatively 'good-looking' videos from YouTube, I realized that they still had an extensive variety of attributes. Some of them were short, others were longer,

some combined animations and visual cues, while others had voiceover narrations etc. (to watch sample video scan QR-Code 2).

QR-Code 1. YouTube video 1.

QR-Code 2. YouTube video 2.

An essential question I wish to answer is: ***"What is a 'good' surgical video?"*** In other words, what features makes a surgical video more or less effective in achieving its intended educational aim? How should a surgical video be recorded, edited, and disseminated to maximize its educational impact? In order to answer these questions, I conducted a comprehensive literature review, which will be presented in the next chapter.

Chapter II. The Use of Video in Surgical Education. Literature Review

Video technology has settled deeply into our modern lives. In just a few decades, the use of 'moving pictures' has transferred from the television in the home, to the video cassette and DVD, into tiny recording and playing devices that we carry in our pockets. The rapid development of digital technology has made video ubiquitous, allowing not only instant recording but instant sharing too. Because of video, we can see from others' perspective what it is like to be in an open space, in the cabin of a Formula 1 racing car or on a battlefield. Video allows us to save the best moments of our lives in full, vivid color and share them with others. The literature review will explore the use and impact of this technology in surgery and in surgical education.

History of Recording Operations

Surgeons have made records of procedures using writing and picturing almost from the very first time that surgery was performed. In ancient Egypt, the vizier Imhotep authored the first treatise on surgery, dated around 2700 BCE. Following this, operations were often recorded for posterity or training purposes using writing, painting, and drawing. One famous example is 'The Anatomy Lesson of Doctor Nicolaes Tulp' painted in oils by Rembrandt in 1632. After the invention of photography in the early 1800s, it was mainly used in plastic and reconstructive surgery as a way to document pre- and post-operative appearances (Rogers, 1991). In 1863, when James Balossa took the first photograph of a surgical procedure for his book on nasal reconstruction (Wallace, 1985). Maury and Duhring established the first journal to use medical photography in 1870. Argentinian surgeon Alejandro Posadas was among the first to record an operation using 'moving pictures' when he filmed the removal of a pulmonary cyst in 1899 (Viegas, 2015). Film recording of surgeries continued in the 20 century and accelerated with the

introduction of digital video technology and the production of smaller recording devices. Digital video technology is a medium for capturing, storing, and presenting moving visual images encoded in an electronic system instead of on film. In contrast to analog videos, which represent still images captured in a film, digital videos are encrypted electronic sequence of ones and zeros. The technology has been employed for a range of uses in surgery. For example, surgeons have used video to archive data (Gambadauro & Magos, 2012), to evaluate technical skills (Kasparian, Martinez, JoverClos, & Chercoles, 2014), for self-reflection (Casswell, Salam, Sullivan, & Ezra, 2016), for teleconferencing (Obuchi et al., 2011), for assessment of team performance (Guerlain et al., 2005), to record minimally invasive procedures (Kaiser & Corman, 2001), for patient safety (Anthony et al., 2003), for surgical "black box" analyses (Bowermaster et al., 2015), and for medicolegal purposes (Turnbull & Emsley, 2014).

The remainder of this review will focus on the recent use of digital video technology in surgical education for teaching and learning purposes. The use of video in surgical education for assessing surgical skills will not be discussed in this review, as it is out of the scope of this study.

Challenges of Recording Operations

Producing a video recording designed to be watched by others is a complicated process. For example, a 'big budget' Hollywood movie takes around 800 days from the start of pre-production until release, and principal photography takes place on specially-designed sound stages and on location. Often the budget for this endeavor is counted in the hundreds of millions of dollars. It may involve more than 3000 people, including writers, producers, cameramen, actors, artists, composers, visual effects specialists, and animation specialists.

Producing a video intended to enhance the learning of surgery is a different type challenge. It is perhaps most similar to the style of 'guerilla film-making' in which film-makers

must work quickly within the limitations of a hostile environment, getting in and out as quickly as possible and capturing only whatever footage is possible. An operating room is designed to perform surgery, not to record video, and it possesses its own rules and restrictions based on patient safety and sterility. Therefore, the process of shooting a surgical video needs to conform closely to the conditions of the operating room.

Relevant Psychological Theories

In order to create useful educational videos and maximize student learning from it, Brame (2016) suggested taking into consideration three main factors: cognitive load, student engagement and active learning. Further, I will discuss a theoretical foundation for cognitive load and will address the methods based on theories, to enhance the production of videos in surgical education.

Cognitive Load Theory.

Cognitive load theory was developed by Sweller in 1988. According to this theory, memory consisted of 3 key elements: sensory memory, working memory and long-term memory. Sensory memory represented information perceived from sensory organs for a very short duration (1/5 - 1/2 second). Based on biological and psychological importance for an individual, some of this information, selectively, passed to working memory for processing. Working memory was also characterized as a short-term memory, which usually lasted 10-15 seconds and had limited capacity. Processed information transferred to the long term memory. It was believed that long term memory had unlimited capacity. For the surgical educator intending to create an educational video, it was essential to know that the attention of the learner will play a crucial role in determining which information proceeds from sensory memory to working memory. This was the key moment of the learning process (Brame, 2016).

In compliance with the described structure of human memory, cognitive load theory suggests 3 core determinants of learning: intrinsic load, germane load, and extraneous load. Intrinsic load is a cognitive effort needed to comprehend the connections within the subject of learning (Sweller and Chandler 1994). For example, memorizing the steps of surgical procedure may require less intrinsic load than understanding the surgeon's decision to use a particular technique during the surgery. Germane load is a cognitive effort for reaching the learning goal. In other words, it is a cognitive activity which grasped the key messages of the subject and incorporated into the inner hierarchy of knowledge (Sweller, van Merrienboer, Jeroen J. G., and Paas, Fred G. W. C., 1998). For example, each surgical procedure has around 15-20 steps. But in general, these steps can be grouped into 3 main parts, which always have a constant sequence: surgical incision, main surgical act, and closure of the surgical wound. A cognitive process, which allocates various steps of procedure into this hierarchy of 3 main sequences can be an example of germane load. Extraneous load is a cognitive activity which distracted from reaching the learning goal (Sweller, van Merrienboer, Jeroen J. G., and Paas, Fred G. W. C., 1998). For example, extraneous load may be relevant when surgical learners watch videos of excessive duration or featuring other irrelevant, distracting factors.

Cognitive Theory of Multimedia Learning.

The cognitive theory of multimedia learning is based on cognitive load theory. It suggests that working memory has two separate channels for perception and processing of the visual and audial information (Mayer, 2005). Using both channels simultaneously may expand the possibilities of working memory, which has a limited capacity. However, the cognitive load applied using multimedia learning objects needs to be distributed wisely, to avoid the learner becoming overwhelmed. For example, YouTube has some surgical videos, which present on-

screen textual narration of a procedure which is shown. This practice may overwhelm the visual channel and may be does not use the opportunity of the audio channel.

Possible Solutions.

According to the theories discussed, an educational video which controls intrinsic cognitive load, optimizes germane cognitive load, and avoids extraneous cognitive load, while providing an appropriate amount of audio and visual material at a time can be defined as a good, learner-oriented surgical video. Brame (2016) discussed 4 approaches for this, in context of educational videos: 1) Signaling, 2) Segmenting, 3) Weeding, 4) Matching. Further, I will discuss how these approaches are equally applicable to videos for surgical education.

Signaling.

Signaling means emphasizing the key information on the screen, using brief text, visual cues, or changes in colour and contrast. This helps learners to pay attention to the key elements of the presented material and pass information from sensory memory to the working memory. This method can be used in surgical videos by adding a heading as a text for each surgical step or cueing important elements of surgical anatomy on the screen. Signaling reduces the extraneous cognitive load and increases the germane cognitive load.

Segmenting.

Segmenting suggests separating the information into groups and organizing it hierarchically. This approach assists learners in arranging new information and controlling the learning process. In surgical videos, segmenting can be applied by shortening the duration of videos and labelling key steps while allowing learners to quickly switch between them. Segmenting increases the germane load and regulates the intrinsic load.

Weeding.

Weeding involves the exclusion of irrelevant or distracting information. According to this method, surgical videos should be edited to exclude repeated actions or scenes which are not essential to learning goals. Also, it is helpful to delete the background noise of the operating room and unnecessary conversations between surgeons. Weeding helps to decrease extraneous load.

Matching.

Matching modality to content means choosing a proper channel for particular information and keeping a balance between visual and audial channels of working memory. For surgical videos, this approach can be applied by accompanying the footage with voiceover narration of the surgical process and not overwhelming learners with excessive on-screen text while procedures are being shown. Matching modality to content helps improve germane cognitive load.

Five Perspectives for Understanding the Use of Video in Surgical Education

The search for this section of the literature review was completed in the 'PubMed' database using a combination of search terms 'video' and 'surgical education'. At the time of performing the review, there were 3126 articles under these search terms. In order to demonstrate the variety of uses of video in surgical education, I organized this review into five perspectives that should be considered when producing a video intended for use in surgical education. These five perspectives will be presented as the following questions: 1) what to record? 2) how to record? 3) how to edit? 4) how to disseminate? 5) how to evaluate? I will present them in a table format first and follow that with detailed description as well as with examples from the literature.

Table 1. Five perspectives for understanding the use of video in surgical education.

1. What to Record?	***a. The Purpose.*** • Learning by observing the performance of an expert surgeon • Learning by observing and reflecting upon one's own performance • Learning by observing the performance of a surgical team • Assessment of learner performance • Assessment of the performance of a surgical team • Patient education.
	b. What is to be recorded? • Video recorded from instruments which capture video as part of the surgery (e.g. video-based surgeries such as endoscopic, laparoscopic, and microscopic procedures) • Video recorded during open surgical procedures
	c. Point of View • Surgeon's point of view • Surgical assistant's point of view • Anesthesiologist's point of view • Operating room nurse's point of view • Circulating nurse's point of view • "Virtual" point of view • Multiple points of view
2. How to Record?	***a. Which Type of Video Camera Should be Used?*** • Head-mounted cameras (e.g. The HERO GoPro and Panasonic HX-A500) • Google Glass • Smartphones • Exoscope • 360° video recording

	b. Where should the camera be positioned? • On the head of members of the surgical team • On surgeon's shoulder • On surgeon's Chest • On objects of the operating room
	c. How should sound be recorded? • Internal microphone of the camera • External microphones • After recording, during the editing process
	d. How should video camera be adopted to the OR environment? • Video camera settings • Video camera modifications
3. How to Edit?	• Video-editing methods • Video-editing applications • Length of videos • Tailoring videos to the level of learners
4. How to Disseminate?	• Videotapes • CD-ROM's and DVD's • YouTube • Society Websites • Commercial Websites
5. How to Evaluate?	***Kirkpatrick's model*** • Level 1. Learners' reaction • Level 2a. Change in learners' attitudes and perceptions • Level 2b. Change in learners' knowledge • Level 3. Change in learners' behaviour • Level 4. Long-term outcomes

1. What to Record?

Deciding "what to record?" involves the consideration of three main questions:

a. What is the purpose of the recording?

b. What is to be recorded?

c. What point of view is desired?

a. The Purpose.

I identified six main purposes from the literature:

1) Learning by observing the performance of an expert surgeon.
2) Learning by observing and reflecting upon one's own performance.
3) Learning by observing the performance of a surgical team.
4) Assessment of learner performance.
5) Assessment of the performance of a surgical team.
6) Patient education.

Learning by observing the performance of an expert surgeon.

A video of a surgical procedure, performed by an expert surgeon, may serve as an instructional guide for the surgical trainees. This type of instructional video is perhaps the most common which is described (Mota et al., 2018) and has been shown to be effective (Willaert et al., 2013). In this setting, a needs assessment is typically conducted to find gaps in residents' knowledge in order to create a valuable instructional video (Hayden, Seagull, & Reddy, 2015).

Learning by observing and reflecting upon one's own performance.

A surgeon who carries out a surgical procedure may record it to reflect upon his or her own practice. Reflection upon practice had two main forms: 1) Self-reflection - when the surgeon or trainee watched a video of a procedure performed by themselves (Jamshidi,

LaMasters, Eisenberg, Duh, & Curet, 2009); 2) Coaching - when the surgeon or trainee watched a surgical video (of a procedure performed by himself or herself) with an expert observer or with a peer (Soucisse et al., 2017; Greenberg, Ghousseini, Pavuluri Quamme, Beasley, & Wiegmann, 2015).

Learning by observing the performance of a surgical team.

Video recordings from operating rooms may also be used for the education of other members of the surgical team. A study showed that skill demonstration video was effective in learning nursing skills (Chuang, Lai, Chang, & Wan, 2018). Operating room videos were also applicable to the analysis of interactions between the scrub nurse and surgeon during the surgery (Korkiakangas, Weldon, Bezemer, & Kneebone, 2014).

Assessment of a learner's performance.

Assessment of the performance of surgical residents is an important component of their education, as it provides objective, actionable feedback to the learner based on actual, recent performance. Modern surgical education has increasingly practiced video-based assessment (Huang, Limsui, & Triadafilopoulos, 2018), and it was claimed to reduce bias in assessment (Bowles et al., 2014). Various authors have studied video-based assessment and concluded that it was as reliable and valid as real-time assessment (Laeeq et al., 2010; Scaffidi et al., 2018). Moreover, the fact that the performance is recorded allows for a "crowdsourced" approach to assessment, in which multiple perspectives can be sought on the same performance, including the viewpoint of non-surgical staff. Many studies suggested that this approach was reliable (Lendvay, White, & Kowalewski, 2015; Mahmood, Dagnæs, Bube, Rohrsted, & Konge, 2018), although others disagreed (Conti et al., 2019). Video-based assessment also made remote assessment possible, (Choy, Fecso, Kwong, Jackson, & Okrainec, 2013) and facilitated an

automated, software-based approach to skills assessment (Baghdadi, Hussein, Ahmed, Cavuoto, & Guru, 2019).

Assessment of the performance of a surgical team.

Analysis of surgical team performance was another reason for recording videos in the operating room. For this purpose, multiple sources of a video were needed, such as a close-up view of the surgical field, points of view of health professionals and a general view of the operating room (Guerlain et al., 2005). This type of video data, in combination with multiple sources of audio and physiological data were used progressively by so-called "operating room black-box" studies (Goldenberg, Jung, & Grantcharov, 2017). The primary goal of these studies was to examine the effects of team performance on surgical outcomes and patient safety.

Patient education.

Video from the operating room served as an educational tool not only for surgical trainees or surgeons but for patients too. This type of video helped patients to better understand and prepare for their experience in the healthcare system, and to give a more informed consent (Lin et al., 2018). Also, video-based learning resources for patients were helpful to reduce pre-surgical anxiety and assisted with pre-operative decision-making (Gadler, Crist, Brandstein, & Schneider, 2016).

b. What Is to Be Recorded?

There are more than 20 surgical specialties and thousands of different surgical procedures. Each of these surgical procedures can be video recorded for a wide variety of purposes. There are two main categories of recording:

1. video recorded from instruments which capture video as part of the surgery (e.g. video-based surgeries such as endoscopic, laparoscopic, and microscopic procedures)

2. video recorded during open surgical procedures

Video-based surgeries are more convenient to record, as all that is needed is to record the high-definition live digital image which is an already essential part of the procedure. Educators can easily "tap the record button" and capture everything they see through the endoscope on the video display.

In the case of open surgeries, the situation is not as simple. Complex decisions need to be made about the positioning and operation of the recording equipment. I will discuss this in more detail in the following sections.

c. Point of View.

A surgical team typically consists of a surgeon, surgical assistants, anesthesiologist, operating room nurse and circulating nurse. Each team member has a unique role and first-person point of view of the procedure which is performed. Recording each member's point of view allows us to capture this complex, multi-faceted team experience. In open surgery, the surgeon's point of view probably provides the clearest view of the operating field, the key steps of the surgery, and how the instruments are manipulated. A video combining two or more points of view of the same surgical case is defined as a video with multiple points of view (Wentzell, Dort, Gooi, Gooi, & Warrian, 2019; Wang et al., 2019). With this feature, the entire operating room can be recorded (Jung, Juni, Lebovic, & Grantcharov, 2018).

All of these points of view also exist in video-based surgery, which adds one more point of view: the operating endoscope, laparoscope, or microscope. These types of equipment provide a close-up, mobile view of the part of the body which is being operated upon (Rahal & Charron, 2017, Houkin & Kuroda, 2000, Ogawa, Shiba, & Tsuneoka, 2016). A point of view of recording devices attached to various elements of the operating room equipment such as the lights, the

wall, the ceiling, etc. is called ‘virtual’ point of view. In this case there is no person who normally has this view; the point of view only exists when the camera is placed in this position.

2. How to Record?

This question addresses decisions relating to the technical aspects of video recording, including:

a. which type of video camera should be used?

b. where should the camera be positioned?

c. how should sound be recorded?

d. how should lighting be arranged?

a. Which Type of Video Camera Should be Used?

I have considered the use of footage captured from endoscopic, laparoscopic, and microscopic cameras above. In this section, I will review the use of head-mounted cameras, ‘Google Glass’, the smartphones, the ‘Exoscope’, and 360-degree cameras.

Head-mounted cameras.

Commercially-available wearable cameras are perhaps the devices most frequently used to record first-person point-of-view video in the operating room. The use of head-mounted sports cameras, such as the ‘GoPro Hero’ has been described relatively often in recent years (Bizzotto, Sandri, Lavini, Dall’Oca, & Regis, 2014; Lee, Chen, Chen, Lu, & Giannotta, 2015; Nair et al., 2015; Vara, Wu, Shin, Sobol, & Wiater, 2016). The reasons behind the popularity of GoPro cameras were the low cost, low weight, high resolution (4K), possibility to record stereoscopic (3D) video and the availability of resources for modifications.

‘Panasonic HX-A500’ is another wearable video camera which has been described less often comparing to the ‘GoPro’ or ‘Google Glass’ (Porras, Khalid, Root, Khan, & Singer, 2016).

One of the possible reasons is that the camera mounts on the head laterally and does not capture the exact point of view of a surgeon.

'Google Glass'.

'Google Glass' was a wearable device with an optical head-mounted display, wireless connectivity, processor, touchpad, microphone, bone conduction transducer and high definition camera, which looked like an ordinary pair of glasses (Muensterer, Lacher, Zoeller, Bronstein, & Kübler, 2014). Surgeons were among the first adopters of Google Glass (Glauser, 2013). Such features as voice control, online search, video conferencing have been noted as potentially useful in the sterile conditions of the operating room (Muensterer, Lacher, Zoeller, Bronstein, & Kübler, 2014).

A study conducted by Lee et al. (2017) examined the video quality and usability in an operating room of three commercially available wearable cameras: 'GoPro Hero 4 Silver' (to watch sample video from the study scan QR-Code 3), 'Google Glass' (to watch sample video from the study scan QR-Code 4), and 'Panasonic HX-A100' (to watch sample video from the study scan QR-Code 5). The researchers concluded that the camera GoPro Hero in the narrow field of view mode produced the highest video quality.

QR-Code 3.

QR-Code 4.

QR-Code 5.

Smartphones.

Modern smart mobile devices were also able to capture high-resolution videos in the operating room, by being attached to the surgical lights (Ozucer & Dizdar, 2016), to the surgeons' head (Hakimi, Hu, Pham, & Wong, 2019), or to the surgical microscopes (Perry, Albert, & Akyurek, 2015). By installing two smartphones on the microscope surgeons were able to record even a three-dimensional (3D) surgical video (Gallagher, Jain, & Okhravi, 2016). These described methods are simple solutions for surgeons to produce videos, as mobile devices are ubiquitous, cheap, and easy to operate.

'Exoscope'.

A unique approach was taken by O'Leary et al. (2016) for video recording of open surgical procedures: a laparoscope was arm-mounted externally, facing the surgical field. The so-called 'Exoscope' was initially introduced into the operating theatre by Mamelak, Nobuto, & Berci in 2010, as an inexpensive substitute for a surgical microscope.

During the experiment, the arm-mounted 'Exoscope' demonstrated the best performance in comparison with the 'GoPro Hero 2' or 'Sony Handycam HD Model' (O'Leary, Deering-McCarthy, McGrath, Walsh, & Coffey, 2016). The authors concluded that the Exoscope produced a high definition, magnified, stable and easily transmissible surgical video (to watch sample video from the study scan QR-Code 6).

QR-Code 6.

SCAN ME

QR-Code 7.

SCAN ME

360° video recording.

Modern ‘GoPro’ 360° video cameras, such as ‘GoPro Omni’, ‘GoPro Odyssey’, ‘GoPro Fusion’, and ‘Insta360™ Nano’ enable users to record immersive, interactive virtual reality videos with a full 360 degrees of view around the camera. A study conducted in Ireland, found that 360° surgical video facilitated higher levels of engagement and attention among students in comparison to traditional videos (Harrington et al., 2018). A randomized controlled trial, carried out in England, showed that 360° video teaching promoted better acquisition of knot tying skills compared to 2D video teaching (Yoganathan, Finch, Parkin, & Pollard, 2018).

b. Where Should the Camera Be Positioned?

As noted above, the most commonly described position for the camera to be positioned is on the head of one or more members of the surgical team. A variety of other person-mounted options have been reported.

The ‘Go Pro’ can be used as a shoulder-mounted camera using a harness. This has been reported to be significantly more comfortable to wear during long operations in contrast to the head-mounted version. Also, the shoulder-mounted approach did not interfere with wearing surgical loupes or headlights on the head (Pham et al., 2017).

Surgeons from Canada introduced an approach for recording multiple points of view, from the perspective of a single person (Warrian, Ashenhurst, Gooi, & Gooi, 2015). They used two ‘GoPro Hero 3+ Black’ cameras, which were mounted on the head and on the chest of the surgeon. The head-mounted ‘GoPro’ camera was set up to capture a close-up view of the surgical field. Meanwhile, the chest-mounted camera was arranged to shoot a broader view of the surgeon's hand position and surgical instruments. Later, the separate videos were merged into a

single frame (to watch sample video from the study scan QR-Code 7). The authors believed that this dual camera approach is efficient in surgical education.

A video camera can also be installed on any of the objects of the operating room, such as the ceiling, wall, surgical lights, and surgical equipment. In this case, the camera records video from a point of view which may be mobile (lights, instruments) or predominantly fixed (wall, ceiling). For example, Lin et al (2016) and Zoltie & Ho (2018) reported modifying a 'GoPro' to be attached to the surgical light, which allowed high-quality and magnified video capture in the operating room without damaging sterility or affecting the surgeon's comfort.

c. How Should Sound Be Recorded?

In comparison to the description of how cameras can be used to record video footage, very little has been written about the recording of sounds in the operating room. Many cameras have an internal microphone which able to record high fidelity sound. In addition, the cameras support the use of external microphones (Ho, Shah, Yates, & Shah, 2017). It is also possible to record sound separately from video using a dedicated device, a practice which is common in most digital media production. The video and sound recordings can be synchronized later during the editing process.

d. How should video camera be adopted to the OR environment?

A common problem when recording video in the operating room was overexposure of the recording due to the bright lights of the surgical field (Vara, Wu, Shin, Sobol, & Wiater, 2016). This is an example of the surgical environment being hostile to film-making: the lights need to be bright in order to operate and they cannot be turned down to facilitate video recording. Therefore, video recording process have to be adopted to the operating room environment. For

example, Vara et al. (2016) described ‘GoPro’ camera’s optimal settings when the surgical lights were on and when the surgical lights were off.

Others have described a variety of camera modifications also intended to adapt to the surgical environment. For example, Nicolaou & Rowe-Jones (2016) replaced the body and the lens of the ‘GoPro’ camera to reach a good focus and magnification of the surgical field. The authors also suggested to set up the optimal focus of the ‘GoPro’ camera before starting surgery. To detect the optimal focus, the authors preferred to use an external screen connected to the video camera through an HDMI cable. Nicolaou & Rowe-Jones (2016) have also suggested replacing the standard battery with an external power bank. This made possible several hours of uninterrupted video recording and lightened the weight of the head-mounted part of the camera.

3. How to Edit?

In comparison with the literature on the technical aspects of video recording in operating room, less has been written about how to edit the resulting recordings. The first academic paper about the design of surgical videos was written by Gilder in 1988. He discussed a sequence of video shots, audio commentaries, and technical aspects of videotape editing. At that time, video editing involved videotape machines, cassette tapes, and handwritten record sheets (Gilder, 1988). Nowadays, digital technologies made possible a non-linear method of editing surgical videos (Rehim & Chung, 2015). Therefore, editors can work with video and audio content in each frame of the footage and change its order, meanwhile keeping the source-video unaltered (Rehim & Chung, 2015). With desktop applications, such as Adobe Premiere Pro, Avid Media Composer, Corel Video Studio, Sony Vegas Movie Studio, and iMovie, editing has become more straightforward (Rehim & Chung, 2015).

Several studies have considered the ideal length of an educational video in surgery. A quantitative study, conducted among 169 Canadian medical residents, showed that video and audio podcasts between 5-15 minutes were most preferred (Matava, Rosen, Siu, & Bould, 2013). Fisher, Kaplan, and Egol (2017) suggested removing instances of repeated actions and including only key points of the procedure. However, no studies have compared the educational effectiveness of a "full-length" surgical video with a shortened, edited version.

A study conducted by Mota et al. (2018) suggested that different groups of surgical learners may have different preferences when using surgical videos. Practicing surgeons seemed to value the presence of tips and tricks, as well as information about technical skills, while surgical residents favoured illustrations, narration, and other forms of explanatory information. This suggested that surgeons may used videos to sharpen their own surgical technique, while residents watched to learn more generally. However, this study used survey instruments with suggestive questions, which was a limitation of the quantitative approach. Therefore, the knowledge around tailoring surgical videos for various groups of surgical learners remains poor.

4. How to Disseminate?

In this section, I will consider how a surgical video can be shared with its intended audience. The rule of electronic commerce claiming "the purpose of a distribution channel is to make the right quantities of the right product/service available at the right place, at the right time" is also applicable to surgical videos (Watson, Berthon, Pitt, & Zinnkhan, 2000).

In 1971, Bronson described the distribution of surgical videos using videotapes. He stated that because of the invention of videotapes and videotape recorders, and because of their lower price compared to the film, and because of reusability of the tapes, video recording had become accessible to every surgeon. The author added that from now on surgeons will able to use

surgical videos to show rare and interesting cases to surgical residents, and to share them with colleagues during meetings and conferences.

Around 1995, due to the development of digital technologies, CD-ROM (compact disc read-only memory) became a new medium for disseminating surgical videos (Keerl & Weber, 1995). Educators appreciated the advantages of this medium over videotapes: the possibility to access certain sections of interest directly, in a preferred sequence, without a need to fast-forward through the whole video (Desrosiers, 1998). DVD's (digital versatile discs), introduced in 1997, offered similar advantages to CD-ROMs with additional capacity up to 4.7 GB.

The development of the world wide web revolutionized distribution of material intended for education and entertainment. At the time of writing in early 2020, there are a range of websites devoted to the dissemination of surgical videos.

YouTube is a video-sharing website founded in 2005 and owned by Alphabet Inc. (a subsidiary company of Google). Since its foundation, YouTube has revolutionized the video industry and has become the second most visited website globally (https://www.alexa.com). YouTube allows anyone to upload, watch, rate, save to the playlist and comment on videos. YouTube is probably the biggest resource of surgical videos, which are represented from the perspective of a broad variety of producers, including individual surgeons, medical centers, hospitals, institutes, universities, surgical societies, private companies, etc. Consequently, the quality and reliability of the surgical content also fluctuates widely. Surgical residents watched YouTube more often in comparison to practicing surgeons, both groups watched YouTube more often than any other sources of surgical videos (Mota et al., 2018; Rapp et al., 2016).

Society webpages, such as American College of Surgeons, Royal College of Surgeons of England, SAGES, and The Rhinoplasty Society of Europe have media libraries composed of

good quality, verified and validated surgical videos. Studies conducted by Mota et al. (2018) and Rapp et al. (2016) showed that these sources were more valued by practicing surgeons compared to surgical residents.

There are a number of commercial websites which also provide high quality videos (e.g. AccessSurgery). These types of videos seem also to be watched more frequently by practicing surgeons than surgical residents (Mota et al., 2018; Rapp et al., 2016). There were also a number of other websites, such as SCORE, WebSurg, EyeTube, BroadcastMed which were more preferred by surgical residents in comparison to surgeons (Mota et al., 2018; Rapp et al., 2016). These websites provided surgical videos in a broad variety of surgical fields for free.

5. How to Evaluate?

This section considers studies on the impact of videos as an educational tool in surgery. To frame this discussion, I will employ Kirkpatrick model of evaluation for educational interventions. This model will allow stratifying various studies by the extent of the impact of videos as an educational intervention.

Kirkpatrick's model evaluates the impact of training interventions on learners, based on four steps or 'levels': reaction, learning, behaviour, and results (Kirkpatrick & Kirkpatrick, 2006). In the first level, learners' reaction is evaluated regarding their satisfaction, opinions, and feelings about learning intervention. In the second level of evaluation, the various tests and exams need to be carried to determine what is actually learned. The learning intervention reaches the third level of Kirkpatrick's model when it changes the behaviour of the learners, while they implement learned knowledge and skills into practice. The fourth level is achieved when the knowledge and skills from learning intervention result in outcomes after being implemented into

practice. Barr et al. (1999) revised Kirkpatrick's model and divided the second level into two: 2a) modification of attitudes/perceptions; 2b) acquisition of knowledge/skills.

Level 1. Learners' Reaction.

A number of studies have examined learners' reaction to surgical videos. For example, Poon et al. (2017) developed a video-library in "multimedia-style format" for otology and neurotology surgical procedures. After watching these surgical videos, otolaryngology residents reported that intervention was highly useful and believed that it will increase self-efficacy.

Level 2a. Change in Learners' Attitudes and Perceptions.

A few studies have explored the association of watching surgical videos with learners' attitudes and perception. Reck-Burneo et al. (2018) studied the impact of watching video and reading manuscript on confidence in performing a difficult pediatric surgical procedure. The confidence of 101 pediatric surgeons and fellows was assessed using an 11-item questionnaire before and after the interventions. Researchers summarized that self-reported confidence of participants improved significantly after both interventions.

Level 2b. Change in Learners' Knowledge.

A number of studies have demonstrated learning associated with the use of surgical videos. For example, Yilmaz et al. (2017) conducted a study which examined the learning impact of a laparoscopic appendectomy video on general surgery residents and specialists. Using questionnaires before and after the intervention, the authors measured the baseline knowledge and its improvement. The researchers found that scores had significantly increased after watching the video. Another study, conducted by Mongelli et al. (2018), showed that surgical trainees resulted on average two times higher in tests, after watching a laparoscopic cholecystectomy surgical video.

Level 3. Change in Learners' Behaviour.

A number of studies have investigated changes in learners' behaviour and skills associated with the use of surgical videos. A study conducted at the University of Alberta examined the influence of a video teaching module for thyroidectomy on the surgical performance of residents (Hamour et al., 2018). The residents performed thyroidectomy on patients before and after watching the video, while their surgical skills were assessed using the Observational Clinical Human Reliability Assessment (OCHRA) system (Tang, Hanna, Joice, & Cuschieri, 2004). Hamour et al. (2018) concluded that the intervention decreased the error occurrence by 49%.

Another study, conducted by researchers from the Netherlands, analyzed the effect of an INtraoperative Video-Enhanced Surgical Training (INVEST) on surgical residents' technical skills and compared to the traditional master-apprentice model (MAM) (van Det et al., 2011). The residents were randomly assigned to the groups (INVEST and MAM) and performed a series of laparoscopic cholecystectomies on patients. An Objective Structured Assessment of Technical Skills (OSATS) global rating scale was used to measure the residents' surgical performance after each procedure (Martin et al., 1997). The improvement of the residents' scores was significantly higher in INVEST group (59,1%) in comparison to MAM group (34,6%) (van Det et al., 2011).

Level 4. Long-term Outcomes.

The examples of studies on surgical videos that reaches the fourth level of Kirkpatrick's model were not found.

Conclusion

This literature review demonstrates that surgical videos have become an essential tool for modern surgical education. The majority of surgeons and trainees watch videos regularly for preparation before surgery. This is not surprising, as watching surgical videos provides several advantages over the direct observation and improves technical skills along with surgical performance. This has resulted in the generation of a tremendous amount of online surgical videos, with a wide range in quality.

A number of psychological theories are relevant to the production of effective surgical learning videos. Cognitive load theory and the cognitive theory of multimedia learning suggest that there are several key features which are likely to make surgical videos more educationally effective. Even these theories were broadly applied for designing educational videos in other fields and were shown to be effective, they were not examined in case of surgical videos.

To understand the full variety of implementations of videos in surgical education, I looked at them from the five main perspectives: 1) What to record? 2) How to record? 3) How to edit? 4) How to disseminate? 5) How to evaluate? The review of the literature from these five perspectives revealed the gaps in the existing knowledge regarding the use of videos in surgical education. The perspectives of 'What to record?' and 'How to record' were discussed extensively in the literature. However, the knowledge of 'How to edit?' surgical videos remained poor, especially from the viewpoint of tailoring it to different groups of learners. Exploring the learners' purposes of watching videos could enrich the knowledge in this area. The perspective 'How to disseminate' surgical videos acknowledged that YouTube was used the most often by learners, despite the content, quality, and educational value of surgical videos on this platform were doubtful. Exploring the learners' practices of watching videos could improve

our understanding of this phenomenon and supplement the knowledge on tailoring videos to various learners. The perspective ‘How to evaluate?’ revealed that even surgical videos were studied for their effectivity, the long-term effects of using videos in surgical education were not studied yet. In addition, the effectiveness of surgical videos was not considered from the perspective of their various attributes. However, exploration of these attributes is needed before examining the effectivity.

This literature review shows that the question “what is a ‘good’ surgical video?” from the learning perspective still remains open. In exploring this concept, I will use qualitative methodology approaches with following research questions:

- What do learners use video for, how do they use it?
- What are the attributes of a ‘good’ video?

Chapter III. Research Methods

This chapter describes the research methods utilized for this study. First, it will present the study methodology and its justification. Following, it will describe the methods of data collection, the participants, the process of recruitment, the process of data collection, the development of data collection tools, and the ethical considerations. Finally, this chapter will discuss the methods and process of data analysis in detail.

Study Methodology and Justification.

Qualitative methodology approaches were used in this study. Data were collected through semi-structured interviews with three groups of participants: medical students, surgical residents, and surgeons. Thematic Analysis method was used for data analysis.

Quantitative methodology approaches were also considered for this study, such as experimental methods with various edits of a single surgical video to reveal attributes of surgical videos that are effective, or survey methods with different groups of surgical learners in order to reveal attributes of videos that are valued. However, these methods would limit participants with the researchers' knowledge and perspectives of attributes of ‘good’ and effective surgical videos. Moreover, as the literature review suggested, the existing knowledge regarding the various attributes of ‘good’ surgical videos and their effectivity is poor. Therefore, the qualitative approaches were favoured over quantitative since the qualitative approaches were expected to explore the perspectives of surgical learners regarding the attributes of ‘good’ and effective videos.

Methods of Data Collection.

In-depth semi-structured face-to-face interviews were conducted with participants due to the qualitative nature of the research questions that evolved during the literature review.

Interviews can be defined as a “professional conversation” (Kvale, 2007), during which participants are encouraged to share their comprehensions and insights regarding the topic of the research, while the researcher intends to register the participants' language and beliefs (Rubin & Rubin, 1995). These qualities were the underlying motive for choosing this approach for the data collection. Furthermore, as Braun & Clarke states, interviews are “the most common” form of collecting qualitative data (Braun & Clarke, 2013, p. 77).

The in-depth nature of the interview allows a researcher to receive rich, detailed descriptions of participants' thoughts, perceptions, and experiences by asking open-ended questions and following-up with probing questions. The semi-structured scenery of the interview (Patton, 2002) gives more freedom to a researcher; the researcher may ask additional questions for clarification or exploration of unexpected and interesting topics that may emerge during the interview rather than strictly following the order of questions from an interview protocol. The semi-structured interviews are the “dominant form for qualitative interviews” (Braun & Clarke, 2013, p. 78). The face-to-face interviews were preferred over the virtual alternatives for this study, as they claimed to be the “ideal way to collect interview data” (Braun & Clarke, 2013, p. 79) or the “gold standard” (Novick, 2008, p. 394).

The Process of Participants Recruitment.

The purposeful sampling approach was utilized for recruiting participants from three separate groups of surgical learners: medical students, surgical residents, and surgeons. This approach perfectly fits qualitative study, as it allows involving samples that have “something to say”, have experience and interest on the research topic. No exclusion criteria were applied to recruiting participants other than not belonging to one of these three groups of surgical learners.

Convenience sampling, friendship pyramiding, and stratification strategies were used for recruitment. For the convenience sampling strategy, e-mail invitation letters were sent to surgical residents and surgeons throughout all surgical divisions at the University of Alberta, as well as to medical students throughout the Medical School of the University of Alberta. The e-mail invitation letters included a brief description of the study, research questions, and a brief overview of the interview process. The friendship pyramiding strategy allowed for the recruitment of participants through personal connections of the research team and through recommendations of participants who already took part in this study. Variations in years of study for medical students, years of training for surgical residents, years of experience for surgeons, as well as variations in surgical specialties and diverse gender representation were considered for the stratification strategy.

Process of Data Collection. Interviews.

Participants were contacted through e-mails to arrange for interviews at a convenient time and location for them. The locations preferred by the surgeon participants were their offices, situated at three hospitals of the City of Edmonton: University of Alberta Hospital, Royal Alexandra Hospital, and Grey Nuns Hospital. However, the surgical residents and medical students preferred meeting at one of the neutral and quiet spaces, like library study rooms. Therefore, the interviews with medical students and residents were conducted in the study rooms at the John W. Scott Health Sciences Library of the University of Alberta.

The “Information letter & Consent form” document was sent to participants through e-mail before the interview, in order to allow them to familiarize themselves with the content of the document. This document represented a broader description of the study, explained confidentiality and anonymity considerations, and outlined rights, benefits, and risks for the

participants. The hard copy of the document was signed by the interviewer and by each interviewee prior to starting the interview. Additional questions were answered orally and more information regarding the course of the interview was provided upon request.

The interviews started with an introductory speech by the interviewer about himself and his research project. It followed with a chat about the current position of the participants, their relationships with surgery, and surgical videos. Then, it moved to the discussion of the questions from the interview protocol. As the interviews continued, the sequence of the questions from the interview protocol was not followed strictly, leaving some freedom for important topics to unfold. Also, there were additional questions that were not listed in the interview protocol and were asked by their relevance to the topics of discussions, or for further clarifications and explanations. The duration of the interviews varied between 20 to 40 minutes.

Pilot Interviews.

Two pilot interviews were conducted with graduate students in Surgical Education program, before the start of the formal data collection. These interviews served as a practice session for me to reflect on my interviewing skills, to refine the interview questions and to check audio-recording equipment. The pilot interviews were not included in data analysis.

Data Recording, Storing, and Transcribing.

Data from the interviews were recorded in two ways: audio-recording and note-taking. Two independent audio-recording devices were used at the same time to prevent data loss. In addition, I was taking field notes during the interview to capture my reflections, insights, and observations.

All digital files of audio-recordings and transcripts are stored within a secure, password-locked, encrypted personal computer. Digital data will be stored for five years and then will be

securely discarded. The field-notes and signed hard copies of the "Information letter & Consent form" document are stored within a password locked secure office space and also will be securely discarded after five years.

The audio-recordings of the interviews were transcribed by the interviewer, using the orthographic style. Offering the transcription to third-party services was avoided so the interviewer can thoroughly get familiar with the data and to prevent a potential breach of anonymity or confidentiality standards.

Interview Tool.

The interview protocol was developed by M.A. and was further refined in collaboration with J.W. The interview protocol included three main groups of questions that were aimed to explore: 1) learners' overall experiences of using surgical videos, 2) learners' habits and practices of using surgical videos, 3) learners' perspectives regarding the use of videos to prepare for surgical cases. The majority of questions were composed in an open-ended style, so an interviewee cannot simply give yes or no answers, but encouraged to provide rich, profound, elaborate, and comprehensive answers. Some of the questions for the interview protocol were borrowed and adapted from a questionnaire that was created for the study of Rapp et al, 2016. The full list of questions from the interview protocol can be viewed in Appendix A. As was discussed earlier, this document served as a guide for the interviews and was not followed strictly. The overarching goal of the interviews was to understand why and how the learners use surgical videos, as well as what attributes in surgical videos they value, which also stated as the research questions of the study.

Ethical Considerations.

Ethical approval was obtained from the Health Research Ethics Board of the University of Alberta (Pro00091584). The identifying data, such as names, occupations and email addresses of the participants were known only to me. No identifying data was associated with the transcripts, analysis, presentations, or anything related to the dissemination of the research results. The participant names were coded with generic pseudonyms in accordance with the groups they belong to. For example, surgeons' names were coded with the letter "S" and a unique number, such as S1, S2 and so on. In the same fashion, the letter "R" was assigned for the surgical residents and the letter "M" for the medical students.

Methods of Data Analyses.

Data were analyzed by using the Thematic Analysis method - a systematic approach that intended to recognize the meaningful patterns and information across the data, which are capable to answer the research questions (Braun & Clarke, 2006). Combination of Inductive and Theoretical variations of the Thematic Analysis was applied, which allowed patterns and themes emerge from the data in "bottom-up" fashion, as well as identifying those patterns and themes through existing theories of learning and psychology in "top-down" fashion (Braun & Clarke, 2006).

The initial reading of the interview transcripts was performed in order to get familiar with the data. Notes about primary patterns in the data were taken during the transcription of audio-recordings and during the initial reading. These notes served as a guide and support for the next step - Complete Coding, which means assigning a short description or phrase that represents each meaningful data unit (i.e. phrases, topics, or concepts participants spoke about) that has the potential to answer the research questions. Two types of codes were assigned to the data units:

in-vivo codes, that capture exact phrases or expressions that participants used, and descriptive codes, that summarize participants' understandings, ideas, or beliefs. Complete Coding was performed for all transcripts in groupings, in accordance with the three groups of surgical learners that were recruited for the data collection: medical students, surgical residents and surgeons.

The process of coding was performed electronically using 'Microsoft Word Document'. All transcripts from the same group of participants were organized into a single 'Word Document'. As a result, there were three 'Word Documents', that represented each of the groups of learners. Each of the 'Word Documents' contained a table with three columns. The transcription texts were arranged into the first column of the table, the codes were entered to the second column within the same line with the data unit that was coded, and the third column was assigned to candidate subthemes and themes, that were also entered within the same line as data units and codes that they represent. The text color highlighting function was used to emphasize the meaningful data units that were coded. Different colors for highlighting were used to classify the data units in accordance with both research questions. The example of the coding process is presented in Appendix B, in the form of a screenshot from one of the 'Word Documents'. During the process of coding, each transcript was read repeatedly three times, in order to make sure that coding was complete and all meaningful data units were acknowledged. After the complete coding, initial patterns and candidate themes have emerged from the data.

Three independent analysts were involved in the data analyses: myself., J.W., S.T. The codes, initial patterns across the data, as well as candidate themes and subthemes, were compared between the independent analysts. All of the independent analysts met four times, in-person and online due to the COVID-19 pandemic of 2020, until a complete agreement between

the analysts was reached regarding the final codes, subthemes, themes, and their relationship. Another two meetings were held between me, J.W., S.T. and B.Z. for the discussion of data analysis strategies, reviewing and refining the results of the analysis. The relationships and connections between the themes, subthemes and codes were systematized into two conclusive thematic frameworks. Based on the answer to the research question about a ‘good’ surgical video, a hypothetical model of attributes of ‘good’ and ‘bad’ surgical videos was developed, as a validation step.

Chapter IV. Results

Two independent frameworks were developed in accordance with the research questions of this study. The first framework answers the question of ‘what do learners use surgical video for and how do they use it’. The second framework answers the question of ‘what are the attributes of a "good" surgical video’.

In this chapter, the process of development of both frameworks will be explained. Following that, the participants of the study will be described. Finally, Framework 1 and Framework 2 will be presented by providing schematic illustrations, explaining relationships between themes and subthemes, as well as supporting them with representative codes and quotes.

The Development of the Frameworks.

Before the start of the data analyses, it was expected that the medical students, surgical residents, and surgeons would have distinctive purposes and practices of using surgical videos from each other. However, the process of data analyses revealed that the answer to this research question was more complicated than was expected. For instance, there were variations in purposes and practices of using videos among the learners within each of these groups. These variations were not distinctly allocated between three groups, since some of the learners from one group had similar purposes and practices of using videos with the learners from another group. Moreover, some of the surgical learners had multiple purposes and practices of using videos that were similar to the different groups at the same time, depending on the type of surgical procedure that they were preparing for. Therefore, it was decided to view all of the learners in a continuum of a growing surgical proficiency, instead of binding them to the initial three groups. This continuum served as a basis for the development of Framework 1. (Notably,

there were several attempts with various underlying concepts before building the final version of the framework. These intermediate frameworks can be viewed in Appendices C, D, E, and F.)

Another round of data analysis was conducted to address the second research question on the attributes of a 'good' surgical video. These attributes were similar for all of the groups of learners and resulted in the development of Framework 2.

Participants.

The data saturation principle defined the number of participants for this study, which means the recruitment continued until the data was rich and new patterns or themes were not emerging. The data saturation principle also assumes that processes of data collection and data analyses were ongoing at the same time. However, the availability of participants and time limitations have also influenced the number of participants included in this study.

The number of participants was 25 in total including 9 medical students, 8 surgical residents, and 8 surgeons. The participants were represented by medical students from years 1 to 4, by surgical residents from years 1 to 5, and by surgeons, varying from the ones in their early careers to the ones with more than two decades of professional work experience (see Table 2). The surgeons and residents were recruited from a broad variety of surgical specialties, such as General Surgery, Cardiac Surgery, Thoracic Surgery, Neurosurgery, Otolaryngology - Head & Neck Surgery, Gynecology & Obstetrics, Trauma & Acute Care Surgery and Bariatric Surgery (see Table 3). Among the participants, 2 medical students, 3 surgical residents and 1 surgeon were females. The rest of the participants were males.

Table 2. Number of medical students and surgical residents by years of training.

Group of learners	Year of training	Number of participants
Medical students	1st year	2
	2nd year	3
	3rd year	2
	4th year	2
Surgical residents	PGY-1	4
	PGY-4	3
	PGY-5	1

Table 3. Number of surgical residents and surgeons by specialties.

Group of learners	Specialty	Number of participants
Surgical Residents	General Surgery	3
	Cardiac Surgery	1
	Neurosurgery	1
	Otolaryngology - Head & Neck Surgery	2
	Gynecology & Obstetrics	1
Surgeons	General Surgery	2
	Cardiac Surgery	1
	Thoracic Surgery	1
	Neurosurgery	1
	Otolaryngology - Head & Neck Surgery	1
	Trauma & Acute Care Surgery	1
	Bariatric Surgery	1

Framework 1. The Journey of a Surgical Learner.

Three major themes were developed to demonstrate the variety of the purposes and practices of using surgical videos: 'Seeing', 'Doing' and 'Perfecting'. These themes represent the journey of a surgical learner through continuous stages of the surgical career, where 'Seeing' includes learners in the early phase of the career, 'Doing' includes learners in the middle phase, and 'Perfecting' – in the later phase of their career (see Figure 1). Further, each theme will be described in detail by presenting definitions, subthemes, and key concepts with examples from the data.

Seeing.

This theme represents learners in early phase of the continuum, who intended to build a fundamental understanding of Surgery as a discipline, to learn more about surgical cases and to acquire a procedural knowledge of surgeries by 'Seeing' them in videos. This theme constituted from three subthemes: 'Acquaintance with Surgery', 'Understanding a surgical disease', and 'Understanding a surgical procedure'. These subthemes also can be viewed as steps that learners progress through, as their proficiency and experience increase.

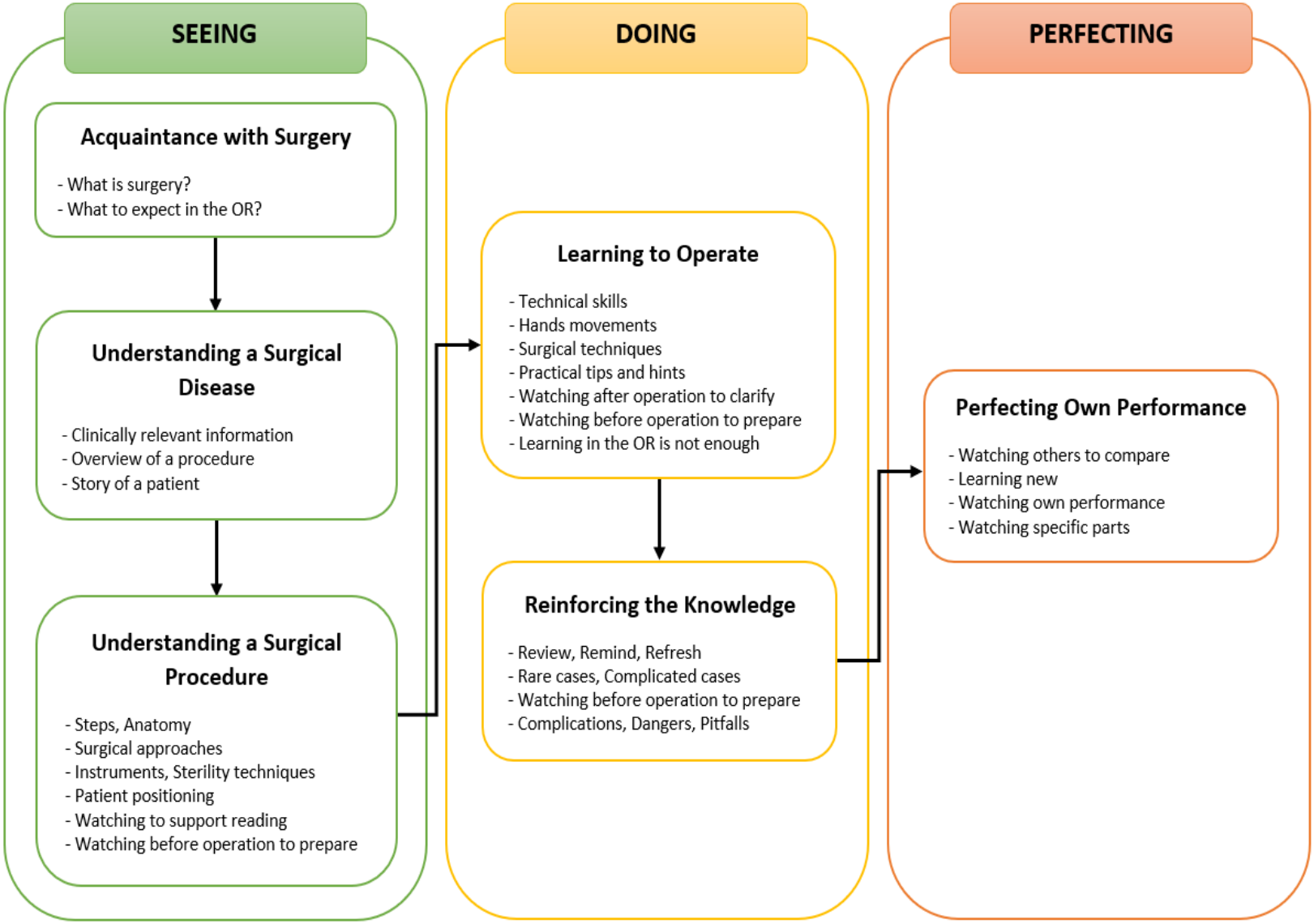
Acquaintance with Surgery.

At the step of 'Acquaintance with Surgery' learners were interested to know what Surgery is as a discipline, what surgical operations look like, and what to expect when they visit the operating room.

"What is Surgery?"

For example, some of the participants stated that they watched videos as they were learning about surgery during classes and they were interested to know how it looks in practice:

Figure 1. Purposes and practices of using surgical videos.



- “If we learn about certain surgeries in class and want to have an idea of what happens in the OR - so that's why I watch them” (M4)
- “I think it [surgical video] adds a measure of realism to what surgery is” (M2)

One of the participants, while thinking back about earlier years in medical school mentioned watching videos to have a basic understanding of what surgery is:

- “Early on it was like ‘what is surgery?’. So now I guess I'd be looking more for a broader understanding of each procedure” (M5)

What to expect in the operating room?

Also, at this step, learners were interested to know what to expect when they visit the operating room, what are the rules of shadowing in the operating room, how long they going to be in the operating room, what they will be able to see and learn:

- “[Surgical video] can set your expectations where they need to be. For example, how long the operation is going to take, what levels of exposure you're going to have” (M5)
- “Clear description of… what we're allowed to do, and where we're allowed to stand, or what we're allowed to see - maybe explaining that beforehand would give people realistic expectation before heading into OR for shadowing” (M2)

Understanding a surgical disease.

At this step, surgical learners were intended to 'Understand a surgical disease' as a complete path of a surgical patient through a disease, whereas a surgical procedure is a substantial but single part of the path. Therefore, these learners watched surgical videos for a brief overview of a surgical operation and relatively detailed information about the surgical case: clinically relevant information about the patient, what caused the need for the operation, and what this patient can anticipate after the operation.

Clinically relevant information.

Learners at this step described type of clinically relevant information that they were looking for, such as physiology and epidemiology of the disease, treatment strategies, indications for operation as well as postoperative outcomes:

- "The physiology of disease, and some of the prevalence epidemiology and stuff; and then learning about what the different treatments are, both medical and surgical; what indications for surgery are, and then trying to learn them. I'll focus on it a little bit less at my stage, but some of the steps of surgery, what the important parts are, what we actually be doing. And then postoperative outcomes and stuff - so trying to just learn the disease start to finish, and then where the surgery fits into that." (M7)
- "Provide a full contextual detail of what the disease is, and then follow that up with you think how would work it up, and then follow that up with the actual procedure" (R2)

Overview of a procedure. Story of a patient.

The learners at this step also addressed that they were not interested as much in seeing procedural and technical aspects of operations, such as steps, approaches, techniques, landmarks etc. They believed those aspects were not essential at this step and preferred to learn more about what happens with a patient before the operation and what follows after it, as was discussed earlier:

- "At my stage I don't pay too much attention to the steps of the surgery per se, or what happens first what happens next as much, or what kind of cuts you need to make, or where exactly those cuts, how to landmark those cuts and all that. I think that's more very technical stuff and in time I'll learn that. But for me what's helpful is to just get an idea of

what someone can expect when they go into one of these surgeries, or what you can expect maybe after." (M4)

The following quotes also demonstrate that learners at this step were not interested in details, but looked for an overview of a procedure:

- "I found them to be helpful in providing you a broad overview of what you can expect throughout a procedure. I think this is mainly because at this stage of my training I don't know all the ins and outs of particular operations" (M5)
- "I like the ones that kind of give you an overview start to finish… just to focus on the main aspects" (M9)

Understanding a surgical procedure.

After acquiring the clinically relevant information about surgical cases and about patients at the previous step, learners at the step 'Understanding a surgical procedure' were aimed to learn specifically about surgical operations in more detail. Thus, the main purpose of watching surgical videos was to see steps, anatomy, surgical approaches, instruments, sterility techniques, and patient positioning.

Steps.

Seeing steps of the operation was one of the major reasons for watching videos, although the learners preferred to see them in association with the anatomy:

- "I think they [surgical videos] are very helpful for knowing steps of a procedure" (M9)
- "Associating the steps with the anatomy and with the procedure, so that you actually know all things together instead of being them disassociated" (R2)
- "Association between what your steps are and what the anatomical equivalent to that [is helpful in surgical videos]" (R3)

Anatomy.

Anatomy also was of major interest for the learners at this step and they watched videos to see the "in-vivo", "3-dimensional" anatomy, or how it looks "inside the body":

- "I find that videos are helpful in terms of showing in-vivo anatomy" (M6)
- "I think it helps with the 3-dimensional view of anatomy, a lot better than, you know, a lot of the textbooks do" (M1)
- "I also want to learn more anatomy… how does that look like inside the body? So, having an idea of that as well is something that I'm interested in" (M3)

Surgical approaches, instruments, sterility techniques, patient positioning.

The learners also emphasized the value of seeing surgical approaches, instruments, sterility techniques, and patient positioning in surgical videos:

- "Surgery is really a visual discipline. So, I feel it's really useful for the anatomy and also for surgical approach, and the way to position the patient and position the patient's head. It's really useful to see it on video" (R1)
- "Paying attention to positioning, paying attention to instruments, and the different I guess sterility techniques" (R3)

Watching to support reading.

These learners seemed to be reading surgical textbooks more often, but they found that sometimes texts or drawings in textbooks were not explicit and easy to follow. Therefore, they watched videos to clarify and support their reading, to have a clearer visual representation of the subject they read:

- "I'll read about the procedure, and if for some reason in my mind I can't understand the anatomy or something doesn't quite make sense, then usually I turn to the videos to have

a look and see if I can understand or sort of pinpoint what the issue is between the way it was written and the way that it's actually done" (R3)

- "I find having just a visual representation of a video is way superior to spending hours in a textbook" (M6)
- "They are helpful in supplementing textbook materials, not only visually but also information that are current and more detailed" (M8)

Watching before the operation to prepare.

The other reason of watching surgical videos for the learners at this step was to prepare themselves before shadowing a surgeon in the operating room. Therefore, they watched videos for 'pre-seeing' the procedure, which made it easier for them to understand anatomy and follow the procedure. Moreover, learners believed that by 'pre-seeing' the operation they can ask more meaningful questions from the surgical team and get the most out of their learning in the operating room:

- "I usually try to find at least one type of video before I go into a case in the OR... I think it prepares me for what I should be looking for, and then I find that I can actually follow along with the steps of the OR much better" (M6)
- "As someone who would like to become a surgeon, I watch them so that I can get more out of my actual experiences when I am in the operating room shadowing… Because if you prepare yourself by knowing what's some of the basics about the procedure, then I think you can actually retain and absorb more because it's not all brand new information to you. So, when you're actually seeing, it is actually more of a repetition on your first exposure… And also, to avoid bothering the staff and the surgeon constantly in the operating room with questions" (M9)

Doing.

The theme ‘Doing’ describes learners in the middle phase of the proficiency continuum. This theme is organized into two subthemes: ‘Learning to operate’ and ‘Reinforcing the knowledge’, which also can be considered as consecutive steps of learners' progression through the continuum. Contrasting to learners at the previous steps, learners at these steps watched surgical videos in order to do surgeries. Therefore, these learners mainly aimed to learn how to perform operations or just to review, remind, and refresh the knowledge that was acquired in the earlier steps of the continuum.

Learning to operate.

The step ‘Learning to Operate’ represents learners that used videos mainly to learn how to perform operations. The crucial difference from the previous steps, where learners watched videos to see ‘what surgeons do in the operating room and why?’, at this step learners were interested to learn ‘how they do it?’.

Surgical techniques, technical skills, hand movements, practical tips and hints.

For learners at this step, the primary purpose to watch videos was to apprehend surgical techniques, technical skills, hand movements, manipulation of instruments, as well as to receive practical tips and hints. For example, some of the learners described what aspects of the operation they payed attention while watching videos:

- “Looking more at the techniques and trying to focus on how the surgeon is moving their hands or using laparoscopic tools, so I can have a better idea of what I need to be doing and what may it should look like” (R5)
- “If there is a good teacher then they give you tips and hints on how they're doing the procedure” (R6)

- “I think you get more interested in the actual techniques of operating. As a medical student and a junior resident, you want to know ‘why am I going to the operating room?’ and ‘why we are doing operation?’ And then as a senior resident, you're more interested in actually physically ‘how I'm going to do this operation?’” (R8)

These learners emphasized the advantages of videos over texts and illustrations for mastering surgical skills:

- “In hand skills you cannot really learn by looking at pictures and by reading - so videos help in that way a lot” (M8)

Watching before the operation to prepare.

The learners at this step also described that they watch videos before going into the operating room to prepare for it. However, the purposes of ‘pre-seeing’ operations were slightly different compared to the learners from the previous step and were more practically inclined in character. For example, these learners claimed that ‘pre-seeing’ makes operation easier, helps them to orient better during the operation and to communicate more effectively with other surgical team members:

- “I feel like by seeing the videos I'm preparing for that operation. Because then, when I look at it in a real life, then I can recognize what the staff wants me to do or how to do that dissection.” (R6)
- “When you watch something before it looks more familiar when you are doing it and so it's a bit easier than if it's completely brand new” (R5)

Watching after the operation to clarify.

One of the other reasons to watch videos for these learners was to clarify and consolidate the knowledge after the operation. For example, learners noted that videos are helpful to clarify

certain techniques, approaches, and concepts that were confusing during the operation or to consolidate the acquired knowledge:

- “Same thing after the case - if I'm not sure, I didn't really see where my staff took that bite at the coronary, so I want to take a look and see what it looks like again, and I'll try to find a video demonstrating that particular step” (R8)
- “They’re great for review afterwards as well, to consolidate knowledge” (R7)

Learning in the operating room is not enough.

Notably, the learners explained that learning in the operating room is not enough, especially when cases are unique, complex, or require special equipment. Moreover, the learners seemed to be implying that they may miss some learning opportunities, as they were usually occupied with assisting. Consequently, these learners watched videos to compensate for those missed learning opportunities because of rare cases or being distracted by assisting:

- “We don't get as many opportunities, especially for laparoscopic or robotic procedures, to see the operations as many times. When you get that one chance and you want to do well. I feel like by seeing the videos I'm preparing for that operation.” (R6)
- “Because we don't get enough time in a case to learn everything we need to learn about the case. So, I'll watch them in preparation... Just to prime myself for what it's going to look like, what to expect going in there.” (R8)

Reinforcing the knowledge.

The step ‘Reinforcing the knowledge’ represents learners that already had acquired the knowledge about surgery as a discipline, about surgical disease, about surgical procedures and how to perform them. Thus, at this step learners used videos to reinforce the knowledge that they acquired at the previous steps.

Review, Remind, Refresh.

Learners at this step described watching videos mainly to review and remind the knowledge, or simply to refresh their memory regarding the anatomy, steps, surgical technique, and technical skills:

- "I watched them to refresh skills" (R4)
- "I used to review the anatomy… that I need to be up to date on. I'd like to remind myself that technique by reviewing that video." (S1)
- "As a staff, I definitely use them just to remind myself what to look for, to give myself a refresher. Because now I have all the skills, I just need some kind of refresher in order to be more comfortable with it." (S7)

Rare cases. Complicated cases.

The learners also described watching videos to refresh, remind, and review when they came across relatively rare or complicated cases:

- "If it's a procedure I haven't done in a while, or rare procedure, or something I just haven't been involved with for a while - I do it is kind of I call refresher course" (S2)
- "If I am doing an operation that have not done for a while, I will go and watch a surgical video" (S4)
- "For routine cases really not much of a role. For something that's rarely done, or very complicated, or a new innovation on a procedure - those things I think video could be useful." (S5)

Watching before the operation to prepare.

Learners at this step, likewise to the learners at steps before, also reported that they usually watched videos before operations to prepare for them. One of the learners even described

this concept in further detail, stating that watching videos helps to visualize the operation and be more attentive about it, as professional athletes do before important performances:

- "[I use surgical videos] to confirm steps in a process or steps in a procedure that I may have done 2 years ago that I haven't seen; as a way of refreshing my memory and refreshing my skill set prior to starting in case" (R4)
- "I think they prepare you for the OR. Just like as an athlete, when you have a big game you close your eyes and you're mindful before and kind of visualize. I think it's exact same thing is when you're a surgeon - so it kind of gets me in the headspace, gets me thinking about what sort of technique I want to use… And seeing it and then doing it is really helpful I find" (S7)

Complications, Dangers, Pitfalls.

Despite the learners at this step used videos to prepare for operations, their objectives were different from the learners at the previous steps. The learners at this step seemed to be more attentive about preparing for the operations and they used videos to be reminded of potential dangers, pitfalls, and complications that may occur during the operation:

- "Video may also be a good refresher on the pitfalls and things to keep in mind as you are doing a surgery" (S1)
- "One of the ones that stands out in terms of good video is a video of complications. That almost never do we see. Surgeons people show what they do well, and there's been in the past a I think a barrier to showing how you did something wrong. And I think for me a lot of the learning in surgery is to learn how to get out of a problem." (S3)
- "It's better to be reminded before the OR then when you're in the OR" (S7)

Perfecting.

The theme 'Perfecting' represents learners in the later phase of the continuum. The main reason for them to watch videos was to perfect their surgical performance or skills previously acquired:

- "I use videos to further refine and optimize procedures that I'm currently doing" (S2)
- "Videos are very applicable for staff… who want to really improve their outcomes and maybe learn other additional techniques" (S7)

This theme is presented as a single step that outlines three major reasons for watching videos – 'Watching others to compare', 'Learning new' and 'Watching own performance'. Also, this theme describes a major characteristic of the reasons to watch videos – 'Watching specific parts'.

Watching others to compare.

Learners at this step stated watching videos just to see how other surgeons operate, so they could compare their own methods, approaches, techniques and improve them. Some of the learners even equaled watching videos to visiting other surgical centers. 'Watching others to compare' also implies that videos have become a medium for surgeons to communicate, where they can share their practices and learn from each other:

- "Just to see how other people do it, right? To compare my technique against others. I found it quite helpful to watch a good surgical video to see how they're doing, and I'll be trying to improve my own practice, technique" (S1)
- "I'll often watch numerous videos from different institutions to see different ways of doing the same procedure and then often combine those to make my own planner conduct of operation" (S2)
- "It's almost like visiting another center, to see how things are done differently" (S4)

- “I like to watch them just to get a sense of how other surgeons approach a problem or a management of an issue… So, I can learn some different techniques or different ways.” (S8)

Learning new.

Also, learners at this step described using videos to see something new - new approaches, new techniques, new skills, new technologies or instruments:

- “[I watch surgical videos] to see new skills or learn new skills or to see things that have not seen” (R4)
- "[I watch surgical videos] if there's some new technology, new techniques” (S1)
- “Something new - new approach, new technique, new instrument… those are I think the very useful things” (S3)

Watching own performance.

Some of these learners also reported watching videos of their own operative performances. They found watching their own videos to be helpful to analyze and improve their own performance, or to prepare for the operations:

- “I have enormous library of my own surgical videos… I watch the videos of previous one or two or three operations, so I am ready for the next operation.” (S4)
- “They can be useful for if you go back and watch yourself, you're like wow! What did I do? or why I was so inefficient in that particular part?” (S5)

Watching specific parts.

Furthermore, learners at this step reported having somewhat narrow learning objectives when they watch videos. Therefore, they usually were not interested to see the general conduct

of the operation step by step, but looked for a very specific part of the operation with a very specific goal in mind:

- “I may watch a very short portion of, for a very specific reason” (S3)
- “If you're an adult learner you know really what you're looking for, and you'll go fairly quickly to that. So, I'm more practical, more discerning, more choosy in what I will watch.” (S5)

Although learners at this step watched videos for a very specific part of the operation, they were expecting greater descriptive details of it. For example, they were interested to know the operator's thoughts, motivations, intentions, and concerns:

- “It's not just how they're doing the key steps, but providing rationale for why they're doing things, and actually explaining the nuances that you can't see by watching video but only by understanding the surgeon's thoughts. Keyword being thoughts” (S2)
- “Share their insights to exactly how they do or what they think at that time… Why did it slow down right there? What was the concerning part? What were you worried about? Or What were you making sure to accomplish? If you can have audio narrating as well that really can make it really excellent.” (S5)

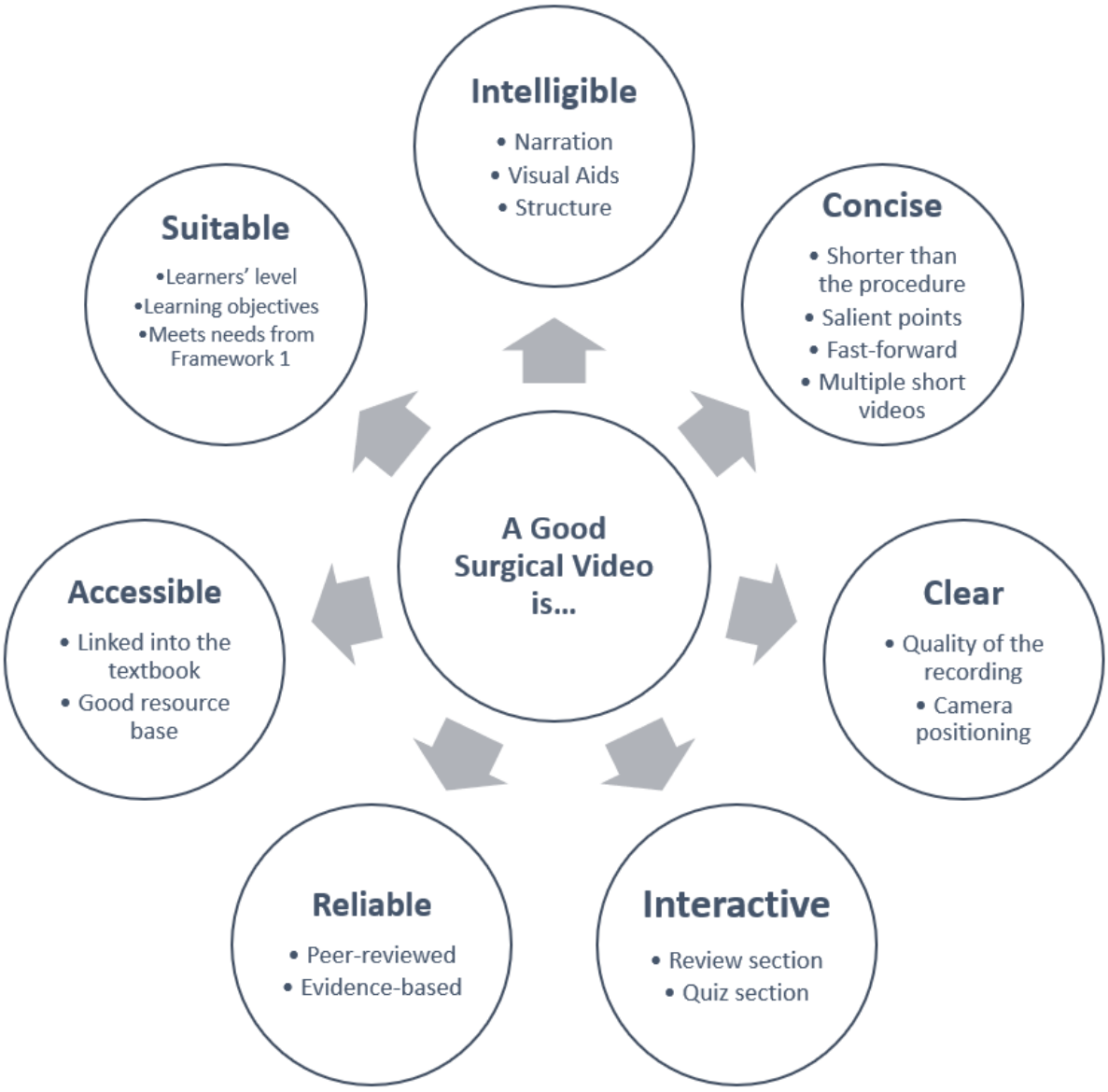
Importantly, one of the learners stated that as proficiency and experience increased, the learning objectives became so specific, that he/she watched the video of the same patient to prepare for the operation:

- “I don't usually watch a long video on how to do a certain procedure step by step. Because to senior for that, I have been through all that. So, I use the videos specifically for preparation for a case**,** and it’s usually a video of that same child [cases of reoperation]” (S4)

Framework 2. What Is a 'Good' Surgical Video?

This study identified the attributes of a 'good' video from the perspective of the different groups of surgical learners. These attributes were similar for all groups of learners, as long as the content of the video suited their learning objectives. Participants described a 'good' surgical video as having the following attributes: 1) Intelligible, 2) Concise, 3) Clear, 4) Interactive, 5) Reliable, 6) Accessible, 7) Suitable (see Figure 2).

Figure 2. Attributes of a 'good' surgical video.



Further, each theme will be described by providing definitions, subthemes, and relevant concepts with examples from the data. Following, a hypothetical construct that compares a 'good' surgical video to a 'bad' surgical video will be presented in a table format.

A Good Surgical Video is… Intelligible.

The learners seemed to appreciate 'Intelligible' surgical videos. This theme describes attributes of a surgical video to be explicit, obvious and easy to understand for the learners. This theme introduces three main approaches to make the video more intelligible: providing a 'Narration', using 'Visual aids' and adding a 'Structure'.

Narration

Learners specified that voice-over narration, where a surgeon spoke through the procedure, or textual narration, where explanations were presented as subtitles – both were helpful in videos:

- "Procedural videos with audios of surgeons explaining the steps of surgery – that is one aspect to which I find to be helpful" (M8)
- "Speech along with it will help to clarify everything to explain and sort of narrate the video effectively" (R4)
- "They [good videos] also have a voice-over and subtitles describing what's happening as you're going through the video" (S1)

Visual aids

Learners discussed the use of visual aids in surgical videos and believed that they are also one of the important attributes of a 'good' surgical video. Such editorial practices as adding text labels, overlays, or colorful highlighters over the recorded operative footage to orient learners, to

indicate anatomical structures or to explain the details of the operation were particularly helpful in videos:

- "Using visual aids and augmented video like devices, like text labels, and annotations and things like that - things that add value" (R7)
- "Using overlays, so you can point to specific parts of the anatomy, you can point out things that may not be obvious to the novice, or may not be obvious because of how the camera is facing, or sometimes the anatomy can be atypical as well. So, I find those kinds of overlays on the video helpful, and pausing in specific areas to highlight points" (S1)

Some of the learners appreciated such visual aids as schematic illustrations, textbook illustrations paired to the operative anatomy, or pre-operative imaging paired to the operative anatomy:

- "Couple of still motion pictures demonstrating the anatomy in vivo as opposed to a surgical textbook. Or even having them paired – so you can see what is it looks like in textbook, what is it look like in vivo, comparing two and then moving to actual surgical procedure." (M6)
- "Editing out or editing in imaging pictures or schematics to help people understand that. When I made a video, we cut out and put CT cuts at the points where we were looking at the correlate on the video. So, I think having those extra support media can be quite helpful." (S5)

Structure

Learners also welcomed videos that were structured by having objectives, take-home messages, logical transitions between steps, and by explanations of which parts of the operation were excluded from the video:

- “If they have objectives of what's happening, or what they're going to teach me - I think that's easier to learn” (R6)
- “At the end when they have a take-home message… I feel would be useful” (R1)
- “Ones that have logical transitions between steps and even just if they don't want to show the step because it's particularly onerous or something like that – have an explanation of what happened in between the actual recorded parts of the procedure” (M9)

A Good Surgical Video is… Concise.

The learners stated that they favor ‘Concise’ surgical videos. This theme presents learners' understandings of ‘Concise’ videos, as well as some of the approaches that learners find helpful to create a ‘Concise’ surgical video.

Video shorter than the operation

As modern days require people to be time-efficient, the learners avoided watching lengthy videos. Notably, learners stated that the optimal length of a video depends on the operation type. However, they were assured that the length of the video should be shorter than the duration of the operation:

- “Obviously when your most surgeries take several hours with some exceptions… so you don't want to be watching 4 hours of a video” (M9)
- “In the current day and age people probably aren’t want to sit and watch 45 minute video of a procedure… so if you can get it into a concise thing, I mean it doesn't have to be 2 minutes, depends on the appropriate length of how complex the procedure it is, but I think having it as concise as possible without the downtime… You could probably do in 15 minutes or less” (S5)

Editing-out and fast-forwarding

The learners also discussed how to make a surgical video as concise as possible, suggesting to "edit-out" or "fast-forward" all irrelevant, repetitive, redundant parts and save only salient, substantial, “novel” components of the operation:

- “Every new procedure also has a lot of lot of standardized components too, that are routinely done. So, in other words just editing a video down so that you really just teaching the new and novel components” (S2)
- “Good videos are typically well edited, they only have the relevant parts, or you know, when something is changing, or something is what in an operative procedure is occurring, and they want to go to the next step… Having short videos helps I think” (M4)

Notably, which parts specifically should be edited out or saved in the video will be directly depending on the objectives of a particular learner and from the step that the learner belongs in the continuum, as described earlier in Framework 1. For example, one of the learners while discussing the approaches to make the videos more concise stated that it depends on his/her learning objectives:

- “If there is a particular part of a surgery that dissection that's fairly repetitive from a medical student point of view, you're probably not going to be understanding all the levels of dissection - so maybe just some fast-forwarding at some points” (M5)

Multiple short videos

The learners also preferred using the ‘Multiple short videos’ dedicated to a single part or step of the operation instead of watching the video of an entire operation. They found ‘Multiple short videos’ are easier to comprehend, easier to navigate through and find the needed information:

- “Breaking down each step of surgery and making that into a single video, like a 5 to 10 minute video, on just how to do a cannulation stitch [for example] - those things I find to be very helpful” (M8)
- “I think it makes more sense to have multiple short videos. So rather than have a video of an entire single operation, let's say, I'd rather have multiple videos of the steps of the operation… it's more digestible if it’s in smaller chunks and easier to search” (R8)

For some of the senior learners, ‘Multiple short videos’ were the solution to acquire sufficient details of the operation without spending excessive time to watch a video:

- “I think we've surgeons even of my generation fall into the trap of it has to be short to maintain attention. And so, I think anything over 15 minutes is going to be too long. And that's where I think part of the problem for me is in order to surgical videos may not be able to cover an entire procedure. Maybe they cover a specific portion of a procedure, in order to have me learn something in specific.” (S3)

One of the learners even described the experience of using a video platform where ‘multiple short videos’ were arranged into an algorithm, where learners could watch through it depending on their preferences and objectives. The learner concluded this type of platform is easier, more practical and time-efficient to use:

- “They put their videos into an algorithm… they would have a separate video for every step of the case, but depending on how you went through it you wouldn't actually have to review every video… choose your own adventure algorithm… They actually have a series of small snippets, that you can use to prepare for a specific case… You're also learning when you would use those techniques, because the algorithm actually lays them all out for you. So that puts everything in context, it breaks the videos down into very

small fragments, that are very easily accessible, very short to watch, is not necessarily a big time investment… So, this is the best use of surgical videos that I've seen." (S1)

A Good Surgical Video is… Clear.

The learners highlighted the importance of one of the obvious attributes of videos – being 'Clear' in technical terms, referring to the quality of the recording. They discussed using an appropriate high-resolution video-recording device, that captures steady and smooth footage, with a proper lighting and a clear view of the operative site:

- "Lots of videos that exist are poor video quality. Like there someone holding a laparoscope, that's shaking all over the place" (R2)
- "The resolution of the video, in the current era everything should be at least 1080, if not 4K" (S2)
- "Particularly good video is when the lighting is perfect, not too bright and not too dark, head is still" (S4)

Some of the learners also emphasized the role of proper camera positioning during video recording and believed that viewing the operation from the surgeon's point of view is essential:

- "Some videos are shot from our perspective that isn't realistic for a surgeon, so the way that cameras angle… it's in an unnatural position that is doesn't really have any reference to what you would actually see during surgery - so that's kind of useless as well."(R7)

A Good Surgical Video is… Interactive.

Some of the learners shared that attribute of videos being more 'Interactive' could enhance the retention while watching them. For example, one of the learners appreciated a surgical video platform that has a quiz section at the end of the video:

- “I really like it because not only does it show you that's a tutorial but then also it asks you questions afterwards” (R3)

Another learner described using an interactive platform of videos that has review or quiz sections, and explained how these can improve the retention:

- “Little review segments where it will stop and review - that's one thing I think is useful in videos… being interactive to the point where it's gives an option for the viewer to review things by themselves, reiterate something that's already been said in the video or ask a question and wait for the viewer to come up with an answer and then give the answer after that. I think those are all useful ways to learn that are interactive” (R7)

A Good Surgical Video is… Reliable.

The learners believed that being ‘Reliable’ is an essential attribute of a ‘good’ surgical video. By reliable, they indicated “peer-reviewed videos” and “evidence-based videos”, where the information is supported by references to literature or videos are published after being reviewed by other experts in the field, similar to journal articles:

- “A good repository of evidence-based videos, that actually have references at the end” (M6)
- “Peer-reviewed videos, so submitted and then they will go through a similar process to do a Journal article and they are published online” (S3)

A Good Surgical Video is… Accessible.

The learners stated that accessibility is one of their major concerns regarding ‘good’ surgical videos. They clarified that being ‘Accessible’ means to them finding a good, reliable, consistent, organized, high-quality, readily-available, and free resource of surgical videos:

- “Having a good resource base, somewhere reliable to go, where I know the videos will be good consistently - that would probably make it something I do more frequently” (M5)
- “It's hard to find one resource where everything is organized really well and it's easy to access the videos that you want” (M9)
- “It's difficult to find good surgical videos. The good ones are usually subscription-based, you need to pay for to get the access. So that's a hindrance for sure.” (R8)
- “Hard to find ones that you can rely on or think that are going to be good quality” (S6)

Some of the learners suggested that linking the videos into the textbook could resolve the problem around the accessibility of good videos:

- “If there is sort of a repository that is even tied to a specific textbook… refers to points in the textbook, I think that would be ideal.” (M6)
- “If you're reading a textbook on its specific topic there is no video. I'm just not going to search for video specifically for that it needs to be included in the textbook or in the page that I'm reading” (R1)

A Good Surgical Video is… Suitable.

Learners also described that a ‘good’ surgical video is the one that suits their level and learning objectives. Notably, this attribute of a ‘good’ surgical video has a connection with the concepts that were discussed in Framework 1. As was discussed in Framework 1, the learners’ purposes of using surgical videos were different depending on their surgical proficiency. Therefore, a ‘good’ video that suits learners’ level can also be defined as a video that meets their needs and purposes of using. For example, learners mentioned that some of the videos may not suit their level because of being "too simplified" or being too advanced, and they emphasized the importance of tailoring videos to the learning objectives:

- “It's also important I think to find videos that are appropriate for my stage in training. And some of the videos it's a bit hit or miss - either it's too simplified and it's at sort of patient level and it's not quite where I want to be learning, or it's you know just watching the surgery from the perspective of the fellowship trained surgeon” (M6)
- “The video has to be tailored to the level of learning. Even junior residents have different learning objectives, as are clearly laid out by the Royal College, than senior residents. And the video should be adjusted appropriately.” (S2)

Hypothetical ‘Good’ and ‘Bad’ Surgical Videos.

Based on the attributes of a ‘good’ surgical video introduced in Framework 2, hypothetical ‘good’ and ‘bad’ surgical videos were constructed. First, a hypothetical scenario when a surgical video was ‘good’ was constructed by considering each of the themes and subthemes from Framework 2. Following, a hypothetical scenario when a surgical video was ‘bad’ was envisioned by contrasting to each of the attributes of a hypothetical ‘good’ surgical video (see Table 4). This process of constructing hypothetical scenarios served as a validation step for the study, as it helped me to confirm that all probable attributes of a ‘good’ surgical video were obtained from the data.

Table 4. Hypothetical 'good' and 'bad' surgical videos.

Attributes	'Good' video	'Bad' video
Intelligible	- Easy to understand because of narration, visual aids, and structured story line - Narration provides useful and relevant information - Visual aids, highlight important aspects on the screen - Structured by providing learning objectives, highlighting key messages, and transitions between steps	- Confusing, disjointed video - No narration or poor narration, that provides useless and irrelevant information - No visual aids - No structure
Concise	- Shorter than the operation itself and presents only relevant and important parts. - Irrelevant parts are edited-out - 20 minutes video from 1 hour operation, for example	- Video is longer than the operation itself, includes irrelevant, repetitive, and unnecessary parts - A continuous video-recording, without any editing - 2 hours video from 1 hour operation, for example
Clear	- Has high-resolution, steady image, and appropriate lighting - Presents clear view of the operative site	- Has low-resolution, shaky and blurry image with insufficient lighting - The operative site is out of focus or obstructed
Interactive	- Has review and quiz sections during and at the end of the video	- No review or quiz sections
Reliable	- Created by well-known author - Presents evidence-based material that referenced to scientific literature - Went through peer-reviewing before being published	- The source of video is unknown - No references - No peer-reviewing
Accessible	- Easy to find - Easy to watch - Free to watch - Linked into textbook materials	- Hard to find - Requires registration - Subscription-based - Requires payment
Suitable	- Matches learning objectives - Complies with the level of the learner - Demonstrates everything that the learner is looking for	- Unrelated to learning objectives - Inappropriate to the level of the learner - Demonstrates everything but not what the learner is looking for

Chapter V. Discussion.

In this chapter I will provide a brief restatement of the findings and then compare the findings of this study to other studies in the literature. After that, I will discuss the practical implications, study limitations, and future directions of the study.

This qualitative study explored two questions: 1. The purposes and practices of using surgical videos by medical students, surgical residents, and surgeons; 2. The attributes of a 'good' surgical video from the perspective of the learner. Two frameworks were built to answer these questions. Framework 1 explained that surgical learners used videos for three main purposes: 'to see', 'to do', and to 'perfect'. Learners' purposes and needs were not directly associated with the exact stage of learning but were spread over a continuum of growing surgical proficiency. As learners journeyed through this continuum, their proficiency grew, and their reasons for using videos were observed to change. Framework 2 identified seven key features that learners associated with 'good' surgical videos: intelligible, concise, clear, interactive, reliable, accessible, and suitable.

Comparison of Findings

A quantitative survey conducted by Mota et. al (2018) identified the most valued characteristics in surgical videos among various groups of surgical learners. According to their study, surgeons valued the most the presence of technical skills or tips and tricks, while residents mostly appreciated didactic illustrations and narration in videos. My study also acknowledges the differences in needs and purposes of using surgical videos by various groups of learners but disagrees with the findings of Mota et. al (2018), as I found that the differences in needs and purposes were associated with the proficiency of learners, not with their designated stage of learning. Creating video-based learning resources in accordance with the concept of a

proficiency continuum could help to match the content of videos to the needs of learners at different levels of proficiency. This concept will be discussed in further detail in the Practical Implications section.

A quantitative survey conducted by Rapp et al. (2016) on the use of surgical videos among medical students, residents, and surgeons, identified that 90% of respondents used videos to prepare for surgical cases. The learners in my study also described 'watching videos to prepare before surgery', but they also described a range of other reasons for use, such as 'watching to support reading' and 'watching after an operation to clarify'. This study helped us to gain more detail about precisely how, when, and why learners use videos to learn and will also help to those who are trying to develop videos more closely meet the needs of learners.

My findings regarding the attributes of a 'good' surgical video relate to the psychology theory of cognitive load (Sweller, 1988). The theory presents three types of cognitive load relevant to learning: intrinsic load, germane load, and extraneous load. These three factors explain several of the key features I found to be associated with the 'good' surgical video (Brame, 2016). Intrinsic load is a cognitive process that grasps the connections within the subject of learning (Sweller and Chandler 1994), while germane load is a cognitive process that accommodates the achievement of learning goals by grasping the key messages of the subject and including them into the personal hierarchy of knowledge (Sweller, van Merrienboer, Jeroen J. G., and Paas, Fred G. W. C., 1998). Extraneous load is defined as a cognitive process that distracts from achieving the learning goal (Sweller, van Merrienboer, Jeroen J. G., and Paas, Fred G. W. C., 1998).

The finding that learners want a surgical video to be 'intelligible' is clearly supported by the idea of intrinsic and germane cognitive load. According to the theory of intrinsic cognitive

load, surgical videos that have narration can also enhance the retention and help to reach the learning goals. The concept of germane cognitive load also suggests that surgical videos can be made more effective by presenting objectives and take-home messages, and clearly identifying the steps of a surgery; adding these structures in a video would be anticipated to enhance knowledge retention and help learners to reach their learning goals. The concept of extraneous cognitive load suggests that videos with poor image quality or excessive duration distract from reaching the learning goals and may result in lower retention. This theory explains why learners favoured 'clear' and 'concise' surgical videos.

The cognitive theory of multimedia learning is also relevant to the findings of this study. This theory assumes that human memory has two separate channels for processing visual and auditory information (Mayer, 2005). Using both channels simultaneously may expand the possibilities of working memory, while distributing information between these two channels unwisely may lead to overwhelming the working memory of a learner (Mayer, 2005). According to this theory, voiceover narration in a surgical video would be predicted to use opportunities of both, visual and audial channels of perception, and would enhance retention. However, a surgical video with textual narration (for example in subtitles) may overwhelm the visual channel of perception without using the opportunity of the audial channel. Consequently, this theory supports the finding of the study on voiceover narration making a video more useful, but suggests that adding text presented visually may be less helpful.

Based on theories of cognitive load and multimedia learning, Brame (2016) discussed four suggestions for creating educational videos: signaling, segmenting, weeding, and matching modality. Signaling refers to using a short text, highlighter, symbol, or arrow on a screen to guide the learner's attention. Brame (2016) concluded signaling reduces extraneous load and

increases germane load. This agrees with my findings and explains why learners valued the use of 'visual aids' in surgical videos. Segmenting refers to making a short video or dividing a video into smaller sections. Brame (2016) believed segmenting manages intrinsic load and increases germane load. This agrees with my findings and reveals why learners favoured 'concise' and 'multiple short' surgical videos. Weeding means removing from a video any information that does not benefit to accomplishing learning goals. Brame (2016) stated that weeding reduces extraneous load. This matches with my findings that support the concept of editing-out and fast-forwarding irrelevant or repetitive elements of the operation from the video. Brame (2016) also discussed that weeding will directly depend on the expertise of a learner, as components of a video that cause extraneous load for a 'novice learner' can be helpful for an 'expert-like learner'. Conversely. components that are important for a 'novice learner' can be trivial, and as a result extraneous for an 'expert-like learner'. This complies with my findings on 'suitable' surgical videos and explains why learners emphasized the importance of tailoring videos to their level and learning objectives. Matching modality means choosing a proper channel (audial or visual) to communicate a particular kind of information. Brame (2016) believed this practice improves germane cognitive load. Matching modality refers back to the cognitive theory of multimedia learning (Mayer, 2005), and supports my findings on the use of voiceover narration but contradicts my findings on the use of textual narration, which was already discussed earlier in this section. Due to the qualitative nature of my study and the small sample size, this contradiction may have occurred as an outlier finding. Further work is needed to examine the applicability of the cognitive theory of multimedia learning in the context of surgical videos.

Wachtler and Ebner (2015) found that using various interactions, such as multiple-choice questions during the educational videos helps to maintain the attention of the learner and can

enhance learning from watching videos. This study agrees with the findings of my study and explains why learners in my study valued 'interactive' surgical videos.

Fisher, Kaplan, and Egol (2017) recommended editing surgical videos to exclude repeated actions and presenting only key points. My study agrees with these recommendations, as the learners in my study also described a 'good' surgical video as being 'concise', which presents only salient points by editing-out redundant or irrelevant parts. This emphasizes the importance of editing surgical videos instead of uploading them as a direct or 'raw' footage from the operating room. Matava, Rosen, Siu, and Bould (2013) found that residents mostly preferred educational audio and video podcasts between 5-15 minutes. My study disagrees with this, learners described that the ideal length of a surgical video varied depending on the type of procedure. The only criterion for learners in my study regarding the ideal length of a surgical video was that they should be shorter than the procedure itself. This disagreement may have occurred due to the qualitative nature of my study and using open-ended questions during the interviews, whereas Matava, Rosen, Siu, and Bould (2013) used a quantitative survey with suggestive questions. Further work is required to examine the preferred length of surgical videos considering the type of procedure.

Practical Implications

The findings of this study serve as a guideline for surgical educators who wish to create high-quality learner-oriented educational videos for teaching surgery. This study emphasizes the importance of understanding the intended audience when creating surgical videos. Videos intended to teach surgery should be tailored to the purposes and needs of the intended audience. For example, if a surgical video is intended to be watched by learners at the earlier phase of the proficiency continuum, then the video might be designed to present a brief overview of a surgical

procedure with a more detailed description of clinically relevant information and the story of a patient. If the intended audience is in the middle phase of the proficiency continuum, then the surgical video should probably focus on the process of the operation in more detail, highlighting technical skills, hand movements, surgical techniques etc. If the intended audience is in the later phase of the proficiency continuum, then the video might be designed to demonstrate a specific part of the operation with thorough descriptive details and to focus on something new, unusual, or unique.

This study also lists attributes that are important to consider while creating a surgical video intended to be used for education and explains why some existing videos are less effective than others. These attributes can guide surgical educators for recording, editing, and disseminating 'good' surgical videos. We make the following recommendations:

1) Intelligibility. Surgical educators should consider how a learning video is constructed and should consider adding narration and visual aids. Using an audio narration is recommended rather than using a textual narration to avoid overwhelming learners with visual information. Visual aids such as colour highlights, labels, text boxes, and arrows may be added during the editing process, to focus learners' attention on important moments and elements of the procedure. Videos should also clearly present learning objectives and take-home messages, should clearly announce transitions between steps of a procedure, and inform learners when parts of a procedure are not shown.

2) Conciseness. Surgical educators should present only salient points and edit-out repetitive and irrelevant parts of the operation.

3) Clarity. Surgical educators should use a high-resolution camera and position it appropriately to capture sharp, steady footage with a clear view of the operative field from the operating surgeon's point of view.

4) Interactivity. Surgical educators should consider adding quiz or review sections that ask questions and reinforce knowledge gained from watching the video.

5) Reliability. Surgical educators should identify the source of the video and reference peer-reviewed, evidence-based scientific literature relevant to the subject. The peer-review process may be needed for creating trustable video for surgical education.

6) Accessibility. Surgical educators should disseminate video-based learning resources online on cites that are well-organized, easy to find, easy to search, and free of charge.

7) Suitability. Surgical educators must consider the needs and purposes of the intended audience of learners and should consider whether these learners are in the early, or middle, or later phase of the surgical proficiency continuum. Any surgical video should be capable of being identified as helping learners to see, to do or to perfect.

Limitations

The current study has several limitations. The findings of the study were based on what participants verbalized regarding their purposes and practices of using surgical videos. However, this might differ from their actual practices and purposes – in essence, what someone says they do may be different than what they actually do. This study is also limited by the relatively small number of participants. As qualitative studies usually focus on an in-depth exploration of a small population of participants, the findings of this study are difficult to generalize to all surgical learners.

There are also some limitations that are specific to this study. Even though the diversity of participants was considered during the recruitment, there were fewer female participants compared to males, which can also be viewed as a limitation. The findings of this study may also have been influenced by the academic culture and education practices followed at the University of Alberta. The findings might differ if this study was conducted in another university. Despite having a personal encounter with the subject of the study, I have a different background compared to the participants of the study. As I was educated and trained in a different medical school from a different country than all of the participants, so my culture, academic experience, and perspectives to surgical education are different. This factor could have influenced the course of the interviews, coding, and data analysis, leading to observer bias.

Future Directions

This study sets a foundation for future work in this area. Replication of this work in another institution would be useful to confirm the transferability of the findings. Replication of this study would be especially important in settings that differ from the Canadian system of surgical education (e.g. in European or Asian institutions). The study could be also repeated using a different methodology; for instance, quantitative approaches could be employed to survey a wider population of learners across multiple institutions.

The work also could be expanded to further examine the concept of the surgical proficiency continuum. For example, videos intended for the different phases of the continuum could be created and evaluated by different groups of learners to evaluate their effectiveness and confirm that learners on different parts of the continuum have different needs for video-based learning.

The work could be expanded also by further testing the attributes of a 'good' video. For example, various versions of a video of the same procedure could be developed using the attributes identified (e.g. with/without narration, with/without diagrams, long/short edit, etc) These videos could then be evaluated by learners to conform the effectiveness of certain video attributes, perhaps using the Kirkpatrick framework to objectively evaluate learner impact. I had originally intended to perform such a study as part of this work, but decided to focus more on the qualitative findings as the work evolved.

Summary

Video is widely used in modern surgical education and may have advantages over other ways of learning surgery. However, less was known about purposes and needs of surgical learners who use videos, as well as what learners consider to be the attributes of a 'good' surgical video. In order to answer these research questions, I interviewed medical students, surgical residents, and surgeons, and analyzed these data using qualitative approaches. I found that how learners used video was not simply associated with their designation, but was related to the proficiency of an individual learner on a continuum of growing surgical proficiency from 'seeing' to 'doing' to 'perfecting'. Learners described seven main attributes of a 'good' surgical video: intelligible, concise, clear, interactive, reliable, accessible, and suitable.

The following conclusions arose from this study:

- The content of a surgical video created for education needs to be tailored to the level of the surgical proficiency of the intended audience.
- In order to advance the educational value of a surgical video, the attributes of a 'good' surgical video need to be considered when deciding how to record, edit and disseminate video-based educational materials.

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Appendices

Appendix A. Interview tool.

INTERVIEW PROTOCOL

Introductory preamble: *The purpose of this study is to examine the concept of "good surgical video".*

More specifically, we want to discover the habits and practices of different groups of surgical learners on using surgical videos.

Thank the participant and introduce the researcher.

Start recording: *Review the information on the consent form and outline what is required from the participant.* ***Participant gives consent by signing the consent form.***

---

1. General questions about surgical videos

Have you ever used videos to learn about surgery?
From what sources have you utilized videos?
How often do you watch surgical videos?
In what ways do you find surgical videos to be helpful?
Have you ever watched a particularly "bad" surgical video? What was so bad about it?
Have you ever watched a particularly "good" surgical video? What was so good about it?

2. Questions about habits and practices of using surgical videos

Why do you watch surgical videos? What are you trying to learn from them?
What characteristics of surgical videos make them more useful and effective?
What stops you from using surgical videos more often?
How have your habits of watching surgical videos changed over time?

3. Questions about preparation for surgical cases

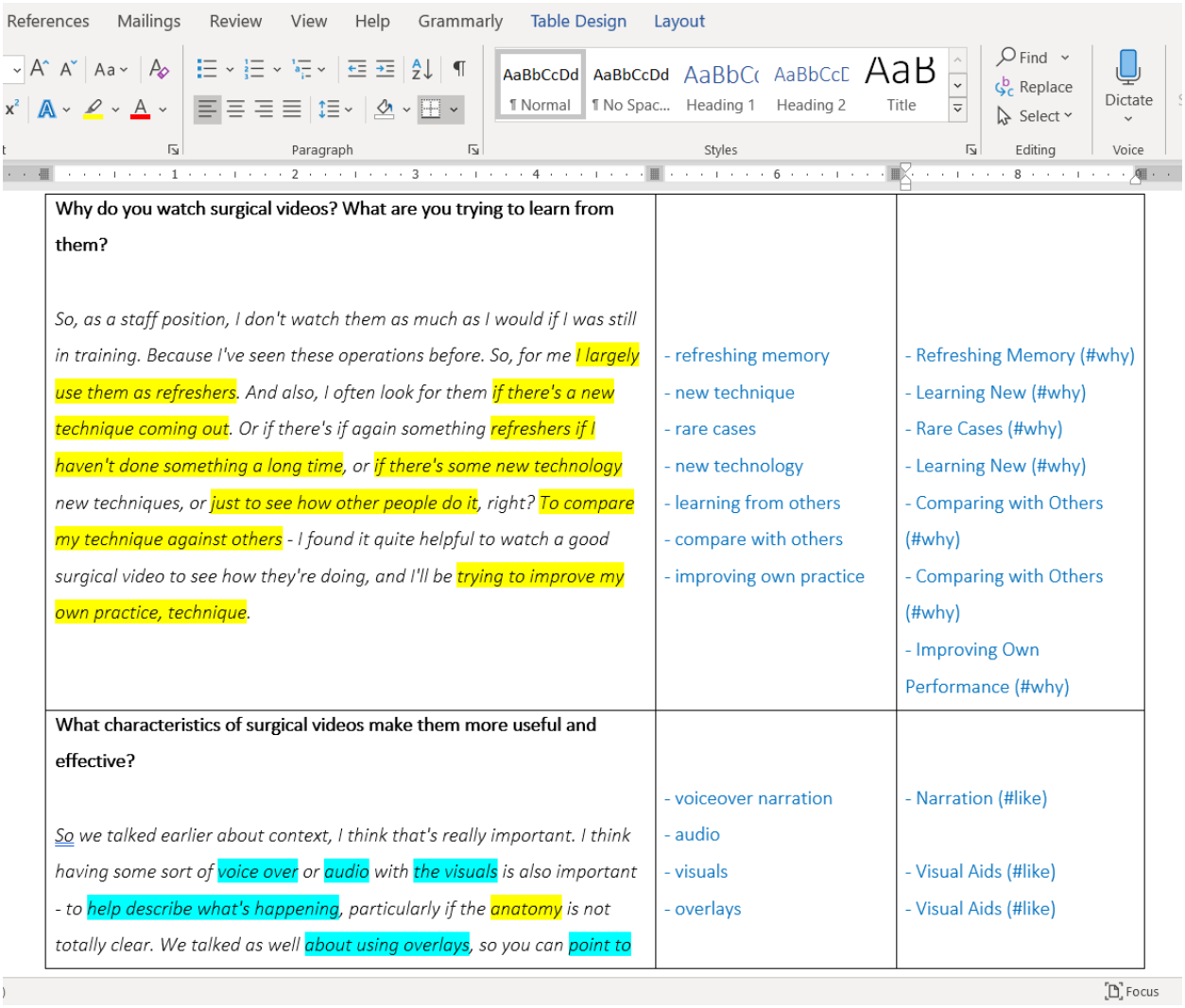
a.	How do you prepare for surgical cases?
b.	To what extend do you think videos are helpful for preparing for surgical cases?
c.	Are there any limitations to using videos to prepare for surgical cases?

4. Closing remarks:

This concludes our interview. Is there anything you wanted to add or further discuss? Is there anything that I might have forgotten to ask or discuss? Do you have any questions for myself?

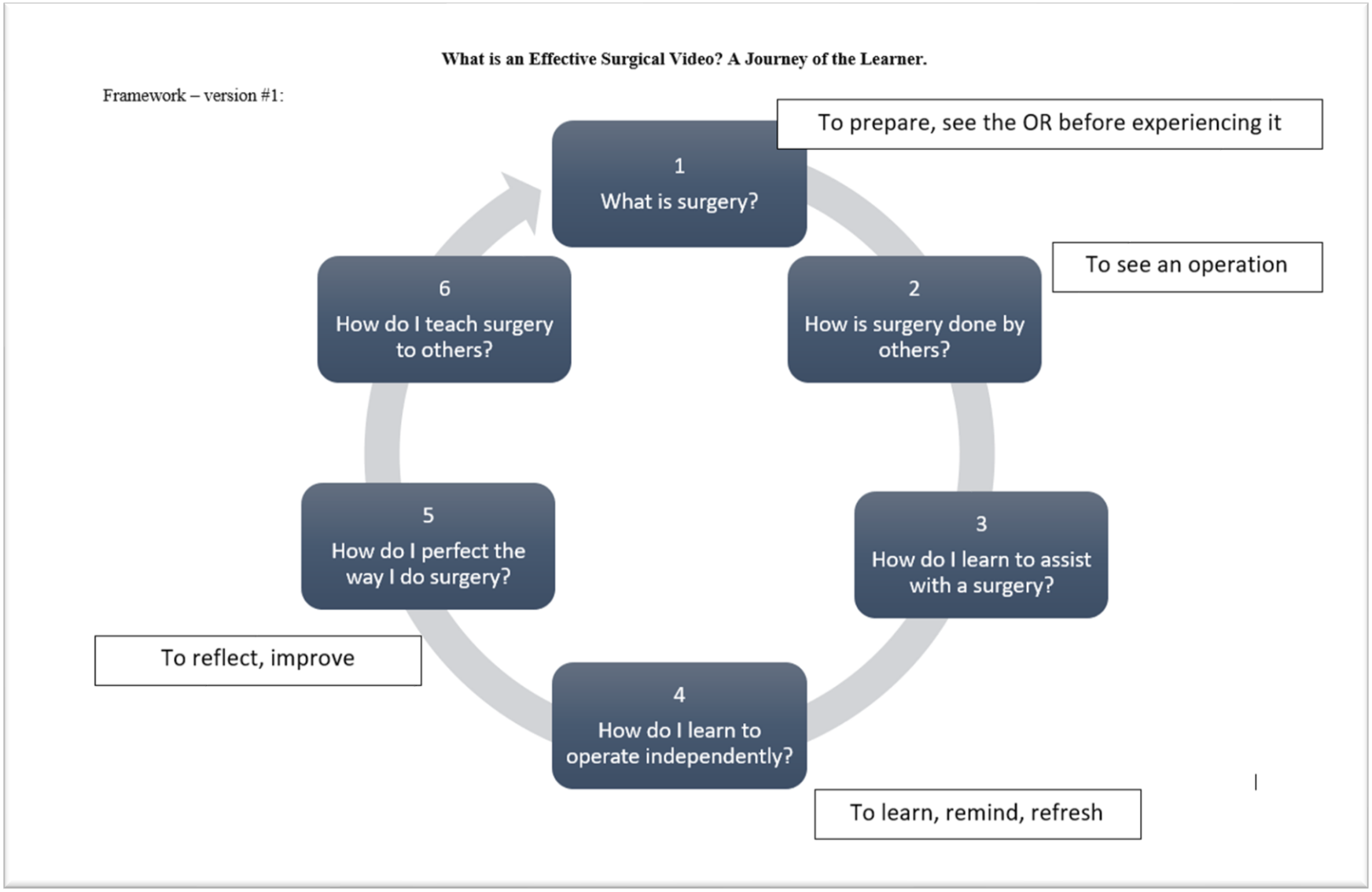
Thank you very much for participating, it is much appreciated!

Appendix B. Example of the coding process.

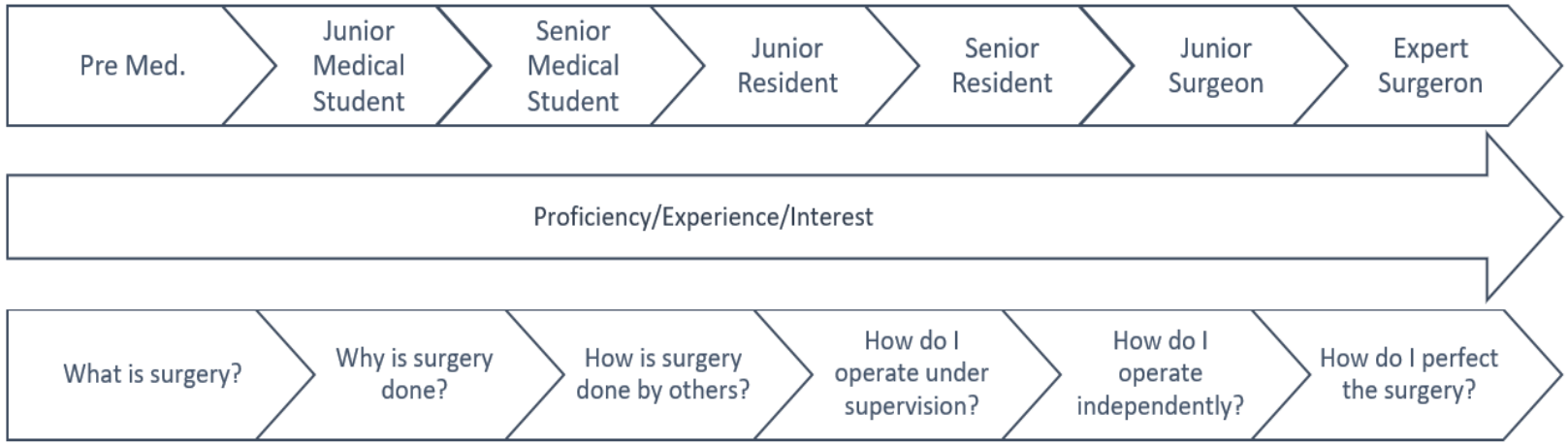


Why do you watch surgical videos? What are you trying to learn from them? *So, as a staff position, I don't watch them as much as I would if I was still in training. Because I've seen these operations before. So, for me I largely use them as refreshers. And also, I often look for them if there's a new technique coming out. Or if there's if again something refreshers if I haven't done something a long time, or if there's some new technology new techniques, or just to see how other people do it, right? To compare my technique against others - I found it quite helpful to watch a good surgical video to see how they're doing, and I'll be trying to improve my own practice, technique.*	- refreshing memory - new technique - rare cases - new technology - learning from others - compare with others - improving own practice	- Refreshing Memory (#why) - Learning New (#why) - Rare Cases (#why) - Learning New (#why) - Comparing with Others (#why) - Comparing with Others (#why) - Improving Own Performance (#why)
What characteristics of surgical videos make them more useful and effective? *So we talked earlier about context, I think that's really important. I think having some sort of voice over or audio with the visuals is also important - to help describe what's happening, particularly if the anatomy is not totally clear. We talked as well about using overlays, so you can point to*	- voiceover narration - audio - visuals - overlays	- Narration (#like) - Visual Aids (#like) - Visual Aids (#like)

Appendix C. Intermediate framework version 1



Appendix D. Intermediate framework version 2



Appendix E. Intermediate framework version 3

Level / Theme	SEEING		DOING		IMPROVING	
	"What is surgery?"	**"How is surgery done (by others)?"**	**"How will I do surgery?" (assisting)**	**"How will I do surgery?" (operating)**	**"How do I perfect surgery?"**	**"How do I teach surgery?"**
Motivation (Why learners want surgical videos?)	• *Seeing* • *Understanding*	• *Exposure* • *Approach* • *See how things are done* • *Preparing* • *Steps* • *What and why* • *See more* • *Pre-seeing*	• *Preparing* • *Pre-visualizing* • *Seeing to do* • *See more clearly* • *See less common things* • *Assisting* • *Skills* • *Steps* • *Why* • *Hands and instruments* • *Key details*	• *Seeing to prepare to do* • *Visualizing* • *Learn* • *Refresh* • *Remind* • *Steps* • *Ways to do* • *Anatomy* • *Pitfalls*	• *Improve* • *Refine details* • *Prepare* • *Reflect and rewatch* • *Specific steps* • *See rare and complex things* • *See others do it* • *Learn new things* • *Tips and tricks*	• *Attention* • *Teaching others*
Content (What learners want from surgical videos?)	• *Terminology* • *Expectations* • *Procedures* • *Orientation* • *Patient story*	• *Anatomy* • *Landmarks* • *Field* • *Instruments* • *Incisions* • *Steps* • *Framing*	• *Steps* • *Tips*	• *Context* • *Why* • *Steps, sections* • *Instruments*	• *Nuance* • *Thoughts* • *Insights* • *Set up* • *Focus on critical parts* • *Danger* • *Critical steps* • *Complications*	• *Critical and challenging parts*
Technical characteristics (How learners want surgical videos?)	• *Accessible* • *Animation* • *Voiceover*	• *Short* • *Slow* • *Voiceover* • *Text* • *Drawing and animation* • *Interactive* • *Review*	• *Multimodal* • *Short* • *Point of view*	• *Text* • *Algorithms* • *Voiceover* • *Arrows*	• *Peer Review*	

Appendix F. Intermediate framework version 4