Rethinking Transfer: How Supervision and Support during Self-regulated Learning Impacts Medical Trainees’ Preparation for Future Learning in a Simulation Setting

by

Julian Carmine Manzone

A thesis submitted in conformity with the requirements for the degree of Masters of Science
Institute of Medical Science
University of Toronto

© Copyright by Julian Manzone 2015
Rethinking Transfer: How Supervision and Support during Self-regulated Learning Impacts Medical Trainees’ Preparation for Future Learning in a Simulation Setting

Julian Manzone
Masters of Science
Institute of Medical Science
University of Toronto
2015

Abstract

Contemporary medical education curricula cannot cover the multitude of problems trainees will encounter in their future practice. Hence, researchers must understand how trainees adaptively transfer recently acquired knowledge and skills into subsequent learning situations (e.g. clinical context); a concept referred to as preparation for future learning (PFL). We compared the effects of instructor supervision and different educational supports during self-regulated learning (SRL) on medical trainees’ (n=45) acquisition, retention, transfer, and PFL of simulated endotracheal intubation skills. We assessed PFL abilities using a ‘double’ transfer design requiring a second learning session before testing of a new skill. Results showed that SRL-supported interventions led to better PFL than a SRL-unsupported intervention, whereas instructor supervision did not. Therefore, we recommend educators incorporate educational supports for learners’ SRL within simulation-based training environments. This thesis furthers our understanding of how educators can cultivate lifelong learners who adapt their learning flexibly in the ever-changing medical landscape.
Acknowledgments

Completing my MSc was undoubtedly the most challenging academic endeavour I have undertaken to date and at the same time, was an experience I will never forget. Luckily for me, I had an extraordinary team of people, both personally and academically, that have been in my corner offering support, guidance, and expertise throughout the entire process.

First and foremost, I would like to acknowledge my supervisor and advisory committee: Dr. Ryan Brydges, Dr. Charlotte Ringsted, and Dr. Maria Mylopoulos. It has been nothing short of a privilege to be able to work under a team so dedicated to their craft. Together, they each brought in their areas of expertise and shaped my understanding of the Medical Education landscape and where I fit into it. I must say this, I am confident that they went about the best way possible of preparing me for my future endeavours, whatever those may be.

Second, I would like to acknowledge the Wilson Centre. My time as a Research Fellow has been a transformative experience. The diversity of perspectives coming from the Scientists and my colleagues has helped me to question my basic assumptions and shape my interpretations of my work.

Third, I would like to acknowledge everyone who played a substantial role collecting data for my thesis. Thank you to the Wightman-Berris Academy for lending me simulators on nothing but trust that I would bring them back in working condition. Also, I could have never collected data for my Instructor-led intervention without the four extremely helpful and enthusiastic clinicians that ran the sessions: Dr. Alberto Goffi, Dr. Christie Lee, Dr. Marco Garavaglia, and Dr. Ghislaine Doufle.

Fourth, I would like to acknowledge the organizations that helped to fund my MSc studies, the Royal College of Physicians and Surgeons of Canada, the Institute of Medical Science, and the School of Graduate Studies at the University of Toronto.

Saving the best for last, I would like to acknowledge my family. The unwavering patience of my mother, the genuine curiosity of my father, the pride of my older brother, and the stimulating discussions with my younger brothers have all contributed greatly to the completion of this MSc. For that I am truly in their debt.
Contributions

Julian Manzone was responsible for the conception and design of the project; data collection of all participants; running the statistical analyses and interpreting the data; and writing the thesis.

Dr. Ryan Brydges, Dr. Charlotte Ringsted, and Dr. Maria Mylopoulos supervised and provided guidance for the conception and design of the thesis; data collection, analysis and interpretation; and provided comments, edits, and approval of the written thesis.

Dr. Kulamakan Mahan Kulasegaram provided statistical support to ensure the appropriate statistical analyses were performed.

Dr. Alberto Goffi, Dr. Christie Lee, Dr. Marco Garavaglia, and Dr. Ghislaine Doufle were responsible for leading the Instructor-led Practice intervention during data collection.

Dr. Matteo Parotto and Dr. Dipen Thakrar rated the quality of participants’ video recorded endotracheal intubations for all groups and assessments.

The Wilson Centre provided the lab space needed for data collection.

The Wightman-Berris Academy provided the simulators and equipment needed for data collection.

The Royal College of Physician and Surgeons of Canada funded the project through the Medical Education Research Grant.
# Table of Contents

List of Tables .................................................................................................................. viii  
List of Figures ................................................................................................................... ix  
List of Appendices .......................................................................................................... xii  

Chapter 1 *Introduction* ................................................................................................. 1  
1.1 Expertise in the Health Professions ....................................................................... 3  
1.2 Preparation for Future Learning ........................................................................... 6  
  1.2.1 Broudy’s Types of Knowing ........................................................................... 7  
  1.2.2 PFL Assessments and Methodology .............................................................. 10  
  1.2.3 Educational Interventions Promoting PFL ....................................................... 14  
1.3 Self-regulation of Learning .................................................................................... 19  
  1.3.1 Conceptual Frameworks of SRL ................................................................. 20  
  1.3.2 Supporting SRL through Educational Interventions .................................... 23  
1.4 Summary of the Literature ..................................................................................... 31  

Chapter 2 *Research Aims and Hypotheses* ................................................................. 33  
2.1 Significance ............................................................................................................ 35  

Chapter 3 *Methodology* ............................................................................................. 37  
3.1 Overview of Study Design ....................................................................................... 37  
3.2 Participants, Recruitment and Group Assignment ................................................. 39  
  3.2.1 Sample Size Calculation ............................................................................... 40  
3.3 Simulated Procedural Skill .................................................................................... 40  
3.4 Protocol and Intervention Design ......................................................................... 42  
  3.4.1 Session 1: Initial Practice Session ................................................................ 42  
  3.4.2 Session 2: Second Practice and Testing Session .......................................... 48
3.5 Outcome Measures .................................................................................................................. 50
  3.5.1 Endotracheal Intubation Performance .............................................................................. 50
  3.5.2 Participant Perceptions of Educational Sessions ............................................................ 52
3.6 Data Analysis .......................................................................................................................... 53
  3.6.1 Instructor-led Intervention Manipulation Check ............................................................. 53
  3.6.2 Baseline Questionnaire Data .......................................................................................... 53
  3.6.3 Endotracheal Intubation Performance Data .................................................................. 54
  3.6.4 Participant Perception Data ............................................................................................ 55
Chapter 4 Results .......................................................................................................................... 56
  4.1 Instructor-led Intervention Manipulation Check ................................................................. 56
  4.2 Participant Demographics and Baseline Questionnaire ......................................................... 59
  4.3 Endotracheal Intubation Performance .................................................................................. 60
    4.3.1 Intubation Completion Time ......................................................................................... 60
    4.3.2 Intubation GRS Score ................................................................................................ 65
  4.4 Participant Perceptions of Educational Sessions ................................................................. 70
    4.4.1 Supports Used During the Educational Session .......................................................... 70
    4.4.2 Requests for Additional Supports .............................................................................. 73
    4.4.3 Compensating in the Absence of Support .................................................................. 75
Chapter 5 Discussion ..................................................................................................................... 77
  5.1 Endotracheal Intubation Performance and Learning ............................................................... 78
    5.1.1 Skill Acquisition and Retention .................................................................................. 78
    5.1.2 Standard Transfer vs. PFL ......................................................................................... 79
    5.1.3 Relating Intubation Performance & Learning Data to the Guiding Conceptual
          Frameworks ................................................................................................................ 82
  5.2 Participants’ Perceptions ...................................................................................................... 87
    5.2.1 Support as: Making the Session Easy, Efficient, and Authentic ............................... 87
5.2.2 Supports that Fall Outside of Ease, Efficiency and Authenticity .........................89
5.2.3 Compensation in the Absence of Support..........................................................90
5.2.4 How Trainees Appear to Define Educational Supports........................................91
5.3 Combining Trainee Performances and Perceptions.................................................92
5.4 Implications for Research, Practice and Faculty Development...............................94
   5.4.1 PFL Assessments in the Simulation Context....................................................94
   5.4.2 SRL is More Than Learning Independently ....................................................96
   5.4.3 Refining the Definition of ‘Educational Support’ ............................................97
   5.4.4 Effective SRL Supports May Produce More Adaptive Learners.......................99
5.5 Limitations .............................................................................................................101
5.6 Future Directions ...................................................................................................104
5.7 Conclusions ............................................................................................................107
References ....................................................................................................................108
Appendices ....................................................................................................................116
List of Tables

Table 1: Example of field notes taken during an Instructor-led practice session.

Page 56

Table 2: Participant demographic data as distributed between the three interventions.

Page 59
List of Figures

**Figure 1:** Representation of the hypothetical adaptability corridor which clinicians should operate in. If they fall within the corridor, they are considered adaptive experts (switching between innovation and efficiency when appropriate) and if they fall outside (relying primarily on efficiency), they are considered routine experts. Adapted from Schwartz et al. 2005 (Schwartz, Bransford, & Sears, 2005).

Page 5

**Figure 2:** Depicts a) the double transfer design allowing transfer in and transfer out, b) the standard transfer design allowing only transfer out, and c) the standard vs. double transfer design comparing the two former designs. Adapted from (Schwartz et al., 2005)

Page 11

**Figure 3:** Bandura’s (1986) theory of triadic reciprocality, with examples given for each of the three interacting variables: environmental, behavioural, and personal. Adapted from (Schunk, 1999).

Page 21

**Figure 4:** 2 x 2 orthogonal coding structure which includes presence of an instructor (supervised/unsupervised) and presence of SRL supports (supported/unsupported). Adapted from (Brydges et al., 2015)

Page 29

**Figure 5:** Overview of the modified standard vs. double transfer protocol used in the thesis.

Page 38
**Figure 6:** Pictorial representation of the a) Supine, b) LLD, and c) Straddling variations of endotracheal intubation. Adapted from (Tesler et al., 2003).

Page 41

**Figure 7:** Supported SRL session 1 protocol.

Page 46

**Figure 8:** Representation of the three groups present in the study: Supported SRL, Unsupported SRL, and Supported Instructor-led practice.

Page 58

**Figure 9:** Mean completion times of the pre-test, post-test and retention tests across a) SRL-supported and SRL-unsupported and b) Supervised and Unsupervised interventions. Error bars represent the standard error of the mean.

Page 62

**Figure 10:** Mean completion times of the standard transfer test. Error bars represent the standard error of the mean.

Page 63

**Figure 11:** Mean completion times of the double transfer test. Error bars represent the standard error of the mean.

Page 64

**Figure 12:** Mean GRS Scores of the pre-test, post-test and retention tests across a) SRL-supported and SRL-unsupported and b) Supervised and Unsupervised interventions. Error bars represent the standard error of the mean.

Page 67
Figure 13: Mean GRS scores of the standard transfer tests. Error bars represent the standard error of the mean.

Page 68

Figure 14: Mean GRS scores of the double transfer test. Error bars represent the standard error of the mean.

Page 69

Figure 15: Framework describing the factors that influence participants’ perceptions of educational supports.

Page 76
List of Appendices

**Appendix 1:** Baseline Questionnaire  
Page 116

**Appendix 2:** Endotracheal Intubation Global Rating Scale  
Page 118

**Appendix 3:** SAS data analysis coding  
Page 119
Chapter 1
Introduction

Given the pace at which the horizons of medical science and technology expand, we can be certain that the doctors of tomorrow will be applying knowledge and deploying skills which are at present unforeseen . . . We cannot teach science that is as yet undiscovered nor can we forecast its future implications. But some of the present day art and science of medicine is fundamental to its practice and will certainly endure . . . For the rest, we can best strive to educate doctors capable of adaptation and change, with minds that can encompass new ideas and developments and with attitudes to learning that inspire the continuation of the educational process throughout professional life [p. 4] (Education Committee, 1993).

As reflected by the 1993 General Medical Council, existing medical school curricula simply cannot cover the multitude of challenges encountered in daily clinical practice (Mylopoulos & Scardamalia, 2008). Thus a critical aim of medical education must be to prepare trainees for their future learning to ensure a trajectory of adaptability throughout their career. Despite the importance of this concept, little work has been done within the context of medical education to explore the ways in which this aim can be achieved. Instead, much of the effort has been placed, as in broader education literature, on studying how learners can replicate and apply knowledge at varying points in time (Broudy, 1977).

To address this gap in the literature, I will present the concept of Preparation for Future Learning (Bransford & Schwartz, 1999) as it relates to expertise in the health professions and explore the extent to which different instructional interventions within the simulation-based
training context promote it. The simulation-based training context is defined as a training method in which learners practice tasks in life-like circumstances using models or virtual reality, with feedback from observers, peers, simulated patients, and video cameras to assist improvement in skills (Gulluoglu & Tingoy, 2009). And to fully appreciate the addition of the Preparation for Future Learning framework to this context, we must highlight that it provides the foundation for rethinking what is meant by the concept of transfer of learning. Traditionally, within the simulation context, transfer has been defined as the application of what is learned in one context (i.e., the simulation setting) to another context (i.e., the clinical setting) (Hamstra, Brydges, Hatala, Zendejas, & Cook, 2014) and has been studied by authors whose work extends well beyond simulation-based training (Day & Goldstone, 2012; Durning et al., 2012). Although this definition of transfer is a necessary aim of simulation-based training and medical education more broadly it does not fully address the expectations placed on medical trainees when they enter clinical practice due to the dynamic and ever changing nature of treating patients.

As this thesis develops, it will become apparent that preparing trainees for future learning entails preparing them to transfer more than just their knowledge and skills into new situations. It requires them to transfer strategies, attitudes and learning approaches in order to be flexible and adaptive when new problems arise. Also, we will highlight how the aim of adaptive expertise brings with it conceptual, methodological, and assessment implications, which are important for both educators and researchers in the field. Specifically, we will attempt to answer the question, what is the impact of supervision and support during self-regulated learning on novice trainee’s preparation for future learning of endotracheal intubation?
1.1 Expertise in the Health Professions

Perhaps the most crucial ability of an expert in the health professions is the ability to efficiently and effectively solve problems of daily practice (Mylopoulos & Regehr, 2009). It is presumed that this ability comes from years of experience and an accumulation of knowledge throughout training. Specifically, on the path from novice to expert, trainees are expected to gain knowledge of basic science mechanisms, clinical signs and symptoms, case examples and technical skills (Mylopoulos & Woods, 2009). This extensive knowledge base is what experts will draw upon as they treat patients in their daily practice (Mylopoulos & Regehr, 2011). In addition, researchers have argued that it is not only the size of the knowledge base that makes an expert, but also how all the information is organized, with experts drawing on both analytic, purposeful reasoning and non-analytic, pattern-recognition reasoning in their problem solving (Mylopoulos & Regehr, 2011).

However, although this extensive repertoire of organized knowledge allows experts to solve most problems in their daily practice, they are often confronted with problems they have never seen before, which they lack the knowledge to solve, or which they feel they are not addressing as well as they might (Mylopoulos & Regehr, 2009). In these cases, the expert can either choose to look up the knowledge when appropriate or create a new solution by innovating in practice if they judge that is required. This ability to innovate, and consequently create new knowledge, is the core principle of what is known as adaptive expertise (Mylopoulos, Regehr, & Ginsburg, 2011). To understand adaptive expertise, we must first note that the definition of expertise mentioned above is labelled as routine expertise in this framework. To reiterate, routine experts have mastery of knowledge in their domain; they are able to apply their knowledge
effectively and efficiently when solving well-known problems of practice and their learning is aimed towards making them more efficient in their work (Mylopoulos & Woods, 2009). In addition to these core competencies, adaptive experts possess additional cognitive and metacognitive processes that allow them to move beyond solely applying knowledge in ways where they approach problems as opportunities to innovate, to construct new ideas, learn and improve practice (Mylopoulos & Woods, 2009).

Therefore, effective expert practice includes appropriate use of past knowledge and experience to solve problems of practice, as well as the ability to break free of old routines and discover novel ideas. Such experts are committed to lifelong learning and possess a drive to continually improve daily practice. Thus, a core process of adaptive expert performance is the practice of working within an optimal adaptability corridor which is represented in Figure 1 (Mylopoulos & Regehr, 2009; Schwartz et al., 2005). Optimal adaptability is a conceptual way to think about how experts must maintain an appropriate balance between efficiency and innovation for any given problem (Regehr & Mylopoulos, 2008).

However, it appears that adaptive expertise is not an inevitable or emergent property of experience (Mylopoulos & Regehr, 2009); instead, it is the outcome of processes, attitudes and habits that must be instilled, practised and learned early in training and must be regularly enacted and refined throughout a clinician’s career. Ensuring that trainees progress along this trajectory of development towards adaptive expertise should be a focus of medical education interventions. In addition to exposing trainees to the efficiency dimension of expertise through assessments that target skill retention and application, trainees must also be exposed to assessments that target the adaptive dimension. To study the latter effectively, researchers and educators in medical education will likely need to adopt and adapt conceptual frameworks and methodologies from
other academic disciplines. Thus, the following section includes an in depth analysis of the preparation for future learning framework, a concept from Educational Psychology that is designed to help educators and researchers understand how to train for and assess learners’ development of adaptive expertise.

**Figure 1:** Representation of the hypothetical adaptability corridor which clinicians should operate in. If they fall within the corridor, they are considered adaptive experts (switching between innovation and efficiency when appropriate) and if they fall outside (relying primarily on efficiency), they are considered routine experts. Adapted from Schwartz et al. 2005 (Schwartz et al., 2005).
1.2 Preparation for Future Learning

Preparation for Future Learning (PFL) is defined as the ability to learn new information from available resources, relate new learning to past experiences and demonstrate innovation and flexibility in problem solving (Bransford & Schwartz, 1999). Conceptually, this framework aims to understand how trainees use their past knowledge to solve novel problems when they cannot use “routine practices” efficiently or effectively. Methodologically, Bransford and Schwartz (1999) proposed using a “double transfer paradigm” to test for trainees’ abilities to solve novel problems adaptively and efficaciously. Here, the focus shifts to assessments of trainees’ abilities to learn in knowledge-rich environments, looking for evidence of learning trajectories rather than evaluate whether people can generate a finished product (Bransford & Schwartz, 1999). For example, when a trainee transitions from pre-clerkship medical training involving lecture-based learning, to clerkship training involving clinical rotations within the hospital, it is not expected that they will have the requisite knowledge to solve all the problems they will encounter. However, the PFL framework would explore how the pre-clerkship years have prepared trainees to learn while on rotation in clerkship.

To fully understand the implications of the PFL concept requires study of the work that helped inform it, the methodologies and assessments used to refine it, and the types of educational interventions that best support it. Such an in-depth analysis will explore the PFL framework’s relationship with adaptive expertise, and its importance to the medical field. The following analysis will also reveal the gaps in current literature, which this thesis will attempt to address. It will become apparent that the work justifying the methodology and assessments
presents strong evidence for their effectiveness, however more work must be conducted to clarify which educational interventions best promote PFL.

1.2.1 Broudy’s Types of Knowing

The work of Broudy (1977) has been cited as foundational in the development of the PFL framework. His work categorized three distinct types of knowledge and reflected on how the education system promoted and assessed them. Specifically, he considered knowledge to be replicative, applicative, or interpretive and concluded that the education system focused primarily on the former two, while neglecting the third (Broudy, 1977).

Replicative knowing is defined as recalling input similarly to how it is learned (Broudy, 1977) and is often referred to as knowing ‘what’ (Bransford & Schwartz, 1999). For example, a learner may learn the multiplication table and arithmetical operations in school and subsequently use them as needed in arithmetical computations (Broudy, 1977). Notably, this information is used replicatively, and although this type of knowledge is not held to a high esteem, higher and more complicated mental processes, such as the application of knowledge, would suffer without it.

Applicative knowing is therefore defined as the formulation of a solution to a problem using facts, rules and principles learned through replicative knowing (Broudy, 1977) and is often referred to as knowing ‘how’ (Bransford & Schwartz, 1999). An example of this would be the use of chemistry learned in school to solve problems in agriculture and nutrition.

Lastly, interpretive knowing is defined as the ability to think, perceive, and judge with everything that has been studied, even though the knowledge cannot be recalled on demand.
(Broudy, 1977), and is often referred to as knowing ‘with’ (Bransford & Schwartz, 1999). That is, Broudy suggested that the categories and concepts of our various learning experiences guide our expectations, perceptions, and judgments when approaching new problems (Broudy, 1977). For example, a learner trained in kinesiology will approach the problem of population health differently and using different background knowledge than a learner trained in sociology. The two learners’ interpretations will impact what they find salient in the problem, guide how they work through it, and lead them to create the answers they believe to be most appropriate. And although the interpretation of the situation invariably involves using a previous experience, it cannot be reduced to a simple replication of that experience (Broudy, 1977).

1.2.1.1 A Call for Change

Replicative and applicative knowing are the predominate criteria used to assess the effectiveness of most contemporary education systems. Trainees are often tested on their ability to remember and recall information directly and how they apply this knowledge to broader problems as exemplified by multiple choice and short answer questions, respectively. However, by these criteria, most schooling is a failure (Broudy, 1977). The failure of replicative knowing is demonstrated by the amount of rote learning that a learner retains after the completion of a course and how this significantly degrades in the absence of opportunities for frequent recall. Thus, even after numerous courses in chemistry, few citizens can directly recall the structural properties of different compounds. The failure of applicative knowing is demonstrated by the gap between the generalizations of science and its application to effect major changes. For example, applying the principles of chemistry to the energy crisis involves more than remembering what was learned about hydrocarbons in school (Broudy, 1977). For these reasons, Broudy (1977)
argued that the effectiveness of education cannot be assessed solely by replicative and applicative knowing, but rather, the system must include an assessment of trainees’ interpretive knowing. In order to do so, he suggested we attempt to reach an understanding on how trainees incorporate past educational experiences into approaching new problems or situations. To what extent do they use past educational interventions to:

I. Organize the new information, and set up their expectations and judgement of the problem?

II. Influence how they decide on and select a response?

III. Enrich or elaborate their response?

Thus, if we expect trainees’ to approach novel problems and learn in new situations using past knowledge and experience, we must engage in more in-depth research surrounding the ways in which education prepares trainees for future learning and promotes these adaptive behaviours.

Broudy’s (1977) work suggests that education, in general, increases a learner’s interpretive knowing and provides them with a foundation of knowledge when approaching new problems. However, since this has not been the main focus of most assessments, we have consequently failed to capture how prepared trainees are for future learning. Therefore, the next steps are to assess this more thoroughly in trainees so that we can begin to understand how each educational intervention contributes to preparing them for future learning; an emerging research focus in educational psychology. Bransford and Schwartz (1999) built on this concept to ask if certain educational interventions better prepare learners than others, leading to their creation of the current PFL framework and methodology.
1.2.2 PFL Assessments and Methodology

The distinguishing feature of a PFL assessment is that it allows learners to use their past experiences, knowledge, and learning strategies when learning new material. A specific version of such an assessment is the double transfer design mentioned above (Bransford & Schwartz, 1999). Double transfer is built on the premise that there are two types of transfer that occur when learning new material: Transfer In and Transfer Out. Transferring In refers to the process of using past knowledge to understand new material and Transferring Out refers to using that new material to perform a subsequent, related task (Bransford & Schwartz, 1999). Therefore to test double transfer, a research design must have an initial learning session, subsequently allow learners to transfer in this information to a second learning session, and lastly allow learners to transfer out this new knowledge in completing a test on the new information (Figure 2a). PFL, defined here as how efficiently learners transfer in their past experiences into learning the new information, is inferred from their ability to complete the application problem (transfer out) (Bransford & Schwartz, 1999).

A key point is that this double transfer methodology is distinct from a standard transfer methodology. A Standard Transfer methodology consists of allowing learners to practice a certain skill/topic and subsequently testing them on a related but different skill/topic (e.g., practice lumbar puncture and transfer test on thoracentesis). Double transfer designs allow learners to transfer in their past knowledge into the learning of the new material, then transfer out this new knowledge into the completion of a target transfer test. Standard transfer designs only allow learners to transfer out their knowledge to a target transfer test, and does not leave any room for learning the new material (Figure 2b). Schwartz and colleagues (2005) have
incorporated these two methodologies to create the ‘standard vs. double transfer’ design (Schwartz et al., 2005) (Figure 2c).

**Figure 2**: Depicts a) the double transfer design allowing transfer in and transfer out, b) the standard transfer design allowing only transfer out, and c) the standard vs. double transfer design comparing the two former designs. Adapted from (Schwartz et al., 2005).
1.2.2.1 Empirical Evidence Supporting the PFL Methodology

An illustrative example of the double transfer design used in a study by Schwartz and Bransford (1998) revealed two important findings. First, that certain interventions better prepare learners for future learning than others, and second, that a PFL assessment may be a more sensitive measure when evaluating the differences between interventions than a retention (i.e., replicative) test. Bransford and Schwartz (1998) randomized learners into three groups when learning statistics. Group 1 was asked to analyze simplified data sets of two experiments and graph what they found; Group 2 was asked to read a modified book chapter that described the same experiments and write a one to two page summary of the chapter; and Group 3 was asked to complete the same exercise as Group 1. After a few days Groups 1 and 2 heard a common lecture that explained the experiments and the theories that were designed to accommodate the results. Group 3, instead of attending the lecture, analyzed the data a second time looking for any patterns they may have missed.

To assess which learners were better prepared to learn from the lecture (common learning resource) a true and false recognition test (retention) and prediction transfer test was used (PFL assessment). Findings showed that Group 3 did poorly on the recognition test, whereas Groups 1 and 2 performed equally as well. More importantly, the PFL assessment revealed the hidden benefit of actively analyzing experimental data before being taught about a concept in lecture, as Group 1 significantly outperformed Groups 2 and 3. Notably, this benefit was only seen when learners were given the opportunity to learn from the lecture, as the double data analysis performed by Group 3 did not lead to these same results. Therefore, the authors concluded that the PFL assessment was more sensitive to group differences than a retention test and that the
benefit of certain interventions may only be seen when assessed on how they prepare learners for their future learning (Schwartz & Bransford, 1998).

More recently, a study conducted by Mylopoulos and Woods (2014) in medical education revealed that PFL assessments may also be more sensitive than standard transfer assessments. The authors used a modified standard vs. double transfer methodology to assess differences in the way two instructional methods (clinical-focused instruction versus basic science instruction) prepared trainees for future learning. Participants first studied four general classifications of neurological disease (upper motor neuron lesions, lower motor neuron lesions, neuromuscular junction disorders and muscle disease) using one of the two instructional methods in the initial instruction phase and completed a standard transfer assessment. The standard transfer assessment consisted of 12 clinical vignettes describing signs and symptoms, each of which participants had to diagnose as one of the four categories learned. Performance on this assessment was measured by their diagnostic accuracy.

Participants subsequently completed a PFL Instruction phase that required them to learn four new disease categories (brainstem stroke, myasthenia gravis, spinal cord compression and polyneuropathy), which were specific examples of the broader categories learned in the initial learning session. Importantly, participants in both the basic science and clinical science groups received the same material to learn these diseases, which only consisted of signs and symptoms. Finally, in the PFL assessment, trainees were required to transfer their new learning to the diagnosis of novel clinical vignettes based on the material they learned in the PFL instruction phase. Results showed that there were no significant differences between the two groups on standard transfer. However, the participants who received basic science information in the initial
instruction phase were better prepared to learn the new material in the PFL phase, as inferred by their higher diagnostic accuracy on the PFL assessment (Maria Mylopoulos & Woods, 2014).

Together, these two studies provide evidence supporting the notion that PFL assessments measure a different process in learners than both retention and standard transfer tests. Therefore PFL assessments should be included to assess the quality of interventions as the other tests currently used fail to capture how well trainees learn to learn and instead emphasize how well they perform after a learning session. It is important to address this gap as research has shown that a focus on immediate outcomes can be short-sighted (Dubrowski, 2005; Schmidt & Bjork, 1992). Thus, the addition of PFL assessments and designs brings with it the need to research the types of educational interventions that best prepare learners for their future learning. The following section will review the theoretical and empirical literature to provide an argument for certain educational interventions over others when it comes to their effectiveness in promoting PFL in learners.

1.2.3 Educational Interventions Promoting PFL

To understand the link between the different educational interventions that prepare learners for their future learning, the learning theory of constructivism must be introduced. This is important as there are a wide range of interventions, which at the surface may not seem related, however, the theoretical implications of constructivism act as a unifying concept in which the majority of these successful educational interventions fall under in empirical studies. Although there are differences between the interventions, they all attempt to facilitate learners in creating their own knowledge during practice.
1.2.3.1 Theory of Constructivism as it Applies to Formal Education

Constructivism is a theory of knowledge growth and life-long development, and in the context of formal education, it is often used as a label for educational interventions such as discovery, inquiry, exploration, and hands on learning (Duffy & Jonassen, 1992). Constructivism emphasizes the need to consider learners’ ability to create new knowledge when they leave the classroom and educators no longer have control over the precise instructional variables. Therefore, constructivism argues that instruction should not focus on transmitting plans to the learner, but rather give opportunities for the learner to construct his or her own plans to promote adaptability in varying situations or contexts (Duffy & Jonassen, 1992).

Notably, constructivist interventions are often compared against direct instruction, where external resources, such as an instructor, regulate learning and show learners exactly what to do (Schwartz, Lindgren, & Lewis, 2009). This presents two opposing ends of a continuum with total learner control (unsupervised constructivism) on one end and total teacher control (direct instruction) on the other (Schwartz & Bransford, 1998). Proponents of constructivist instruction do not argue that there should be total learner control, as evidence suggests that it is not as beneficial as direct instruction for efficiently remembering facts, executing skills, or solving similar problems to what they were taught (Schwartz et al., 2009). Rather, they advocate for finding a balance between teacher and learner control to best optimize the efficiency of learning what is being taught while also preparing learners for their future learning when they enter new situations or contexts (Schwartz & Bransford, 1998).

Therefore, it is apparent that measuring the effectiveness of educational interventions with PFL assessments aligns with the goals of constructivism. Consequently, it follows that
instructional methods that include constructivist techniques should better promote PFL than instructional methods that do not (Schwartz et al., 2009). In the section that follows, empirical evidence will be presented from different domains to support this claim. To reiterate, the educational interventions vary from study to study, but the general premise of comparing constructivism to direct instruction acts as the unifying comparison between them.

1.2.3.2 Empirical Evidence Supporting Constructivist Interventions

Schwartz and Martin (2004) demonstrated the hidden efficiency in allowing learners to invent solutions to statistical problems before being shown the correct formula to organize the data. Specifically, they allowed learners to prepare for a test using either a self-regulated invention method or an instructor led tell-and-practice method. Subsequently, both groups learned new statistical concepts through a worked example, and then applied them to a set of test questions. The results showed a benefit for the invention group when there was a worked example within the test to demonstrate the new statistical concept (double transfer). When the worked example was not present, the invention and tell-and-practice groups performed similarly on the transfer problem (standard transfer). Therefore, the invention method better prepared learners to learn the new material as inferred from their higher score on the transfer questions with worked examples embedded within the test (Schwartz & Martin, 2004).

Further evidence supports the notion that the timing of constructivist aspects within an educational intervention also makes a significant impact on learners’ ability to learn new information. Specifically, does direct instruction prepare learners for future discovery learning or does discovery learning prepare learners for future direct instruction? Kapur (2014) completed a study manipulating the timing of allowing learners to generate their own knowledge. One group
of learners completed a problem-solving session in which they were asked to generate as many solutions as they could to solve a problem on standard deviation (SD), and then proceeded to listen to a lecture given by an experienced mathematics teacher that taught the concept and procedures. The second group received this same training, but in reverse order; lecture first, problem-solving session second. Results showed that the group who engaged in the problem solving session prior to the lecture outperformed those who had the reverse order when assessed on transfer (Kapur, 2014). The author attributed this finding to the idea that learners were able to construct their own knowledge regarding SD, and although this knowledge was incorrect, it prepared learners to learn more effectively from direct instruction; a concept referred to as ‘productive failure’ (Kapur, 2014). This study is but one example of accumulating research with consistent findings that constructivist interventions prior to direct instruction, prepares learners to learn more from the direct instruction that they receive subsequently (DeCaro & Rittle-Johnson, 2012; Kapur, 2014; Schwartz & Bransford, 1998; Schwartz, Chase, & Bransford, 2012; Schwartz, Chase, Oppezzo, & Chin, 2011).

1.2.3.3 Gaps in the Current Literature Regarding Educational Interventions

It is apparent that the PFL assessments and methodology have a solid foundation of evidence supporting that they measure different processes in the learner than both retention and standard transfer assessments. To reiterate, the former assesses a learner’s capability to acquire knowledge and learn in future learning situations or contexts, while the two latter assessments focus on evaluating the knowledge that a learner has already acquired. However, in all of the cases presented above, the PFL assessments measured learning in a cognitive domain, and consequently, cognitive skills (i.e., math, statistics, diagnostic reasoning). To date, no studies
have looked at the goal of preparing learners for future learning in a healthcare simulation context which is predominantly focused on procedural skills training (e.g., endotracheal intubation). Therefore, this link between PFL and procedural skills cannot be readily generalized from the evidence above, and must be studied further to expand the validity of the assessments and methodology.

In addition, proponents of PFL have provided evidence linking constructivist or discovery learning paradigms to preparing learners for their future learning and, furthermore, have explored how the timing of such interventions provide even greater benefit. However, only a handful of studies have moved beyond the original emphasis on how best to assess PFL, with recent work prioritizing how to refine educational interventions to promote PFL. An illustrative example of this new work is the distinction between the invention and tell-and-practice groups in Schwartz and Martin’s (2004) study. The invention group can be interpreted as a self-regulated learning (SRL) intervention because the learners were given the opportunity to interact with a data set to develop descriptive statistics to explain it, but received little guidance on how to accomplish this. Thus, they were forced to regulate their own learning and explore different solutions during this process of inventing the organizing equations. Conversely, the tell-and-practice group can be interpreted as an instructor-led practice intervention because the learners were taught the appropriate descriptive statistics and were subsequently asked to practice them on a data set. By teaching the equations, the instructor guided the learners practice and minimized their need to regulate their own learning. Within educational psychology, there is an accumulation of literature that has explored the merits of SRL vs. instructor-led interventions, but few studies have used the concept of PFL when comparing the two interventions. The following section will present the promises and perils of different amounts of instructor/trainee
1.3 Self-regulation of Learning

As mentioned above, allowing learners to construct their own knowledge and understanding around a concept is paramount in preparing them for their future learning. Put another way, learners must be active in self-regulating their own learning. Self-regulated learning (SRL) is defined as the modulation of affective, cognitive, and behavioural processes throughout a learning experience to reach a desired level of achievement (Sitzmann & Ely, 2011). Relating this back to the medical profession, practicing clinicians are expected to self-regulate their learning in order to address identified gaps in their knowledge and maintain a specified level of competence (Brydges & Butler, 2012). Therefore medical professionals’ success will rely on their ability to assess and manage their own learning to meet the demands of the contexts in which they work (Brydges & Butler, 2012). However, early on in training, we cannot assume that learners will be effective self-regulated learners (Butler & Brydges, 2013). It is apparent then, that another focus of medical education must be to develop trainees SRL capabilities to ensure they are able to cope with the demands placed on them when they enter clinical practice.

SRL is firmly grounded in a number of theories within educational psychology. And understanding these theories can act as a foundation for creating educational interventions that support trainees as they develop SRL skills. The following section will present two of the main theories surrounding SRL. Subsequently, I will argue for the need to support trainees in their SRL and provide empirical evidence highlighting promising educational supports. I will then
address the promises and perils of having an instructor present, and end with an example comparing SRL to instructor-led practice in a simulation-based training context.

1.3.1 Conceptual Frameworks of SRL

The two prominent SRL theories, Triadic Reciprocality (Bandura, 1986) and Phases of Self-Regulatory Development (Schunk & Zimmerman, 1997) are branches of the social-cognitive theory of learning. The social-cognitive theory is a model of social-self interaction which states that there are bidirectional relationships that develop between an individual and the social environment during learning (Schunk, 1999). The concept of triadic reciprocality involves the factors that play a part in these relationships, whereas the phases of self-regulatory development explain how this develops over time.

1.3.1.1 Triadic Reciprocality

Bandura (1986) proposed that human functioning, and consequently learning, is comprised of a series of reciprocal relationships between behavioural, environmental, and personal variables, giving rise to the theory of triadic reciprocality (Figure 3). The theory states that each variable can influence the others, creating 3 reciprocal interactions:

1. Personal traits influence behaviour, and vice versa. For example, self-efficacy influences an individual’s performance and performance gains (or lack thereof) influence an individual’s self-efficacy.

2. Environments influence behaviour, and vice versa. For example, a teacher’s introduction of new material will influence a learner’s attention and the learner’s reaction towards it will influence the teacher’s structuring of that material.
3. Environments influence personal traits, and vice versa. For example, feedback received from the environment (i.e., formative assessment) influences a learner’s self-efficacy, which influences the learner’s ability to structure their environment to promote their own learning.

**Figure 3:** Bandura’s (1986) theory of triadic reciprocity, with examples given for each of the three interacting variables: environmental, behavioural, and personal. Adapted from (Schunk, 1999).
1.3.1.2 Phases of Self-Regulatory Development

The phases of self-regulatory development model predicts that academic competence develops initially from social (environmental) sources and gradually shifts to self (personal and behavioural) sources during the learning of a particular task (Schunk & Zimmerman, 1997; Schunk, 1999). This shift occurs along four levels of development which have been labelled the observational, emulative, self-controlled, and self-regulated phases. Broadly, the former two rely primarily on social factors, whereas the latter two rely primarily on the learner (Schunk, 1999). Specifically, learners in the observational phase learn about major features, strategies and procedures through social modelling and encouragement, but they cannot necessarily complete them. Subsequently, learners enter the emulative phase when they are able to imitate the performance which has been modelled. These two levels are therefore social in nature as the learner requires exposure to external models of performance for observation and emulation.

In the self-controlled phase, learners are now capable of using the skill or strategy independently. However, learners have not yet developed their own representation of the skill, limiting their ability to modify the performance to account for variations if they are encountered. Lastly, learners enter the self-regulated phase when they are capable of adapting their skills and strategies, and incorporate adjustments based on variations in their environment. These two levels are therefore learner driven as learners actively practice skills, seek out resources to help them refine their skills, and develop internal representations of what has been modelled to them in the former two stages (Schunk & Zimmerman, 1997; Schunk, 1999).
1.3.1.3 Combining the Conceptual Frameworks

Together, the theory of triadic reciprocality and the phases of self-regulatory development explain the dynamic relationship between the individual and social environment and how this changes throughout the learning process. They depict learning as an activity that learners self-regulate in the presence of instructors, peers, as well as independently. Furthermore, the models imply that it is the availability of social and environmental supports that make the difference in a learners’ ability to self-regulate, and not the presence or absence of an instructor. Thus, the definition of SRL must be elaborated. Given this information, SRL can be conceptualized as a process involving an individual who, with or without supervision, actively modulates his or her own affect, cognition, and behavior using supports designed to facilitate the achievement of desired learning goals (Brydges et al., 2015). This creates an important distinction between SRL and unsupervised learning, where researchers and educators shift their conceptualization of SRL from being a sole responsibility of the trainee to a shared responsibility between the trainee and the instructional designer (Brydges et al., 2015; Butler & Brydges, 2013).

1.3.2 Supporting SRL through Educational Interventions

Relating this conceptualization of SRL to medical education research highlights that there are current assumptions within the field that are counter-productive to supporting trainees. The first assumption is that simply designing an educational session to be completed independently is sufficient for trainees to learn the content and develop their self-regulation capabilities (Brydges & Butler, 2012). The second assumption is that self-regulation occurs entirely within the learner, and consequently, educators need to play little to no role in supporting them (Miflin, Campbell,
& Price, 2000). These two assumptions ignore the two theories presented above as they overlook the influence that the environment and, thus the available educational resources, have on learners and their ability to self-regulate.

In addition, the argument of simply providing ample resources for opportunities to self-regulate is not enough as learners are not always in tune with strategies that are optimal for learning. Kornell and Bjork (2007) provide examples where learners choose learning strategies that promote short term performance (e.g., blocked practice of a technical skill) over strategies that promote long-term retention (e.g., variable practice of a technical skill). Also, through survey data, they concluded that learners were more confident in their learning when exposed to mass practice than spaced practice, which is at odds with the results seen when long-term retention is measured (Kornell & Bjork, 2007).

Therefore, educators must be cognizant about providing ample resources, but also about including ample supports to help learners interact with those resources. Specifically, a support can be defined as an explicit component of an educational intervention that guides trainees’ thinking or behaviour by relating learning processes to conceptual and procedural knowledge of the task. For example, support can come in many forms, such as through facilitation, prompting, or modelling, and from many sources such as text, video, online modules, or instructors (Brydges & Butler, 2012; Sitzmann & Ely, 2010). However, it is important to explore these supports more fully to develop answers to questions such as what exactly should educators be prompting? For this reason, Brydges and Butler (2012) recommend that educators learn from empirical evidence within medical education and elsewhere to help create an educational intervention that facilitates the learning of content knowledge while also promoting trainees’ SRL capabilities. The following section will review illustrative examples of this literature to shed light on some of the
supports that show evidence of promoting SRL within the context of medical education more broadly, and simulation-based training more specifically.

1.3.2.1 Empirical Evidence for SRL Supports

1.3.2.1.1 Supports identified in Educational Psychology

Sitzmann and Ely (2011) conducted a systematic review and meta-analysis on SRL in work-related training. This review is particularly relevant to medical education as the results account for knowledge and skill-based learning of adults. The authors included the personal and behavioural variables from the theory of triadic reciprocity, and assessed which aspects of each had the greatest impact on SRL. Results showed that self-efficacy (personal) and goal level (behavioural) had the largest impact on learning, with strong to moderate effects (Sitzmann & Ely, 2011). Although the two variables separately predicted learning, it is important to reiterate their bidirectional relationship in which goals increase self-efficacy if they are achieved, and conversely, high self-efficacy leads to setting more difficult and specific goals (Bandura, 1986). In addition, the results from the meta-analysis revealed that the impact of goal level was strongest when learners had set their own goals after familiarizing themselves with the task (Sitzmann & Ely, 2011).

From these findings we can interpret that prompting participants to set informed personal goals should have a positive impact on their learning while simultaneously supporting their SRL. Expanding further, work in both educational psychology and medical education suggests that it is more beneficial to orient learners to process goals (i.e., the mechanisms of performance) than to outcome goals (i.e., the products of performance) when learning psychomotor skills (Brydges, Carnahan, Safir, & Dubrowski, 2009; Manzone, Garbedian, & Brydges, 2013; Zimmerman &
Kitsantas, 1996, 1997, 1999). Therefore, when designing an educational intervention, instructional designers should aim to support learners in setting their own process oriented goals, and one way this can be achieved is through prompting learners with questions about the task (Sitzmann & Ely, 2010).

1.3.2.1.2 Supports identified in Motor Learning

In addition to educational psychology, it is imperative to consult the motor learning literature on procedural skills as it provides a solid foundation of evidence for possible ways to structure a simulation-based training environment that supports trainees’ SRL abilities. Specifically, when learning procedural skills there are two structural components that have a large effect on delayed retention of a skill: variability of practice and random practice (Merbah & Meulemans, 2011; Schmidt & Lee, 2005; Wulf, Shea, & Lewthwaite, 2010). Variability of practice requires presenting the learner with different variations of the task instead of providing only one variation. Doing so forces a change in behaviour between variations, encouraging learners to engage in additional information processing to compare the similarities and differences between them (Schmidt & Bjork, 1992).

Random practice adds yet another layer of complexity in learning the skill by forcing learners to sequence the variations in a random order (i.e., ACB CBA BAC) as opposed to a blocked order (i.e., AAA BBB CCC). The random sequencing requires learners to remember and forget the specific aspects of each variation from trial to trial, which increases the learner’s internal representation of the variations through repeated retrieval of the skill’s main components (Merbah & Meulemans, 2011; Schmidt & Bjork, 1992; Schmidt & Lee, 2005). However, at first glance, this type of practice may seem unappealing to learners as it is more difficult and leads to
decreased short-term performance (Merbah & Meulemans, 2011), and they may not be aware of the positive effects on long-term retention (Kornell & Bjork, 2007). Therefore, it may be imperative that instructional designers make the benefits known to learners so that they are willing to structure their practice schedule in this manner, knowing full well they are sacrificing short-term gains.

1.3.2.2 Instructors as SRL Support

The conceptualization of SRL presented above allows for the presence of an instructor during the learning process. Indeed, an instructor may be more than capable of facilitating the aforementioned supports to create an optimal educational intervention for a trainee. This is the promise of instructor-led practice. However, this is not necessarily what happens when an instructor is present. Instead, traditional instructional designs in simulation-based training emphasize the role of the instructor as regulator of learning, especially given the evidence that trainees are often ‘incompetent and unaware of it’ (Eva, Cunnington, Reiter, Keane, & Norman, 2004; Kruger & Dunning, 1999).

One limitation is that this attitude compels instructors to act in ways that are contradictory to learner self-regulation, such as providing concurrent, hands-on feedback (Walsh, Ling, Wang, & Carnahan, 2009; Xeroulis et al., 2007). Concurrent feedback is defined as the delivery of feedback to trainees while they are in the process of completing a skill. Research in Motor Learning has shown this method of delivery to be detrimental to SRL as it does not allow learners the opportunity to internalize their actions and create their own representations of the skill. It is often referred to as a ‘crutch’ in the sense that it helps learners to get through the skill, but ultimately results in a reduction in learning when it is taken away. In contrast, waiting until
the end of the trial to give feedback, also referred to as terminal feedback, allows learners to create their own representations of the task before turning to the instructor. This allows the feedback to be added to the learner’s internal representations versus replacing them and acting as the aforementioned crutch (Hattie & Timperley, 2007; Walsh et al., 2009; Wulf & Shea, 2004; Wulf et al., 2010).

Therefore, if instructors are to be used as supports for learners’ SRL, they must be involved in the designing of the intervention and be taught how to facilitate learners as opposed to regulate them. They must be comfortable with letting the learner fail (a particular affordance of simulation contexts) in order to allow them to produce their own understanding of the task (Kapur, 2014) and move through the four phases of self-regulatory development (Schunk & Zimmerman, 1997; Schunk, 1999).

1.3.2.3 SRL versus Instructor-led Practice in Simulation-based Training

Brydges et al. (2015) completed a systematic review and meta-analysis comparing SRL and IRL interventions in technology-enhanced simulation-based training. In their review, the authors provided a nuanced analysis and coding structure that incorporated two variables: presence of an instructor (supervised/unsupervised) and presence of supports designed to enable SRL (supported/unsupported) which are represented in Figure 4 (Brydges et al., 2015). Notably, they could not code any studies that showed evidence for supervised, supported interventions. Therefore, comparisons were made between the three remaining groups.
## Figure 4: 2 x 2 orthogonal coding structure which includes presence of an instructor (supervised/unsupervised) and presence of SRL supports (supported/unsupported). Adapted from (Brydges et al., 2015).
The results of the meta-analytic comparisons confirmed previous research in simulation-based training (Brydges & Butler, 2012; Brydges, Dubrowski, & Regehr, 2010), showing that when compared to no-intervention control conditions, interventions designed to support trainees’ SRL (unsupervised, supported) were associated with greater learning gains than interventions that did not include such supports (unsupervised, unsupported). When SRL-supported interventions were directly compared to SRL-unsupported interventions, results showed both immediate post-test (effect size = 0.23) and retention (effect size = 0.44) benefits for SRL-supported interventions (Brydges et al., 2015).

Notably, all studies that included a supervised intervention were coded as not including SRL supports (i.e., supervised, unsupported). Furthermore, those interventions were only compared to unsupervised, unsupported interventions. The results showed immediate post-test benefits of the instructor-led groups (effect size = 0.34), whereas that benefit shifted (albeit negligibly) to the unsupervised interventions for skill retention (effect size = 0.11) (Brydges et al., 2015).

1.3.2.4 Gaps in the Current Literature Regarding SRL in Simulation Contexts

The systematic review published by Brydges et al. (2015) provides compelling evidence that the majority of simulation-based training interventions, both supervised and unsupervised, are not designed to support trainees’ SRL. Consequently, when making comparisons between the different interventions, there was a limited ability to clarify how to design a support to be maximally effective for enhancing SRL and learning outcomes (Brydges et al., 2015). Thus, the first gap that must be addressed is this lack of research on SRL supports within this context. Turning our attention back to Figure 4, it appears that further research must explore supervised,
supported interventions more fully and compare them to the remaining three types of interventions by measuring both post-test and retention performances.

In addition, while a trainee’s retention of a skill is an important measure of what he or she has learned, this does not capture the full spectrum of expertise (Broudy, 1977). As discussed in the PFL section above, the next step is to evaluate how interventions prepare trainees for their future learning. Therefore, a significant gap in the current simulation and SRL literature is that researchers have yet to include these assessments. Brydges et al. acknowledged that their analyses could not determine if the same benefits are seen when evaluating these interventions with PFL assessments. It becomes important then, to recreate some of these comparisons and test if the variables of instructor and SRL support have an effect on helping trainees learn how to learn.

1.4 Summary of the Literature

As we explored the literature surrounding adaptive expertise, preparation for future learning, and subsequently self-regulated learning, it became clear that there may be direct linkages between the three. First, the work of Mylopoulos and Woods (2009) highlighted the different expectations of expertise within the medical profession, showing how past literature has emphasized the dimension of efficiency, while simultaneously providing evidence justifying the need to focus on the dimension of innovation; to be innovative you must be adaptive. An emphasis on innovation requires us as educators and researchers to be able to assess and measure the dimension in the many contexts where medical education takes place. To measure a trainees’ efficiency, traditional assessments such as retention and standard transfer tests have been widely
used in the simulation-based context. However, to measure a trainees’ innovation, the PFL assessment must be introduced.

Second, the work of Bransford and Schwartz (1999) was reviewed to reach a better understanding of preparation for future learning and how this concept mapped onto the innovation dimension of expertise mentioned above. In order to prepare trainees to be innovative, flexible, and adaptive in future scenarios, medical educators must expose them to educational sessions that allow the creation of knowledge and emphasize a deep understanding of what is being taught. This constructivist approach argues that instruction should not focus on transmitting plans to the learner, but rather give opportunities for the learner to construct his or her own plans. One way to accomplish this goal is to allow trainees to self-regulate their own learning, where the trainee, his or her behaviour, and the environment dictate the flow of the learning session in order to facilitate knowledge creation.

Last, the work of Brydges et al. (2015) outlined the potential factors that must be taken into consideration to best support learners’ SRL. Specifically, novice trainees need resources within the environment, provided in the presence or absence of an instructor, to help inform the choices they make during their learning. Constructivists would argue that a potential rationale for why such supports are beneficial is that they help trainees to better internalize the skill as they move through the phases of self-regulatory development, helping them create new knowledge effectively and efficiently. Therefore, given that interventions that support trainees SRL conform to a constructivist approach, it can be hypothesized that they will better prepare trainees for future learning than interventions that do not. In the following section a more nuanced explanation and accompanying hypotheses will be developed to highlight how we attempted to test the linkages between these three concepts.
Chapter 2
Research Aims and Hypotheses

This thesis investigates the effects of supported and unsupported SRL interventions and instructor-led practice on learning in a simulation-based training context. Specifically, it evaluates these interventions based on novice medical trainees’ skill acquisition, retention, transfer, and double transfer of endotracheal intubation on a simulator. The research study was designed to satisfy four research aims:

1. To compare the impact of (a) unsupervised vs. instructor-led practice, and (b) SRL-supported vs. SRL-unsupported practice on trainees’ skill acquisition and retention.

2. To introduce a PFL assessment to the health professions simulation-based training context to assess how training interventions promote future learning of procedural skills.

3. To compare the impact of (a) unsupervised vs. instructor-led practice, (b) SRL-supported vs. SRL-unsupported practice on trainees’ performance on a PFL assessment.

4. To explore novice trainees’ perceptions of the benefits and pitfalls of SRL and instructor-led practice.

To address these aims, the study used a modified standard vs. double transfer design and data collected using quantitative and qualitative methods. The study included three distinct groups: SRL-supported, SRL-unsupported, and Instructor-led practice; three of the four categories from Figure 4 (Brydges et al., 2015). The Instructor-led practice group falls under the supervision variable examined above. However, it is important to note that there was no a priori decision to code this group as Supervised, SRL-supported or Supervised, SRL-unsupported.
Rather, we created an environment with the instructors and documented their interactions with the participants throughout the sessions and then retrospectively categorized the intervention as either supportive or unsupportive of participants’ SRL.

Related to the first aim, the study includes pre-test, post-test and retention assessments to test these hypotheses:

**Hypothesis 1A:** The presence of SRL supports will have a significant, positive impact on trainees’ pre-test, post-test, and retention outcomes.

**Hypothesis 1B:** The presence of an instructor will not have a significant, positive impact on trainees’ pre-test, post-test, and retention outcomes.

These hypotheses are based on the results of Brydges et al (2015), wherein the presence of SRL supports appeared to be associated with greater learning benefits than the presence of an instructor.

Related to the second and third aims, the study includes standard and double transfer assessments to test three additional hypotheses:

**Hypothesis 2:** The PFL assessment (double transfer) will be more sensitive to group differences than the standard transfer assessment.

**Hypothesis 3A:** The presence of SRL supports will have a positive impact on preparing trainees for future learning.

**Hypothesis 3B:** The presence of an instructor will not have a positive impact on preparing trainees for future learning,
Hypothesis 2 is important as PFL assessments have not yet been used to measure the learning of procedural skills. Therefore, obtaining different results from a standard transfer assessment adds validity to the argument that PFL assessments are indeed measuring a different process (Mylopoulos & Woods, 2014; Schwartz et al., 2005). However, hypotheses 3A and 3B are the main focus of this thesis and build off of the extensive work in educational psychology (Schwartz & Martin, 2004), motor learning (Schmidt & Bjork, 1992), and medical education (Brydges et al., 2015) literature reviewed in the introduction.

Finally, in regards to the fourth aim, the study protocol includes open ended questions in which participants in each group have the chance to voice their opinions about what they found most helpful and what they found was missing in the interventions they were randomized to. This last aim is more exploratory in nature. It may help inform our understanding of what learners know about the SRL supports we provide them with and how we can alleviate discrepancies between their opinions and empirical evidence. Therefore, a hypothesis was not generated to avoid the problem of our analysis being clouded by our pre-conceptions of what we think trainees know and do not know.

2.1 Significance

This thesis adds to the literature surrounding SRL and has the potential to increase the learning return from simulation-based training across the health professions. Furthermore, by using the double-transfer design, the thesis tests the sensitivity of PFL assessments, which extends preliminary work in medical education (Mylopoulos & Woods, 2014) and may produce additional evidence for a new testing modality in simulation. Therefore, the significance of this work is seen on two levels:
(i) It introduces new concepts (e.g., Preparation for Future Learning) to, and refines existing concepts (e.g., Self-regulated Learning) in, simulation and medical education literatures.

(ii) It contributes to the educational psychology literature and work on PFL, adding to the evidence supporting its conceptual and methodological validity.
Chapter 3
Methodology

3.1 Overview of Study Design

We conducted a randomized multi-factorial design with test (pre, post, retention) as the within-subjects variable and group as the between-subjects variable: Supported SRL, Unsupported SRL, and Instructor-led one-on-one practice. In addition to the design above, we used a modified standard vs. double transfer design, thus requiring all participants to complete pre-test, post-test, retention, transfer, and double transfer assessments. Specifically, participants completed an initial practice phase (delivered according to their group assignment) which included the pre-test, 16 trials of two different clinical variations of endotracheal intubation, and the post-test. They subsequently returned two weeks later to complete the second practice and testing phase, which included the retention and transfer tests, a second practice session of a new clinical variation of endotracheal intubation (common to all groups), and lastly the double transfer assessment. See Figure 5 below.
Figure 5: Overview of the modified standard vs. double transfer protocol used in the thesis.
3.2 Participants, Recruitment and Group Assignment

Upon receiving ethical approval from the Toronto Research Ethics Board, we recruited 39 clerkship (year three and four) undergraduate medical students and six PGY1 Internal Medicine residents from the University of Toronto. Inclusion required that participants have performed less than 15 previous successful intubations. Initial contact with potential participants was made via a LISTSERV email through the Faculty of Medicine Registrar. Students interested in participating in the study were asked to contact the graduate student investigator to receive additional information about the study and to arrange dates and times for participation. We sent further study information to these students, including an online scheduling survey and directions to where the study was being conducted. Recruitment into the study was contingent on participants’ availability to attend the two sessions two weeks apart (± 1 day) and was completed on a first come first-served basis. Written informed consent was obtained prior to the start of the first session.

As the 45 participants confirmed their participation dates and times; they were added to a randomized list which assigned them a participant code that fully anonymized their identity and placed them into one of the three interventions. We created the random list through an online random number generator using a blocked randomization method with a random number technique to ensure a balance of participants in each group. We did this to ensure that all the interventions accumulated participants throughout the entire duration of data collection as opposed to finishing one intervention before moving on to the next. However, randomization was slightly modified to ensure equal representation of each year of training within each intervention to balance clinical training years across the three groups.
3.2.1 Sample Size Calculation

We used evidence from a previous study for our sample size calculation, which suggested an educationally meaningful difference between groups would be 1.0 unit on a 5-pt global rating scale (Brydges, Nair, Ma, Shanks, & Hatala, 2012). Based on a standard deviation of ~1.0, an alpha level of 0.05 and a desired power of 0.80, a two-sided t-test yielded an estimated sample size of 16 participants per group.

3.3 Simulated Procedural Skill

Participants performed four variations of endotracheal intubation on a part-task trainer for practice and testing purposes during the study. The four variations are the Table-top, Supine, Left-lateral Decubitus (LLD), and Straddling positions used in prior simulation research (Manzone, Tremblay, You-Ten, Desai, & Brydges, 2014; Tesler et al., 2003). Each of the four variations is described below:

*Table-top* – Patient is on the table at the level of the participant’s navel. Participants will perform the procedure from a standing position above the patient.

*Supine* – Patient is on the floor in a supine position. Participants will perform the procedure while in a prone position on the floor (i.e., face to face with the patient, looking down toward the patient’s feet). See Figure 6a.

*LLD* – Patient is on the floor in a supine position. Participants will perform the procedure while lying perpendicular to the patient (i.e., simulates patient on the ground without face to face access as in the ‘supine’ position). See Figure 6b.
**Straddling** – Patient is on the floor in a supine position. Participants will perform the procedure kneeling above and positioned face to face with the patient (i.e., looking up at patient’s head). See Figure 6c.

**Figure 6**: Pictorial representation of the a) Supine, b) LLD, and c) Straddling variations of endotracheal intubation. Adapted from (Tesler et al., 2003).
3.4 Protocol and Intervention Design

3.4.1 Session 1: Initial Practice Session

Session 1 began with participants’ completing a baseline questionnaire on their previous experience performing endotracheal intubation on a simulator and patient, and how many intubations they have seen performed on either (Appendix 1). Next, they watched a 6-minute instructional video, which was a shortened version of the New England Journal of Medicine’s “Videos in Clinical Medicine” (Kabrhel, Thomsen, Setnik, & Walls, 2007). After this preparation phase of the session, all participants completed a pre-test which consisted of two trials of the Supine intubation variation (Figure 6a) before they were told what group they were randomized to. We chose to use the Supine variation over the Table-top variation for the pre-test, and subsequently post-test and retention, as it is more difficult to complete. Manzone et al. (2014) also found that performance on that variation was associated with greater group differences as a ceiling effect was seen in participants’ learning of the Table-top variation.

Subsequently, participants were told what group they were assigned to – SRL-supported, SRL-unsupported, or Instructor-led – and had to complete eight successful trials of the Table-top variation and eight successful trials of the Supine variation on the simulator manikin (Laerdal Airway Management Trainer). Importantly, the structuring of these 16 trials was dependent on group assignment which will be discussed further below, but each participant was to complete at least one trial of each the Table-top and Supine variations as if it was a cervical spine injury, not allowing them to manipulate the neck. In addition, all participants had access to the instructional video for the duration of the session and were permitted to write notes, were oriented to the capabilities of the manikin, and received an anatomical model of the oropharynx to consult if
needed. These aspects were included for all participants to ensure that there was enough content knowledge available to describe the skill.

Lastly, to end the session, participants completed a post-test that consisted of an additional two trials of the Supine variation and participated in a brief, structured interview.

### 3.4.1.1 Interview Questions and Protocol

During the interview participants were asked two questions about the session:

1. Thinking about your experience today, what do you find was most helpful?

2. Again, thinking about your experience today, what do you find was missing?

Given that the interview was conducted between the initial practice session and the subsequent practice and testing session 2 weeks later, participants were not probed to expand on why they gave their answers. However, if only one answer was given, they were asked if anything else was either helpful or missing. We kept the discussion purposefully brief to ensure that the interview itself did not act as a manipulation that could have potentially strengthened or attenuated the differences between the groups. Participant responses are reported below as the participant perception data (see 3.6.4).

### 3.4.1.2 Intervention Group Design

The three educational interventions created for this study were developed using the coding structure presented in Brydges et al (2015) (see Figure 4). However, the review did not specify which SRL supports were most effective, so the supports used in this study were taken from evidence presented in the domains of educational psychology, motor learning, and primary
research in health professions simulation. In addition, a pilot study was run with three participants in each group to refine the interventions for the full study protocol. It is important to reiterate that we did not label the Instructor-led intervention as supportive or unsupportive of participants’ SRL at the time of study conception. Instead, the graduate investigator recorded informal field notes relating the instructors’ interactions with the participant to our initial conceptualization of ‘support’. That conceptualization is based on evidence of best practices from motor learning, educational psychology, and primary research in health professions simulation. Following data collection, the research team discussed those notes and came to consensus on whether the instructor’s approach should be coded as either supported or unsupported (see Results).

3.4.1.2.1 Supported SRL Intervention

Participants in the Supported SRL group self-regulated their practice session with the help of evidence-based SRL supports. Prior to beginning the session, participants received an explanation about variable and random practice schedules from the graduate investigator to highlight the benefits received on delayed retention (Merbah & Meulemans, 2011; Schmidt & Lee, 2005). We provided this as the first form of SRL support so that participants could make an informed decision on how they scheduled the sequence of their practice trials. Next, we gave them a list of process goals to set while completing their endotracheal intubations, as previous research has shown that orienting learners to the processes of performance leads to better retention of a skill (Brydges et al., 2009).

In addition to these two supports, participants were prompted by the graduate investigator that “you will be asked two sets of interview questions during the session with the goal of
potentially getting you thinking differently about your learning” to make it explicit to the participants that the interviews they would be engaging with would be for their own benefit and not necessarily for the benefit of the research study. The first interview aimed to promote participants’ *replicative knowing* of the task and was conducted after the participants’ second trial; the second interview aimed to promote participant’ *applicative knowing* of the task and was conducted after the participants’ seventh trial. We selected the timing of these short interviews based on the pilot data collection. It is important to note that these interviews were not transcribed, nor used in the participant perception data. As explained to the participants, they were mainly there to serve a learning purpose.

We decided to prompt Broudy’s (1977) different types of knowing in order to support participants in reaching the fourth and final self-regulated developmental phase (Schunk & Zimmerman, 1997). We also hoped to help them form their own learning goals, which has been shown to have a large effect on the learning of a skill (Sitzmann & Ely, 2011). Figure 7 illustrates the Supported SRL environment along with the endotracheal process goals used and the interview questions asked.
Figure 7: Supported SRL session 1 protocol.
3.4.1.2.2 Unsupported SRL Intervention

Participants in the Unsupported SRL group did not receive any additional supports other than those given to all three groups (described in section 3.4.1). They were given sufficient content knowledge in order for them to complete the skill, but did not have anything to directly guide how they regulated their own learning. Participants were free to structure the environment and practice schedule to accommodate their preferences, and the graduate investigator recorded their decisions. We designed this group to match the unsupervised, unsupported SRL conditions critiqued in the current simulation literature as it represents the type of SRL intervention that the majority of simulation research has used when studying this concept (Brydges et al., 2015). Therefore, this allowed us to contribute evidence (in favour or in contrast) to previous work calling for the addition of SRL supports to improve trainee outcomes (Brydges & Butler, 2012; Brydges et al., 2015; Butler & Brydges, 2013).

3.4.1.2.3 Instructor-led Practice Intervention

Participants in the Instructor-led Practice group received one-on-one training with a University of Toronto affiliated clinician. Specifically, we recruited two Anesthesiologists (one faculty member and one fellow) and two Intensivists to act as the instructors for the study. We equally divided participants to be taught by instructors from each specialty.

To create the intervention protocol, we held a meeting with all of the instructors and the graduate investigator. At the meeting, the team decided that the session would start with a 10-minute explanation of the skill, its associated equipment, and how to prepare for the procedure.
The instructor would then demonstrated the correct technique before participants proceeded with their first trial.

Subsequently, the instructor predetermined the sequence of trials. Specifically, participants would complete four successful trials of the Table-top variation before moving to four trials of the Supine variation and then complete that sequence a second time, creating a blocked variable practice schedule of the 16 trials. In addition, the cervical spine scenario was completed on the second trial of the second round of both the Table-top and Supine variations. During this acquisition period, the instructor answered questions, provided feedback, and demonstrated the skill at his or her discretion, with the only restriction being that they could only teach the material found in the initial instruction video (available to all groups) and list of process goals (available only to Supported SRL group). Lastly, before the post-test, the instructor led a 10-minute debrief with the participant, asking them to orally repeat the steps that would be needed for a successful intubation.

Importantly, the instructor was not present in the room for the pre-test or the post-test to limit the Hawthorne effect. The Hawthorne effect is apparent when participants act differently when they are being watched, especially by a person with power over them (Campbell, Maxey, & Watson, 1995). By having the instructors step out of the room, this created identical testing conditions for all three interventions, limiting the confounding variables that could affect an individual’s performance on a test.

3.4.2 Session 2: Second Practice and Testing Session

As is typical in the standard vs. double transfer design, all participants returned independently for a second testing and learning session. We chose two weeks as a feasible
timeline for this manipulation. Importantly, no instructors or SRL supports were available, meaning all participants experienced this second session as an unsupervised and unsupported learning activity.

The session began with the retention test, which consisted of two trials of the Supine variation and represented a measure for long-term learning of what they practiced in session 1 two weeks prior. Participants then moved on to the standard transfer assessment, where they performed two trials of the LLD intubation variation. Reiterating why this is considered a standard transfer test, by performing these two trials without any additional instruction on how the principles of performance can be transferred to this new variation, participants are only able to transfer out what they know into the completion of the task (Figure 2b). Subsequently, they went on to complete the double transfer test (PFL assessment), which is described below.

3.4.2.1 Double Transfer Test

As discussed in previous sections, the double transfer test involves a second learning session of new material before the completion of a target transfer problem. Therefore, before being tested on the Straddling intubation variation, all participants were given a maximum of 30 minutes to read an article explaining different variations of intubation (some of which they have seen and some they have not) and practice on the simulator the variations that they thought were important. We chose the Tesler et al. (2003) article because it was succinct, provided illustrations for 6 different endotracheal intubation variations, and prioritized the Straddling position. In addition, although the article presented these variations, there were no explicit instructions on how to complete them. Rather, there are vague descriptions that leave a lot of interpretation on the reader to figure out the exact sequence of steps needed (Tesler et al., 2003). Therefore this
was an ideal choice as the new instructional material as it required learners to transfer in their past knowledge (as developed from their initial session) into the understanding of the new variations.

Subsequently, when the 30 minutes expired, or the participant asked to move on, they were asked to complete two trials of the Straddling position. This position was chosen out of the six that were presented as it requires a much different technique than was taught in the initial session. Specifically, participants had to use the laryngoscope in their opposite hand and mentally rotate the patient’s anatomy in order to be successful. Thus their performance on the last two trials was taken as a measure of how well their initial educational intervention prepared them to learn this related variation on their own.

### 3.5 Outcome Measures

#### 3.5.1 Endotracheal Intubation Performance

The time taken to complete the intubation was recorded for the pre-test, post-test, retention, transfer, and double transfer tests. Time started when the graduate investigator prompted participants to begin and stopped when they confirmed the placement of the endotracheal tube by demonstrating that both lungs inflated when a bag valve mask was attached. All testing trials were stopped by the graduate investigator if the participant did not complete the intubation within 180 seconds. Subsequently for analysis, the times of the two test trials were averaged to receive a more stable measure of participants’ time to completion at each point in the training.
As our primary measure of participants’ performance we used a modified Global Rating Scale specific for endotracheal intubation consisting of four subscales and an overall rating (all 5-pt Likert scales) that Manzone et al. (2014) developed and collected promising validity evidence for in their work (Appendix 2). To facilitate the use of the GRS, all test trials were video recorded and independently rated by an Anesthesiology resident and fellow who were blinded to test that was being completed (i.e., they did not know if they were watching a pre-test or retention test, and so on) and also blinded to the participants’ assigned group. For each GRS the raters produced, the average of the five component scales was taken and an intra-class correlation coefficient was calculated to assess inter-rater reliability and ensure it was at an acceptable level (i.e., ICC > 0.70). Once confirmed, the average GRS score across both raters was calculated and the combined score was used in all analyses.

3.5.1.1 Rater Training

After all participants had completed all tests, the two raters engaged in training with the graduate investigator prior to independently rating all of the videotaped performances. The session lasted roughly one hour and consisted of rating 12 videos picked by the graduate investigator. Videos were picked on the basis of being representative of the different variations that were tested and were split according to the rough percentage of each that the raters would encounter (i.e., 50% Supine, 25% LLD, 25% Straddling). In addition, poor, competent, and clearly superior examples were chosen for each. Before rating the first video, raters were given an explanation about what poor, competent, and clearly superior meant in the context of undergraduate clerkship trainee:
Poor – The raters do not trust the participant to perform the intubation without high levels of hands on guidance from a more senior clinician.

Competent – The raters trust the participant to perform the intubation while being supervised by a more senior clinician, but does not require hands on guidance.

Clearly Superior – The raters trust the participant to perform the intubation in the absence of supervision from a more senior clinician.

The raters then proceeded to rate the videos, stopping between each to compare ratings and discuss any disagreements. This process allowed the raters to establish a shared mental model of what comprised ‘competent’ performance in the context of the study. Notably, the scores assigned to these 12 videos were not used in the calculation of the ICC, but were included in the remaining analysis.

3.5.2 Participant Perceptions of Educational Sessions

We audio-recorded participants’ answers to the post-session interview regarding their opinions of their learning condition for later transcription and analysis. The open ended nature of the two questions allowed participants to expand on what they liked and did not like about the session. The answers were compared across the three groups for analysis to highlight participants’ reactions to the study’s interventions and to explore how trainees conceptualize learning more generally.
3.6 Data Analysis

All statistical analyses were conducted using SAS University Edition. All tests were run for the Intubation completion time and GRS data.

3.6.1 Instructor-led Intervention Manipulation Check

To analyze the practice schedule designed by the instructors for the instructor-led intervention and to determine whether or not it was supportive of the participants’ SRL processes, the graduate investigator recorded observational notes during each of the instructor-led sessions. We compared those notes to the original schedule created by the instructors to confirm that the schedule was followed, and to document the type of feedback that the instructors provided. Subsequently we compared our observations to previous literature, specifically in simulation and more broadly in motor learning to make a determination of the properties that were supportive of participants’ SRL and those that were not. This process led us to the final coding of the instructor-led intervention, which is important to the subsequent analyses and implications of the rest of the results.

3.6.2 Baseline Questionnaire Data

Separate one-way analyses of variance (ANOVAs) were used to assess the variables of past intubation experience and past intubations seen. Such a comparison would inform us on whether the participants in each group came into the study with similar intubation experience. In addition, participants’ gender was documented.
3.6.3 Endotracheal Intubation Performance Data

The rationale behind using two trials for each test was to receive a more stable estimate of participants’ performance on each test. Therefore we calculated the average of the two trials for each participant before conducting the analyses. These values were then used to run the analyses described below.

To best test our research aims and test our hypotheses (Refer to Chapter 2), the groups were analyzed within their broader dimensions of supervision and support, giving a multifactorial design. Given that our Instructor-led intervention was not labelled as being supportive or unsupportive of participants’ SRL, the analysis depended on the retrospective coding of the group. Therefore, the possible analyses were:

I. *Supervision dimension*: Instructor-led group (n=15) versus the SRL-supported plus SRL-unsupported groups (n=30).

II. *SRL support dimension*: SRL-supported plus Instructor-led (n=30) versus SRL-unsupported (n=15) or,

II. SRL-supported (n=15) versus SRL-unsupported plus Instructor-led (n=30)

We used a mixed procedure for all of the analyses as it is flexible to unbalanced group sizes where a general linear model procedure is not (Hamer, Johnson, & Simpson, 1998). Specifically, the skill acquisition and retention data were analyzed using a two SRL support (Supported vs. Unsupported) by two Supervision (Supervised vs. Unsupervised) by three test (pre-test, post-test and retention) mixed effects analysis of variance (ANOVA). The standard transfer, double transfer, and time spent in the PFL Instruction Phase were analyzed using separate two SRL
support (Supported vs. Unsupported) by two Supervision (Supervised vs. Unsupervised) one-way ANOVAs. The coding for all analyses can be found in Appendix 3.

3.6.4 Participant Perception Data

To analyze the participants’ post-session interviews, all interviews were transcribed verbatim by the graduate investigator. Subsequently, a framework analysis was completed to identify emergent themes within the data. The framework method allows for the identification of commonalities and differences in qualitative data, allowing researchers to focus on relationships between different parts of the data and develop descriptive and explanatory conclusions (Gale, Heath, Cameron, Rashid, & Redwood, 2013).

Following this methodology, the graduate investigator entered the interview data and representative quotes into a matrix composed of three preliminary themes: participants’ use of supports, participants’ requests for additional supports, and participants’ compensation in the absence of supports. These were used as general organization tools for initial analysis as the first two themes mapped onto the two questions asked of participants during the interview, while the last question allowed for additional responses that fell outside of those themes. The graduate investigator subsequently created sub-themes through an iterative process and with the aid of supervising committee faculty members to organize the participants’ responses to the interview questions. And lastly, the data was collated and interpreted to explore participants’ perceptions of the supports provided/missing in the educational session and highlight how these mapped on to evidence-based learning supports in the literature.
Chapter 4

Results

4.1 Instructor-led Intervention Manipulation Check

Through the iterative process of documenting the instructor-participant interactions and adding this information to the predetermined practice schedule, the instructor-led group was coded as being supportive of participants’ SRL processes. An illustrative example of the field notes below (Table 1), shows that the instructor frequently asked questions and moved from concurrent, hands on feedback for the first trial to hands off, terminal feedback throughout the session, which is more supportive when learning procedural skills (Wulf et al., 2010; Xeroulis et al., 2007). Lastly, the instructor engaged in a ten minute debrief where the participant went through all of the steps involved in an intubation and had the chance to ask any last minute questions before they were tested.

<table>
<thead>
<tr>
<th>Group</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor-led</td>
<td>-Instructor comes in, asks a lot of questions about how participant thinks you should do it.</td>
</tr>
<tr>
<td></td>
<td>-Instructor demonstrates and then uses hands on concurrent feedback during 1st trial.</td>
</tr>
<tr>
<td></td>
<td>-On the third trial - very hands off and doesn’t say anything during the trial.</td>
</tr>
<tr>
<td></td>
<td>-Participant asks what conditions would make it more difficult and instructor starts a discussion.</td>
</tr>
<tr>
<td></td>
<td>-Instructor lets participant choose what they want to do next [give up on c-spine trial or continue].</td>
</tr>
<tr>
<td></td>
<td>-Instructor keeps quiet during the trials - waits for participant to finish.</td>
</tr>
<tr>
<td></td>
<td>-Instructor engages in 10 minute debrief, asking participant to say steps out loud.</td>
</tr>
</tbody>
</table>

Table 1: Example of field notes taken during an Instructor-led practice session.

This example is representative of the approach that each instructor took when running the practice session. The aspects that were controlled – the 10 minute explanation and demonstration, the practice schedule for the two variations, and the 10 minute debrief – were followed in all sessions. Within these components, the evidence-based learning supports
included demonstrating the skill to aid with learners’ observational phase, and using variability of practice and debrief to aid in the learners’ self-controlled and self-regulated phases of learning. In addition to these components, the instructors were given the opportunity to provide feedback at their discretion and based on the participants’ needs. Overall, the instructors provided a scaffolded approach to providing feedback. Specifically, during the early trials they would provide concurrent feedback to participants. Although unsupportive of learners’ SRL, this type of feedback was requested by the participants until they had become more comfortable with the skill, as represented in the participant perception data below. Subsequently around the fourth trial, the instructors were able to save their feedback until the end of the trial and be much less involved in the participants’ completion of the task. This terminal approach to providing feedback supports learners in reaching the self-regulatory phase of their learning as it allows them to personally internalize the skill so that they do not become reliant on the feedback. Therefore, approximately 12 of the 16 trials led by the instructor allowed participants to regulate their own understanding of the skill.

Combining all of these supports, we determined that the instructor-led group was indeed supportive of participants’ SRL processes. Therefore to expand on the interpretations of the three groups used in the study, there was the SRL-supported group, the SRL-unsupported group, and the Supervised, SRL-supported group, which differs from the interventions present in the systematic review represented in Figure 1 (Brydges et al., 2015). Figure 8 represents the three comparisons in the present study. Notably, for our analysis of the Support dimension, the Instructor-led group will be paired with the SRL-supported group in the mixed effects analyses.
<table>
<thead>
<tr>
<th></th>
<th>Supervised Training</th>
<th>Unsupervised Training</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SRL Supported</strong></td>
<td>Supervised, Supported</td>
<td>Unsupervised, Supported</td>
</tr>
<tr>
<td></td>
<td>Present in Study</td>
<td>Present in Study</td>
</tr>
<tr>
<td></td>
<td>Supported Instructor-led</td>
<td>Supported SRL</td>
</tr>
<tr>
<td></td>
<td>Practice</td>
<td></td>
</tr>
<tr>
<td><strong>SRL Unsupported</strong></td>
<td>Supervised, Unsupported</td>
<td>Unsupervised, Unsupported</td>
</tr>
<tr>
<td></td>
<td>Not Present in Study</td>
<td>Present in Study</td>
</tr>
<tr>
<td></td>
<td>Unsupported SRL</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 8:** Representation of the three groups present in the study: Supported SRL, Unsupported SRL, and Supported Instructor-led practice.
4.2 Participant Demographics and Baseline Questionnaire

We recruited a total of 45 participants (i.e., 15 per group), which left us under our aim of 16 per group and was due to logistical and feasibility constraints. Participants included six PGY1 Internal Medicine residents, 14 fourth year clerkship (CC4) and 25 third year clerkship (CC3) students, encompassing 20 males and 25 females in total. The demographic data for each group are presented below in Table 2. The baseline questionnaire data revealed that there were no significant differences between the groups for both past intubations performed (p=0.533) or past intubations seen (p=0.458), with the means being 7.80 (± 5.99) and 14.80 (± 10.52), respectively.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Year of Training</th>
<th>Past Successful Intubations</th>
<th>Past Intubations Seen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supported SRL</strong></td>
<td>8 male</td>
<td>2 PGY1</td>
<td>6.47 ± 5.37</td>
</tr>
<tr>
<td></td>
<td>7 female</td>
<td>5 CC4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 CC3</td>
<td></td>
</tr>
<tr>
<td><strong>Instructor-led</strong></td>
<td>7 male</td>
<td>2 PGY1</td>
<td>8.93 ± 6.90</td>
</tr>
<tr>
<td></td>
<td>8 female</td>
<td>5 CC4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 CC3</td>
<td></td>
</tr>
<tr>
<td><strong>Unsupported SRL</strong></td>
<td>5 male</td>
<td>2 PGY1</td>
<td>8.00 ± 5.73</td>
</tr>
<tr>
<td></td>
<td>10 female</td>
<td>4 CC4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 CC3</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Participant demographic data as distributed between the three interventions.
4.3 Endotracheal Intubation Performance

4.3.1 Intubation Completion Time

The average pre-test, post-test, retention test times (measured in seconds) for the SRL-supported group were 94.48 (± 34.19), 49.03 (± 17.69), 64.33 (± 24.40); the Instructor-led group times were 92.5 (± 35.19), 56.22 (± 24.05), 60.14 (± 20.04); and the SRL-unsupported group times were 110.33 (± 31.87), 41.27 (± 14.40), 59.53 (± 24.07). According to the two factor mixed effects ANOVA, we found no significant main effect for Support or Supervision (all ps>0.837). However, there was a significant main effect for test ($F_{(2,84)}=47.32$, $p<0.0001$). Post-hoc tests revealed that the post-test and retention test were completed significantly faster than the pre-test (all ps<0.001), whereas there was no significant difference between post-test and retention test ($p=0.074$). In addition there were no significant test x Support ($F_{(2,84)}=1.96$, $p=0.147$), or test x Supervision interactions ($F_{(2,84)}=0.43$, $p=0.653$). Figure 9a displays the impact of SRL support and Figure 9b displays the impact of Supervision on acquisition and retention.

On the standard transfer test, the average performance time for the Supported SRL, Instructor-led, and Unsupported SRL groups were 41.18 (± 7.42), 41.67 (± 16.98), and 38.70 (± 12.29), respectively. The two factor one-way ANOVA revealed no significant differences for SRL Support ($F_{(1,42)}=0.30$, $p=0.587$) or Supervision ($F_{(1,42)}=0.01$, $p=0.915$). Figure 10 displays the impact of SRL Support and Supervision on standard transfer time to completion.

On the double transfer (PFL) test, the average performance times for the Supported SRL, Instructor-led, and Unsupported SRL groups were 52.80 (± 25.44), 50.39 (± 14.71), and 71.93 (± 43.84), respectively. The two factor one-way ANOVA revealed no significant differences for SRL Support ($F_{(1,42)}=3.17$, $p=0.082$; Hedges’ $g = 0.50$, 95% CI = -0.13 – 1.12) or Supervision.
(F_{1,42}=0.05, p=0.823; Hedges’ g = 0.29, 95% CI = -0.34 – 0.91). Figure 11 displays the impact of SRL Support and Supervision on double transfer time to completion. With respect to the time taken in the PFL Instruction Phase with the new material, a separate two factor one-way ANOVA revealed no significant differences in average time taken across all groups (grand mean = 16.03 ± 7 minutes).
Figure 9: Mean completion times of the pre-test, post-test and retention tests across a) SRL-supported and SRL-unsupported and b) Supervised and Unsupervised interventions. Error bars represent the standard error of the mean.
**Figure 10:** Mean completion times of the standard transfer test. Error bars represent the standard error of the mean.
**Figure 11:** Mean completion times of the double transfer test. Error bars represent the standard error of the mean.
4.3.2 Intubation GRS Score

We calculated inter-rater reliability using an Intra-class coefficient (ICC). From the pool of 438 videos (10 videos per participant, minus those used in rater training), the average measures ICC was 0.84, which represents strong consistency. Subsequently, knowing that the ICC was acceptable, the remaining analyses were completed to mirror the completion time data.

The average pre-test, post-test, retention GRS scores for the Supported SRL group were 2.18 (± 0.58), 3.45 (± 0.72), 3.11 (± 0.81); the Instructor-led group scores were 2.44 (± 0.93), 3.31 (± 0.90), 3.22 (± 0.63); and the Unsupported SRL group scores were 2.09 (± 0.67), 3.41 (± 0.47), 3.18 (± 0.71). The two factor mixed effects ANOVA revealed no significant main effects for Support or Supervision (all ps>0.614). However, there was a significant main effect for test (F(2,84)=30.81, p<0.0001). Post-hoc test revealed that both post-test and retention were scored higher than pre-test (all ps<0.0001) but no significant difference between post-test and retention (p=0.448). In addition there was no significant test x SRL Support (F(2,84)=0.11, p=0.900) or test x Supervision interactions (F(2,84)=0.62, p=0.539). Figure 12a displays the impact of SRL support and Figure 12b displays the impact of Supervision on acquisition and retention GRS scores.

On the standard transfer test, the average GRS scores for the Supported SRL, Instructor-led, and Unsupported SRL groups were 3.31 (± 0.69), 3.53 (± 0.47), and 3.48 (± 0.47). The two factor one-way ANOVA revealed no significant differences for Support (F(1,42)=0.76, p=0.388) or Supervision (F(1,42)=1.35, p=0.252). Figure 13 displays the impact of SRL Support and Supervision on standard transfer GRS Ratings.

On the double transfer (PFL) test, the average GRS scores for the Supported SRL, Instructor-led, and Unsupported SRL groups were 3.35 (± 0.64), 3.38 (± 0.69), and 2.86 (± 0.91),
respectively. The two factor one-way ANOVA revealed no significant difference for Supervision (F(1,42)=0.01, p=0.905; Hedges’ g = 0.36, 95% CI = -0.27 – 0.98). However, it did reveal a pattern suggesting the SRL-supported conditions outperforming the SRL-unsupported condition (F(1,42)=3.46, p=0.070; Hedges’ g = 0.67, 95% CI = 0.04 – 1.31). Figure 14 displays the impact of SRL Support and Supervision on double transfer GRS Rating.
Figure 12: Mean GRS Scores of the pre-test, post-test and retention tests across a) SRL-supported and SRL-unsupported and b) Supervised and Unsupervised interventions. Error bars represent the standard error of the mean.
Figure 13: Mean GRS scores of the standard transfer tests. Error bars represent the standard error of the mean.
**Figure 14:** Mean GRS scores of the double transfer test. Error bars represent the standard error of the mean.
4.4 Participant Perceptions of Educational Sessions

The interviews following the initial practice session revealed that participants’ perceived their educational supports as learning aids aimed at making learning more easy and efficient, and at making the simulation experience more authentic (Figure 14). Participants described these aims of ease, efficiency, and authenticity through the supports they perceived to be most helpful in the session, the supports that they failed to mention, their requests for additional supports, and how they compensated for a lack of support.

4.4.1 Supports Used During the Educational Session

When asked what they thought was most helpful, participants in the SRL-Supported and Unsupported groups responded that they benefited from supports that provided them with the content needed to perform endotracheal intubation (content support) and the supports that helped them with their SRL processes (SRL support). In contrast, participants in the Instructor-led group focused mainly on the presence of the instructor as being the most helpful component of the session. However, all participants expressed value in the repetitive practice involved in the session as they were required to complete 20 intubations.

Beginning with the content support, participants were cognisant of the information provided by many of the materials available in the room. For example, participants in the SRL-Unsupported group appreciated the instructional video, given it was one of the few supports available to them:

Having the video was nice to be able to go back to it. In terms of sometimes there were things where I was going through the motions and I had a question. Since I didn’t have someone to ask, going back and being able to watch it and figure it out [was helpful].
This sentiment of the video being the main source of information was shared by many of the participants in both the SRL-Supported and Unsupported groups, however other aspects of the session were also noticed, such as the oropharyngeal model that was provided:

…having the oropharyngeal model was very helpful because I could take a closer look at the anatomy and where I need to place the laryngoscope.

In addition to the content supports, participants in the SRL-Supported and Unsupported groups perceived several SRL supports as having a benefit to their learning. A representative quote from the SRL-Supported group highlights a participant’s perceived benefit of the process goals and being given two variations (Table-top and Supine) to practice:

The fact that I had two different intubation techniques to do…and just having the opportunity to go back and forth between the two situations was really helpful. Also, having some reminders by the piece of paper you provided me with [was helpful].

Also, one of the only SRL supports provided to the SRL-Unsupported group, the increased complexity given by the two cervical spine trauma trials, was picked up by participants:

I think the degree of difficulty [was helpful] because it really pushes you to work hard and get better at is to so you get a rhythm going.

The last support mentioned by the SRL-Supported and Unsupported groups, and also by the Instructor-led group, was the amount of repetition that was involved in the session. A representative example comes from an Unsupported SRL participant:

Repetition definitely [was helpful]. I don’t think that in all of my training I have had such a structured, repetitive type of set up and that really helped with muscle memory.
The content and SRL supports mentioned to this point are those that participants in the SRL-Supported and Unsupported groups used because they perceived that they would receive benefit from them (Figure 14). However, in addition to these supports, participants in the SRL-Supported group used, but failed to mention the other two SRL supports they were provided with: random practice and the in-session interviews. Even though they did not mention them, both of these supports were used in the session, with all participants completing the in-session interviews and the majority of participants following a random practice schedule that was promoted to them before they started. Therefore, these two supports were classified as the supports that the participants used because they were instructed to do so (Figure 14).

The participants in the Instructor-led group, however, gave much different responses when answering what they found was most helpful. The participants did not mention the different supports offered in the session, and chose to focus primarily on the presence of an instructor as being the most helpful component. Importantly, participants often conflated instructor presence with instructor support as they described both supportive and unsupportive behaviours as being helpful. For example, on one hand, a participant highlighted the concurrent, hands on feedback from the instructor (which is unsupportive of learning):

Having the instructor in the room showing you where exactly your technique was wrong and being able to visually see you and correct. Like how the instructor was holding my hand and correcting where I was going was really helpful.

On the other hand, a different participant commented on the instructor’s terminal, hands off feedback (which is supportive of learning):
I would say the actual tips from the instructor on what I was doing [was helpful]. There were some things I didn't know I was doing in ways I was moving my arms and I found it very helpful for her to be able to comment on that and give me some tips and techniques.

Therefore, the presence of the instructor, and not necessarily the support from the instructor, became the defining feature to the participants within this group.

4.4.2 Requests for Additional Supports

When given the opportunity to voice their opinion regarding what was missing from the session, participants in the SRL-Supported and Unsupported groups requested for the presence of an instructor and more equipment to make the skill easier, while participants in the Instructor-led group shared the sentiment about the need for more equipment and requested additional anatomical variability to increase authenticity of the simulation session (Figure 14).

Within the request for an instructor, there were varying details that the participants highlighted, and as with the participants in the instructor-led group, the presence of an instructor was conflated with the support from an instructor. For example, one participant requested for concurrent feedback from an instructor:

…definitely that voice saying no try it this way, or do it this way, because that’s what I have had in the past when someone teaches you.

Whereas, a different participant requested for specific feedback to help her navigate the skill:

It would have been helpful to have some real time feedback. I think the thing I figured out, timing wise I improved over the course of this exercise, but I think I would have been able to figure
things out more quickly if I had [feedback]. It just took some time to sort of figure it out on my own.

Taking the latter quote into consideration, the participant expressed her interest in making the session quicker and more efficient. She mentioned that it took some time to figure it out on her own and that it would be much more efficient if feedback was provided to her. This sentiment was shared by many participants in their request for an instructor:

In the beginning if there was an instructor telling me what I was doing wrong that would have been much more helpful, but I think I eventually go it. Just like it wouldn't waste so much time.

The request for additional equipment that came from participants in all groups, came in the form of asking for a stylet (used to decrease the malleability of the endotracheal tube) to help them get the endotracheal tube in the trachea more easily:

I found that obviously in terms of equipment, not having the stylet made things a little harder because I think the stylet would have helped guide the ET tube down a little bit easier.

Lastly, the requests from the Instructor-led participants to increase the authenticity of the session came in the form of the request for increased anatomical variability:

I guess the manikin is just one type of airway and resistance so if there were more variable airway sizes and stiffnesses that would be better because that's what real people are like.

Interestingly, with the presence of the instructor, the participants in this group now focused on things that were missing from the environment that could add to the session, whereas they failed to mention any of the supports that were already present when prompted to do so in the preceding question.
4.4.3 Compensating in the Absence of Support

Interviews with the SRL-Unsupported group yielded interesting results regarding how they attempted to compensate for the lack of supports they received during the learning session (Figure 14). Specifically, they were the only group to make notes (an option available to everyone) and comment on how this process helped them learn the skill. One participant stated:

Relearning using the video and then jotting down notes. That gives me some time to process the information. Instead of the first time which was like watching the video [once] and then performing.

The participant’s opinion was shared by another participant, but in addition to allowing them to process the information more fully, he states that he now also had a resource to help him throughout the rest of the session:

Also, having the piece of paper made a big difference because the first time I saw the video, I don’t think I processed nearly as much as when I saw it and wrote it down to try and make sense of what the steps were. So I had a resource to look at while I was going through [the session].

In addition, participant’s relied on their past experience to help them make sense of the skill:

I think definitely my prior experience with it was helpful. It was something that I could go back to and think about.

Therefore, when little to no supports were provided, participants were active in regulating their learning, and aimed to make the session easier by creating their own resources and remembering back to their past experiences with the skill.
Figure 15: Framework describing the factors that influence participants’ perceptions of educational supports.
Chapter 5
Discussion

This study examined the effects of supervision and support during SRL on skill acquisition, retention, standard transfer, and PFL of endotracheal intubation in a simulated setting. The following are interpretations of the main results from the study and their implications for researchers and educators in health professions simulation-based training. First, the endotracheal intubation performance data will be explored, highlighting the potential interpretations that can be drawn from the differences (or lack thereof) between the three interventions. The results suggest that novice medical trainees are capable of learning endotracheal intubation in the absence of support, but are better prepared to learn a novel procedural technique in a future session when supports for their SRL processes are present in their original learning session. Notably, these results should be interpreted cautiously as they are based on a non-significant trend towards better performance on the PFL assessment for SRL-supported interventions, and the possible mechanisms explored below must be confirmed through subsequent studies. Next, the participants’ perceptions of their learning sessions will be discussed to lay a foundation for potential future research aimed at triangulating how participant actions and requests relate to their performance, and how we can use this information to help structure our learning interventions. Within these discussions, potential theoretical explanations underpinning these findings will be explored, particularly how the results are both informed by, and add to the PFL, SRL and adaptive expertise literatures. In the final section of this chapter, the study limitations and future directions for further research will be explored.
5.1 Endotracheal Intubation Performance and Learning

5.1.1 Skill Acquisition and Retention

The intubation completion time and GRS data both revealed similar patterns in which there were no significant differences between the three groups immediately following the practice session or on delayed retention. These results are at odds with hypotheses 1A and 1B, and past simulation literature (Brydges et al., 2015) – that the presence of SRL supports, and not instructor presence, would have a positive impact on post-test and delayed skill retention.

To understand the departure of these results from past literature, it must be reiterated that the Instructor-led intervention used in this study was retrospectively coded (see 3.6.1) as being supportive of participants’ SRL processes (see Figure 15 above). In this light, instead of being at odds with hypotheses 1A and 1B, the results highlight that a different comparison was made than originally intended. The SRL support and instructor presence variables were inextricably linked in the instructor-led intervention, preventing an objective evaluation of the latter related to hypothesis 1A. Instead, because both groups contained SRL supports, Brydges et al. (2015) would have predicted that we would not see significant differences between these groups.

However, this interpretation does not account for the lack of performance differences between these two groups and the SRL-Unsupported group. Due to the presence of SRL supports in the SRL-Supported and Instructor-led groups and their absence in the SRL-Unsupported group, there should have been lower performance scores for the latter group on both tests (Brydges et al., 2015). To reconcile the differences between past literature and the present study, a deeper look into the three interventions must be taken. A possible explanation may be that the SRL-Unsupported group received sufficient SRL support to learn endotracheal intubation for the
participants’ experience level and was not a full representation of a completely learner controlled educational session. Supports available to this group included variable practice, different degrees of task difficulty, sufficient content support (i.e., the video), and high exposure to the skill through the repetitive nature of the 16 trial acquisition period. In contrast to this level of support, Brydges et al. (2015) classified other interventions as SRL-Unsupported when participants were provided with only: an instructional video (Youngquist et al., 2008), the number of hand movements they used to complete a task (Porte, Xeroulis, Reznick, & Dubrowski, 2007), or concurrent feedback from a simulator during a five minute acquisition period (Isbye et al., 2008).

In retrospect, therefore, we suggest that the level of support received, even in the most unsupported group in this study, was much more conducive to learning than interventions used in previous research. This unintended higher level of support may have attenuated the differences between the groups on post-test and retention test.

Notably, if these were the sole results of the present study, one might conclude that, given ample time and practice, instructor presence and/or SRL supports may not be necessary instructional design features for learning endotracheal intubation in a simulated setting. However, this conclusion may be problematic as the PFL assessment yielded different results. Hence, without this assessment, the disadvantage of the SRL-Unsupported group would not have been seen, which may have led to incomplete conclusions.

### 5.1.2 Standard Transfer vs. PFL

The results obtained from the standard transfer and PFL assessments confirm hypothesis 2, suggesting that the two assessments are measuring different processes in learners. Specifically, in this study, there were no significant differences between the three groups on the standard
transfer test, whereas there was an expected pattern in the data suggesting that the SRL-Unsupported group had lower GRS scores on the PFL assessment than the groups that had access to SRL supports. Considering that there is only a pattern in the data, this increased sensitivity should be interpreted cautiously. However, the results are in line with previous research that has studied differences between the two types of transfer assessment in educational psychology (Bransford & Schwartz, 1999) and medical education (Mylopoulos & Woods, 2014). Interpretations of both findings from the present study will be elaborated upon below.

5.1.2.1 No Differences on Standard Transfer Test

Two possible interpretations of the lack of group differences on the standard transfer test include the intubation variation performed for the test, and its proximity in time with the retention test. Firstly, although the LLD intubation differs from both the Table-top and Supine variations, all of the major steps and techniques to completing the intubation remain the same while only the position of the trainee changes. Consequently, educational psychologists may classify this as a ‘near’ or ‘low road’ transfer scenario, which is supported by the theories of situated learning and context specificity. Specifically, these theories state that the degree to which transfer will occur depends on how similar the two contexts are (Day & Goldstone, 2012; Eva, Neville, & Norman, 1998). Therefore, it may be that all participants, who were familiar with the Table-top and Supine variations, were equally prepared to ‘transfer out’ performance to the standard transfer task. In order to be successful, participants quickly recognized that they simply needed to keep their technique consistent. Secondly, participants performed the standard transfer test directly following the retention test. Therefore, prior to completing the LLD trials,
participants completed two trials of Supine, which likely refreshed their understanding of the skill and could also have led to similar performances across intervention groups.

5.1.2.2 Differences in PFL Assessments

The results from the intubation completion time and GRS ratings show a pattern of results in which the two groups receiving SRL supports took less time and received higher GRS scores on their PFL assessment than the SRL-Unsupported group. Notably, the effect of the supervision variable did not lead to significant differences on these two outcome measures. This finding is in line with hypotheses 3A and 3B predicting that the dimension of SRL support would have a significant impact on PFL whereas the dimension of supervision would not.

Given this information, the results suggest that it is the presence or absence of SRL supports that more effectively prepare trainees for future learning, compared to whether an instructor is present in the room. Put another way, the results suggest that it is what the instructor does with the trainee (i.e., support SRL) and not simply that the instructor is present, which defines potential success on a PFL assessment. Thus, even though the SRL-Unsupported group performed similarly to the other two groups on post-test and delayed retention, the results seem to suggest that the additional supports provided by the other two groups better prepared trainees to learn a related skill on their own in a subsequent learning scenario.

Using the conceptual frameworks introduced at the outset of the thesis, the following section will expand on the potential mechanisms that may have played a role in the observed results. Specifically, the results will be interpreted through Broudy’s (1977) classifications of knowledge and the theories of Triadic Reciprocity and Phases of Self-Regulatory development.
5.1.3 Relating Intubation Performance & Learning Data to the Guiding Conceptual Frameworks

5.1.3.1 Addressing Broudy’s Questions about Education

Broudy (1977) proposed that educators ask to what extent do trainees use past educational interventions to:

I. Organize the new information, and set up their expectations and judgement of the problem?

II. Influence how they decide on and select a response?

III. Enrich or elaborate their response?

Using the SRL theories of Triadic Reciprocality and the Phases of Self-Regulatory Development, these questions can be reframed to ask: what supports are within the environment that influence learner behaviour and help them develop their own SRL abilities within the context of the skill being learned?

When interpreting the findings in relation to these questions, it may be that the supports within the SRL-Supported and Instructor-led groups helped to frame the original understanding of the skill, provided an approach to experimenting with one’s own technique over several trials, and potentially helped the participants gain a clearer understanding of their level of competence in completing the skill. We suggest that content supports such as the instructional video, the content-relevant points on the process goals list, and the instructor demonstration at the
beginning of the session provided the participants with ample content knowledge to understand endotracheal intubation and its associated techniques. The added practice scheduling supports, including variability of intubation technique (Table-top and Supine), the prompts to use a random practice schedule, and the trials with increased complexity likely influenced how participants went about completing the trials and forced them to create variations in their technique to reach the same goal each time. And lastly, the designed self-regulatory supports including the process goals, in-session interviews and the terminal instructor feedback likely enriched the trainees’ responses as these resources highlighted the important steps to focus on and revealed the areas where they were struggling.

Evaluating the SRL-Unsupported intervention according to Broudy’s questions, we suggest participants did not receive a well-rounded educational session. Specifically, participants could only consult content supports like the instructional video and oropharyngeal model to gain an understanding of the skill. They were not prompted to use a random practice schedule and thusly chose a blocked schedule, completing the Table-top variation before moving to the Supine variation. And lastly, they did not receive self-regulatory prompts (however they could have been doing this without prompts) and did not receive feedback on their performance, which may have affected their understanding of their level of competence. Therefore, it is apparent that this environment lacked the full complement of supports available in the other two interventions.

Without access to all of these supports, participants in the SRL-Unsupported group may not develop a true understanding of the skill, but rather may have finished the acquisition period still in the self-controlled phase of SRL development. That is, they likely could perform the two variations of endotracheal intubation independently, though with limited ability to modify their performance to account for large variations in the skill. Such an endpoint may have left them
able to complete the retention and standard transfer assessments two weeks later due to the consistency of performance needed to complete these assessments, but left them with insufficient understanding of the skill to act as a foundation to learning the Straddling position.

Using the same interpretive lens, participants in the SRL-Supported and Instructor-led interventions seemed to have developed a robust understanding of endotracheal intubation, and the supports may have allowed them to finish the acquisition period in the self-regulatory phase of SRL development. If that was the case, then they were capable of accounting for skill variability and thus had the proper foundation of knowledge to learn the Straddling position, as not only could they complete the original variations taught, they potentially knew what to concentrate on and could better understand how to modify their performance given the significantly different technique required for successful performance.

5.1.3.2 Potential Increase in SRL Abilities

In addition to providing trainees with the necessary content knowledge, understanding, and practice to learn the skill of endotracheal intubation, the SRL-Supported and Instructor-led interventions may have left trainees with strategies and techniques to use in future learning scenarios. By contrast, the SRL-Unsupported group was provided the content knowledge and practice time to learn the skill, but participants may have been left without appropriate strategies to employ in subsequent learning scenarios. This may have caused the patterns in the results that suggest a potential difference between the tests that focused on the replication and/or application of knowledge (post-test, retention and standard transfer) and the PFL assessment, which tested how trainees learned new knowledge.
This aspect of preparing learners is what Schwartz et al. (2009) termed ‘learning to learn’. While a proper foundation of knowledge is needed about the skill in question, Schwartz et al. (2009) suggest that well-developed educational interventions also help learners learn strategies that can affect how they reason their way through the many situations where they will use that skill (Schwartz et al., 2009). In the present study, we expected to affect participants’ ‘learning to learn’ through the SRL supports designed as a part of their acquisition session. For example, the process goals in the SRL-Supported intervention were given to participants to stimulate a process orientation in which they would concentrate on the mechanisms of endotracheal intubation, and how certain mechanisms are related to certain outcomes. Hence, we suggest that participants learned to use a process orientation in the first session and continued using it in the second session, and concentrated on the mechanisms of performance while learning the Straddling intubation variation.

While we did not measure the use of strategies across learning sessions, we posit that interventions that prompt trainees to use strategies learned in one educational intervention in a subsequent intervention will contribute to trainees being prepared for future learning. Such strategies may, however, be bound to the context in which they are learned. That said, trainees may use them flexibly within related fields or skills that share underlying structures and requirements, such as learning and performing procedural skills. Consequently, building upon Schwartz et al.’s (2009) work, we suggest that given enough time, learners who go through interventions with SRL supports appear to develop the skills and dispositions associated with SRL, which in turn seem to prepare them for their future learning.
5.1.3.3 Instructor Presence can be Supportive

The result that having an instructor present better prepared trainees for future learning may seem contradictory to previous work by Schwartz and Martin (2004) as the authors concluded that direct instruction led learners to be less prepared for future learning than a discovery intervention (Schwartz & Martin, 2004). However, it can be argued that the comparison between the two interventions in that study was different from the comparisons being made in this study. Although both studies share the manipulation that there is an instructor within one of the interventions, the way the instructor-led intervention was structured in the present study prevents it from being labelled as ‘direct’ instruction, and instead can be called a constructivist approach to instruction. The instructors supported the participants’ SRL of endotracheal intubation as they facilitated the participants’ interaction with additional supports within the environment. By creating this co-constructed session and finding a balance between learner and instructor regulation, the instructors became SRL supports, contributing to the environment, as opposed to placing themselves at the centre of the environment.

In this light, we suggest that the presence of an instructor is no longer at odds with the ability of an intervention to prepare trainees for future learning. Rather, the results seem to suggest that the instructor’s presence is beneficial, as long as he or she is present to facilitate a learner’s SRL rather than fully regulate the learning session, which is often the case in the ‘direct instruction’ interventions employed by Schwartz and colleagues (Bransford & Schwartz, 1999; Schwartz et al., 2011; Schwartz & Martin, 2004) and the simulation-based interventions coded as ‘supervised, unsupported’ by Brydges et al. (2015).
5.2 Participants’ Perceptions

The final aim of the study was to explore novice trainees’ perceptions of the benefits and pitfalls of SRL and instructor-led practice. The interviews conducted with all of the participants following their initial practice session revealed they interacted with different aspects of the intervention because they perceived benefits, and they interacted with others because they were instructed to do so. Furthermore, participants expressed what they believed was missing from the intervention they were assigned to, with those assigned to the SRL-Unsupported group revealing how they attempted to compensate for the lack of support that they received. Consolidating their responses, the analysis suggested that participants perceived supports in the environment to be learning aids aimed at the ease, efficiency, and authenticity of the simulation-based training session. If a support was not aimed at one of these three dimensions, the participants did not mention that it was a helpful component to the session.

5.2.1 Support as: Making the Session Easy, Efficient, and Authentic

The participants revealed through their responses that they perceived benefit from the presence of an instructor, and specifically the information that made the session easier. On one hand, the instructors’ techniques that lead to perceptions of ease may come at a cost of overall learning, for example, participants stated that they benefited when instructors provided concurrent feedback and hands on manipulation (both known to be problematic for delayed skill retention. On the other hand, participants also stated that when instructors provided positive and negative feedback after a trial (i.e., terminal feedback) that this also made the educational session easier and more efficient (when compared to not receiving any feedback). Hence, the participants also associated beneficial techniques with their aim of ‘ease’ because such terminal feedback is
thought to be effective as it still allows learners to create internalized representations of the skill. Therefore, when it comes to feedback, participants appeared unable to differentiate that delivery after the completion of a trial is supportive of their SRL whereas delivery during the trial is not. This has implications for faculty development, because instructors are in control of what content to include in the feedback and when to deliver it.

Participants also mentioned that use of a stylet would have been an additional support aimed at the making learning easier. They had been exposed to the function of a stylet in the instructional video provided to them and felt it was difficult to complete the intubation without it. Consequently, this discrepancy of what was provided in an ideal situation and what was provided to them in their current practice may have become a variable in their perception of their own competence with the skill. Participants’ requests for a stylet suggest that they may have attributed part of their difficulties with the skill to the fact that not all of the proper equipment was provided within the environment.

Further, the participants’ requests for other supports revealed their desire for efficiency within the simulation session. Participants noted that they would have appreciated additional learning aids aimed at saving time. For example, the overwhelming support requested from the SRL-Supported and Unsupported groups was the presence of an instructor. Surprisingly, their reasoning behind this request was not because they could not figure out the skill on their own, but rather, their responses suggest that they believed that learning independently took up too much of their time (lack of efficiency) and required too much effort (lack of ease).

Participants’ aim of authenticity was apparent when they identified the variable practice created by completing the Table-top and Supine variations as helpful in their learning. They
explained how it helped them to practice two techniques and get a better understanding of the skill. Yet, even in the presence of variability in their body-positioning between variations, participants expressed that having differences in simulator anatomy would increase the realism, and thus the effectiveness of the simulation. These two findings show the value trainees place on the authenticity of their simulation experience as they want their training to be as closely related to patients as possible.

5.2.2 Supports that Fall Outside of Ease, Efficiency and Authenticity

For the SRL-Supported group, participants were instructed to use, yet did not appear to be aware of the benefits of, two remaining supports: use of a random practice schedule and the in-session interviews targeted at their replicative and applicative knowing. That participants did not mention these two supports in their responses is surprising because it was documented that the majority used a random practice schedule and everyone was interrupted to conduct the in-session interviews.

A potential reason for participants failing to mention these supports is that they may not be related to their aims of ease, efficiency, or authenticity of the simulation session, and are therefore not perceived as tangible additions to the educational environment. Instead, a random practice schedule increases the complexity of the learning session, and the in-session interviews prompt personal reflection, but do not provide any increased content, feedback, or variability. In addition, these two supports may have directly contrasted the trainees’ desire for efficiency and ease as they are both interruptive by nature, adding length to the session, and the random practice schedule in specific makes the session more difficult. Notably, the effectiveness of the random practice schedule should not be viewed with excessive scrutiny considering the amount of
previous motor learning literature on the topic (Merbah & Meulemans, 2011; Schmidt & Bjork, 1992; Schmidt & Lee, 2005). However, due to the novel nature of the in-session interviews, we must be open to the possibility of this not being as supportive as originally predicted. Although based in evidence from multiple sources, the interviews were fashioned in a somewhat exploratory manner. Therefore, we can interpret that the interviews may have acted as the SRL support that was intended, yet we must also be cautious and remember that they may not have been designed optimally, or conversely that the participants may not have used them as we had expected them to.

5.2.3 Compensation in the Absence of Support

Participants in the SRL-Unsupported group revealed that they actively sought ways to compensate for the lack of supports in environment. Specifically, they explained how they relied on making notes using the instructional video and used those notes as a resource throughout the session. In addition, to help make sense of the video and their notes, they attempted to remember their past experiences with endotracheal intubation. These two findings are notable for at least two reasons. First, the participants in this group were the only ones to mention the benefit of making notes and creating their own resource, and thus interacting with the environment to create an SRL support. Although only hypothesis-generating, this may be a contributing factor to why there were no significant differences between this SRL-Unsupported group and the other two during acquisition and retention. Second, participants’ use of prior experience fits nicely with the aim of this study, which is to explore the impact of initial learning on future learning. That this idea was only expressed by participants who practiced in the absence of SRL supports, suggests that they were conscious that the environment was not providing enough information or
support for learning, and that a potential way to succeed was by building off of and modifying past experiences.

5.2.4 How Trainees Appear to Define Educational Supports

At a holistic level, we suggest that participants were aware of the benefits of SRL supports that were tangible, but not of those that were not. A tangible SRL support can be described as a support that provides participants with either more explicit information about the skill (e.g., an instructor, process goals, the instructional video), or opportunities to experience the variable nature of performing the skill (e.g., reflecting practice variability with opportunities to practice the Table-top and Supine intubation techniques). Content supports seemed to make learning easier and more efficient as trainees could consult these resources for information when struggling, and the practice schedule supports seemed to increase the authenticity of the simulation experience when they mimicked the possible variation experienced across real patient cases.

In contrast, when the supports did not reflect the aims of ease, efficiency and authenticity, such as the random practice (practice schedule support) and the in-session interviews (self-regulatory support), participants did not appear to perceive them. Although this lack of perception may play a role in how trainees interact with these supports, it is not to say that the supports offer no value within the educational session. Further research is necessary to develop a better understanding of this relationship between trainees’ perceptions of and their interaction with the different educational supports. Furthermore, these results suggest the need for faculty development highlighting trainees’ expectations surrounding support, and where their perceptions fall short. Specifically, we defined support as an explicit component of an
educational intervention that guides trainees’ thinking or behaviour by relating learning processes to conceptual and procedural knowledge of the task. That definition can now be elaborated to include the idea that supports aimed at ease, efficiency and authenticity seem to be tangible to trainees and are perceived to be beneficial. However, this perception should not be the sole factor considered when constructing or implementing supports into educational interventions as evidence shows benefit for supports trainees do not readily perceive. Hence, faculty may need to engage in discussions aimed at relieving this tension, a point that will be discussed in the implications for educators section below.

5.3 Combining Trainee Performances and Perceptions

Combining the results of all of the tests and responses from participants sheds light on the importance of providing trainees with SRL supports during the learning of endotracheal intubation in a simulated setting. Although there are only patterns in the performance data indicating the benefit of SRL supports in preparing trainees for future learning, past literature and participant reactions add depth to those findings. Therefore, it appears that future research must consider not only how the participants performed on each assessment, but also what they thought about the educational intervention they were randomized to, and how their perceptions of support (accurate or not) affected their learning.

Importantly, the perceptions, actions, and requests from the participants in the present study resonate with work from Kornell and Bjork (2007). Those researchers found that learners are aware of different aspects of the educational environment, but they may not be well attuned to which aspects are better than others in supporting their own learning (Kornell & Bjork, 2007). However, even if they are not able to articulate the benefit from a specific SRL support, the
results of this study suggest that medical trainees may still use it if they are instructed to do so (e.g., the random practice and in-session interviews in the SRL-Supported group). That finding suggests that educators and instructional designers must do the work to ensure that the correct supports are present in the environment (even if trainees aren’t aware of their benefit), and that trainees should not be left fully responsible for identifying and using educational supports (Brydges et al., 2015).

Also, results from participants in the SRL-Unsupported intervention reveal that novice trainees are somewhat successful in compensating in environments that provide little support to their SRL. Specifically, those participants were able to successfully learn the Supine variation of endotracheal intubation and were able to perform well in response to the LLD variation they experienced on the standard transfer test. However, their spontaneous creation of learning aids did not include all of the potential SRL supports that were available to them (i.e., random practice). Therefore, the participants appeared not to be as prepared to learn the Straddling intubation technique as well as the other two groups.

Notably, to cope with the lack of support, some participants commented on activating prior experience when learning during the initial practice session. Although never made explicit, one possible interpretation is that the participants were referring to past content knowledge regarding endotracheal intubation, such as airway anatomy. However, another interpretation is that their choice of making notes to cope for a lack of support is a strategy selected from past experience to help them with their learning in the new simulated setting. Consequently, the idea of learners spontaneously activating SRL strategies in new situations represents a promising avenue of research. Such work might investigate whether increased exposure to interventions that include the broad array of supports used in this thesis might result in trainees incorporating
those strategies and approaches into their repertoire of past experience that they draw upon when learning independently in future situations where explicit supports are not provided to them.

5.4 Implications for Research, Practice and Faculty Development

The contributions from this thesis have four main implications for researchers and educators in the field of medical education. First, this thesis is an important step in introducing the PFL framework and methodology into the healthcare simulation setting. Second, it adds evidence to the call from previous research to refrain from defining SRL as learning in the absence of an instructor. Third, it produced evidence from different data sources to help refine the definition of ‘educational supports’ for SRL. Fourth, it provides evidence suggesting that PFL can serve as a link between research on SRL and adaptive expertise. These four implications can be further developed through continued research and through educators experimenting with interventions for simulation-based training.

5.4.1 PFL Assessments in the Simulation Context

A relatively novel contribution that adds to a growing literature in educational psychology (Bransford & Schwartz, 1999) and medical education (Mylopoulos & Woods, 2014), is that we used a double transfer methodology to assess how simulation interventions prepared trainees for future learning. Use of such a study design has implications for researchers as we provided evidence for its efficacy in showing performance differences between educational interventions when other tests failed to do so. Conceptually, this also shows that the PFL assessments detect the ability to learn in future settings whereas other assessments measure how much has already been learned about a particular skill. Hence, future research can concentrate on
collecting additional validity evidence for the PFL assessment and methodology, or it can
concentrate on using PFL assessments to compare the impacts of various educational
interventions. Incorporating PFL assessments into such comparisons may uncover a hidden
benefit of particular interventions, which may have otherwise been missed. Although this thesis
used the PFL assessment to test the construct of SRL, future researchers are not bound by this
choice. Importantly, the PFL framework and SRL theories are not directly linked as the former is
a way of constructing training and assessment activities, whereas the latter is a broader way of
thinking about how trainees regulate and activate their own learning.

For educators, the PFL assessment can be used as a formative or summative assessment
of their trainees. PFL assessments would be valuable additions to assessment practices as all
other tests fail to capture how well trainees learn how to learn and instead focus on what has
already been learned. This is particularly significant for educators aiming to cultivate adaptive,
life-long learners because trainees must be exposed to opportunities to learn in new situations
and contexts, and be permitted to explicitly explore this phenomenon of innovation, in order for
them to develop into adaptive experts (Mylopoulos, Regehr, & Ginsburg, 2011; Mylopoulos &
Regehr, 2009). Thus, including PFL assessments early on in training may help learners realize
that certain strategies, such as solely memorizing what they are taught in the simulation setting,
are not sufficient to be competent in future practice. Indeed, incorporating PFL assessments into
the curriculum would align novice medical trainees’ training with the overall expectations of
adaptive expertise. As an added component to the traditional testing regimes, educators would
capture a more complete picture of a trainee’s understanding of a given skill as well as their
approach to using past information and experiences to solve a novel problem. Therefore, PFL
assessments have the potential to give educators the ability to measure trainees’ commitment to
life-long learning and a drive to continually improve daily practice within their training and assessment.

5.4.2 SRL is More Than Learning Independently

The second contribution from this thesis is additional evidence supporting the need for medical educators to shift their conceptualization of SRL away from learning that only occurs in the absence of an instructor. Instead, like the conclusions of Brydges et al. (2015), SRL is better considered as learning that occurs in all contexts, and which is either facilitated or impeded by design features of the environment, including the presence of an instructor (Brydges et al., 2015). Similarly, this thesis has echoed and expanded on these results by demonstrating that it is the presence of SRL supports in the environment, and not the presence of an instructor, that had the strongest effect on trainees’ PFL assessment performance.

One implication for researchers is that future comparisons between instructor-led and unsupervised interventions will likely add little to the SRL literature. Rather, we recommend that researchers focus on the different supports (e.g., content-related, practice schedule, and self-regulatory) used within the environment, and how they interact to create a supportive or unsupportive intervention for trainees SRL processes. Notably, these findings do not suggest that an instructor cannot be used as a support, but rather emphasize that the actions and behaviours of the instructor must be carefully chosen and tested instead of assuming that instructor presence is automatically supporting trainees’ SRL. For example, this thesis has demonstrated that two very different interventions, one unsupervised and the other instructor-led, were both supportive of trainees’ SRL and resulted in similar PFL performances.
A major implication for educators is that novice medical trainees are capable of SRL, but benefit from learning support provided in their educational session. Therefore, instructional designers must identify and effectively design the educational environment and the available supports in order to facilitate a trainee’s SRL. Faculty development initiatives might be developed to help instructional designers and instructors understand this new definition of SRL so that they have the appropriate foundation of knowledge to help them make effective instructional design choices. Specifically, faculty development for instructional designers should be centred on the inclusion of a balanced set of supports such as the content-related, practice schedule, and self-regulatory supports used in this study. Faculty development for instructors, however, should be centred on how their teaching practices can be either supportive or unsupportive of trainees’ SRL and highlight the need to be cognisant about this. A particular example used in this study and past literature in motor learning and simulation, was the timing of feedback delivery and its effect on trainees’ internalization of the skill they were learning. But, put in the broader context, it is how feedback as a support fits into the conceptualization of SRL and how it can either promote a trainees’ ability to regulate their cognition, behaviour and environment, or act as a barrier to this process.

5.4.3 Refining the Definition of ‘Educational Support’

Throughout the thesis the term SRL support has been used to describe a multitude of resources. However, use of the term ‘SRL supports’ is rather superficial and may prove to be a limited term as it does not leave educators with a generalizable definition, and instead only leaves educators with examples to follow. Examples that were used in the study were a list of process goals, the presence of multiple scenarios of introduce variation, and explanations to use a
random practice schedule. However, these supports can be more broadly categorized as: content-related supports, practice schedule supports, and self-regulatory supports. Therefore, expanding on the original definition posed early on the thesis, the understanding of educational support can be elaborated and redefined as:

An informative resource or activity, designed as an explicit component of an educational intervention that provides either content-related, practice schedule, or self-regulatory information to help guide trainees’ thinking or behaviour by relating learning processes (e.g., goal-setting, experiencing challenge) to the conceptual and procedural knowledge of the task.

Therefore, successful implementation of a support requires educators to share the responsibility with trainees for their learning and to ensure that evidence-based methods are being used to identify, test, and implement the support(s). As revealed by participant responses, trainees are not always aware of and attuned to what strategies or behaviours lead to the best learning outcomes. And that is why educators must take responsibility and provide these supports instead of letting trainees flounder independently with little support from their surroundings.

Another important point from our results is that medical trainees have varying perceptions of what they believe to be educational supports, and there apparent aims are to have resources that impact the ease, efficiency, and authenticity of training. We recommend strongly that educators aim to balance the tensions between evidence-based supports and trainees’ perceptions. It may be worthwhile to engage in a conversation prior to a session to get a sense of what the trainees expect and explore educational psychology, motor learning, and medical education literature to check whether or not their requests match up with supports aimed a long-term learning. This creates an educational intervention which balances the responsibility of the
work and effort put in from the trainees, with the responsibility of the instructional designer creating an environment that is conducive to the self-regulation of learning.

5.4.4 Effective SRL Supports May Produce More Adaptive Learners

The final contribution of this thesis comes in the form of creating a foundation for future research linking supported SRL and adaptive expertise. Specifically, the patterns in the data suggest that there is an association between supported SRL and novice medical trainees’ PFL in a simulation-based training context. This is important given the constraints placed on the current medical system, where lack of time and funding prevent the medical education curricula from disseminating the multitude of knowledge and skills that are required of today’s clinicians (Mylopoulos & Scardamalia, 2008). Although life-long learning does not guarantee trainees will develop into adaptive experts, being prepared for this future learning is an important foundation that must be emphasized as a part of the curriculum. In order to be adaptive and innovative, trainees must be willing and prepared to approach new situations as opportunities for learning. Therefore, employing strategies in our educational interventions to prepare trainees for this process of life-long learning, may represent half the battle in starting them on a developmental path towards adaptive expertise.

A possible interpretation for this potential benefit of supporting trainees’ SRL is that the content-related supports may have assisted the trainees with their interactions with the educational environment, the practice schedule supports may have assisted their behaviours, and the self-regulatory supports may have influenced the formation of their beliefs as they created their own understanding of the skill. Consequently, we would be able to hypothesize that the supports created a constructivist intervention, which allowed trainees to explore different
techniques and grapple with failed attempts, but at the same time provided a means of reflection and opportunities to correct their mistakes. And ultimately, that this process prepared them to learn independently in the subsequent learning session.

This information is important for researchers in the field because the goal of adaptive expertise represents an under represented topic of study, which is a significant gap when one considers how often ‘life-long learning skills’ are listed as competencies of the Royal College of Physicians and Surgeons of Canada (Horsley, O’Neill, & Campbell, 2009). This thesis suggests that there may be a link between PFL and the ways we support learners in their SRL, which in turn may be influential in developing adaptive expertise. However, further research is necessary to strengthen these links, to determine which supports are more effective than others, and to explore what mechanisms might be at play.

As for educators, in addition to advocating for the use of PFL assessments in their curricula, the potential association between supporting novice trainees’ in their SRL and their preparedness for future learning highlights the need to take on the responsibility of building SRL supports into educational interventions. Using a PFL assessment allows educators to assess how well trainees experiencing simulation-based interventions are prepared to learn independently in the future in situations where there is little support to do so. It allows educators to ask questions such as, does this simulation intervention prepare trainees for future learning, and does it provide them with the skills, strategies and knowledge they need to be adaptive and solve novel problems? If the answers to these questions are unsatisfactory, this can act as a catalyst in reforming interventions so that they promote not only the specific procedure or content within the simulation, but also focus on teaching medical trainees to become life-long learners, which would undoubtedly increase the learning return from these sessions. Thus, for educators aiming
to cultivate adaptive experts in the long term, an emphasis should be placed on developing their SRL skills through educational interventions to prepare them for the life-long learning that plays a role in the development of adaptive expertise.

5.5 Limitations

This thesis is not without its limitations. The first relates to how we created the PFL assessment. Specifically, due to the fact that the PFL assessment was a novel addition to the simulation context and has not, to this point, been used to assess the future learning of a procedural skill, the choices that we made were somewhat exploratory. The choices to use a published article as the instructional material for participants to learn from and to give them a maximum of 30 minutes with it were arbitrary decisions. We regard this as a significant limitation as we may not have made the optimal choices in designing the assessment and may have attenuated or biased the effects of the different interventions. However, the fact that the assessment generated an expected trend in group differences presents some validity evidence supporting the choices that were made.

The second limitation lies in the comparison between the standard transfer and double transfer (PFL) tests. In previous literature in educational psychology (Bransford & Schwartz, 1999; Schwartz et al., 2005), these two tests consisted of the same questions, with the only differing variable being the presence of a common learning resource for the double transfer test. In this study, however, we used two different variations of endotracheal intubation for the two tests so that each participant could complete both the standard and double transfer tests. Although this increased the feasibility of data collection as we could analyse within subject and between group differences, the comparison between the standard and double transfer tests is
confounded by the difference in difficulties of the two variations. Nevertheless, that our findings are consistent with results of past studies suggests that our interpretations can be accepted, albeit with caution.

Another limitation of the study is that the effectiveness of the distinct SRL supports used in the three interventions cannot be explicitly described, because they were used collectively as a bundled intervention. As it stands, the thesis cannot make claims about how the specific supports (i.e., content vs. practice schedule vs. self-regulatory) prepared trainees for their future learning and, thus, can only offer interpretations based on integrating our results with those available in the literature. We chose to bundle the supports explicitly from the outset of the study, however, as we were comparing our novel instructional paradigm (i.e., that supported learning would improve PFL) to the standard paradigm (i.e., supervised or unsupervised learning, without attention to supports), with the goal of conducting research on the efficacy of the novel paradigm. That is, we created a set of circumstances aimed at enabling participants to perform better on a PFL assessment, without a focus on which facet led to that improvement. The SRL-Supported group was designed to include a number of evidence-based educational supports that we thought would optimize the learning environment for preparation for future learning. If we had chosen only one support, such as process goals, we would not have been able to claim that this intervention offered much more support than the Unsupported intervention and this would have limited our interpretations of the results. Therefore, further research is needed to clarify if all of the supports were useful, if some were more useful than others, and why this would be the case.

In addition, the Instructor-led group was developed to resemble a realistic instructor-trainee interaction to allow for the most ecologically valid comparison with our two other
groups. We were not as interested in testing the specific features of our SRL interventions as we were in comparing these forms of instruction to the best version of instructor-led practice, which is today’s gold standard in simulation-based training. However, our post-hoc analysis revealing that the instructor-led group was supportive of trainees’ SRL may be a potential limitation due to how these results affected the analyses. On one hand, although the coding was based off of past literature and evidence, this process may seem subjective to prospective readers and may add speculation to the interpretations of the thesis. On the other hand, the patterns found in the results suggest that the right choice was made as they are consistent with the hypotheses generated through theory and past research on the concept. Further research would be beneficial in helping to substantiate this choice.

Also in regards to our analysis, the ANOVAs were run on unequal sample sizes: 30 SRL-Supported versus 15 SRL-Unsupported and 30 Unsupervised vs. 15 Supervised. To account for this we put in careful consideration to run a mixed procedure in SAS statistical software instead of running a general linear model as the mixed procedure can account for the differences in sample size (Hamer et al., 1998). Therefore, we did not violate an assumption of the test and instead selected the appropriate method to ensure accurate results. However, even with the sample sizes larger than what we predicted would be necessary, our results were underpowered to reach significance. This may have happened as the PFL assessment was a novel addition to the protocol and thus the sample size calculation was taken from past studies assessing group differences based on post-test and retention test performances.
5.6 Future Directions

As with any research study, this thesis opens up an area of research by providing more questions than answers. There are a number of claims that need to be substantiated and patterns of results should be confirmed, and the mechanisms of improved PFL assessment scores further explained. Specifically, further work should be conducted on how to implement PFL assessments within the simulation context, how to optimize the timing and/or use of the different SRL supports, all while dropping the label of SRL versus IRL studies.

As mentioned in the previous section, much work needs to be done surrounding the implementation of the PFL assessment within the simulation context. First, the different aspects of the assessment itself must be manipulated to get a better understanding of how the test should be employed. For example, this study made use of an article to disseminate information to the learners, but this may have just as easily been an instructional video to mimic Schwartz and Martin’s (2004) use of a worked example, or clinical vignettes to mimic Mylopoulos and Woods (2014). In addition to manipulating the instructional material, further research must explore the level of interaction that is permitted between the material and learner before testing begins.

However, in addition to these components, researchers in the field must ask whether or not we should be measuring different outcomes than solely final performance on the task. This idea stems from the interpretation made in the thesis of SRL supports providing strategies and behaviours that prepare trainees for future learning. The question then becomes, how do we measure or account for these behaviours? One example of this is currently being conducted by Brydges and colleagues (In process), in which they are measuring whether trainees transfer the goal orientation they are prompted to use in an initial learning session into future practice
sessions, where the prompts are taken away. Preliminary evidence suggests some goal orientations are transferred more efficiently than others. Future studies can explore if the different SRL supports change the types of questions that trainees ask in future sessions, or chart their behaviours in the absence of support to determine whether the SRL supports they were initially exposed to lead to changes in their approach to learning in the long term. To get a sense of what has already been done in medical education to look at behaviours that may have a link to PFL, researchers can consult previous work exploring what trainees took the time to review after they completed a test (Agrawal, Norman, & Eva, 2012), how instruction influenced trainees future approaches to learning simulated heart auscultation (Brydges, Peets, Issenberg, & Regehr, 2013), or how different delivery methods of test feedback affected trainees’ engagement with that feedback (Harrison et al., 2013), to name a few examples.

Moving on to the second avenue of research, this thesis has provided a justification for researching further into the link between SRL supports and PFL, and consequently how these two concepts fit into the development of adaptive expertise. By grouping multiple SRL supports together, we obtained results that suggest their use in educational interventions to promote PFL, however, the effect of each and the interactions that may exist between them must be further explored. Therefore, next steps would be to systematically vary the implementation and use of different supports to better optimize the learning experience. For example, does each support relate to a trainees’ PFL, or do they target different outcomes? Importantly, certain supports may promote the long-term retention of a skill, while others promote standard transfer where a trainee needs to apply what they have learned to a new problem. Thus, the effects of these supports seem to interact to prepare trainees for future learning, but further research must uncover if the
methods used in this study can be further improved to get the most out of an educational intervention.

To give a specific example within this thesis, the least studied SRL support used in the study was the use of in-session interviews prompting replicative and interpretive knowing. With this being a novel creation, this study cannot claim that they were implemented at the optimal time, or that they even asked the appropriate questions. This warrants further exploration, considering emerging evidence from Shanks et al. (In progress) which shows that engaging trainees in metacognitive activities using esoteric or academic language hinders their delayed retention and transfer of simulated lumbar puncture skills (Shanks, Hatala, DenBrok, Tessaro, & Brydges, 2013). However, testing of each variable used is warranted as they have not been assessed in light of how they relate to PFL, but rather have been validated using post-test, retention, and standard transfer tests.

In addition to testing the implementation of different variables, research is also needed in exploring the optimal timing for using an instructor as a support. In this study, the instructor was present from the beginning of the acquisition period and remained there for the entire duration. Consequently, there was a higher rate of instructor-trainee interactions at the beginning of the session than there was at end, when participants became more comfortable with the skill. This represents the current tradition of instructor presence within a simulated setting – scaffolding from high support to low support – but work in educational psychology suggests that this may be not be the optimal order. Specifically, research suggests that there is an advantage in allowing learners to struggle through the learning of a topic independently and fail at coming up with the solution before being given the answer; a concept referred to as productive failure (Kapur, 2014; Lee & Anderson, 2013; Schwartz et al., 2005; Schwartz & Bransford, 1998). This idea of
incorporating an instructor after a learner has plateaued during simulation has been explored in previous simulation research only to reveal no effect over independent practice on delayed retention (Nousiainen, Brydges, Backstein, & Dubrowski, 2008). Importantly though, the participants of this study were not assessed with a PFL assessment, which may have shown a hidden benefit as suggested by results of the current study and previous research in medical education (Mylopoulos & Woods, 2014). Therefore, this warrants a second look at the timing of using an instructor as an SRL support within a simulated setting.

5.7 Conclusions

This thesis has demonstrated that providing a battery of educational supports to novice trainees as they self-regulate their learning is a promising approach for preparing them for future learning and for potentially starting them on the trajectory towards adaptive expertise. Our results indicate that without these SRL supports, trainees are able to perform well on post-, retention, and standard transfer tests, though they struggle relatively on PFL assessments. Our interview data suggest that trainees are not able to spontaneously create the optimal set of SRL supports for themselves and that they may be preoccupied with the ease, efficiency, and authenticity of learning. Therefore, the findings show that educators and instructional designers must assume the responsibility of identifying, providing, and explaining the utility of educational supports needed to benefit a trainees’ SRL within the simulation context. Our results suggest that such learning may occur in the presence or absence of an instructor, as long as careful thought is placed in how the different supports will be used. And if well-developed, these interventions will become an important component for researchers and educators aiming to cultivate life-long learners and adaptive experts.
References


doi:10.1111/medu.12307


doi:10.1080/00461520.2012.696438

doi:10.1016/j.jecp.2012.06.009


Appendices

Appendix 1: Baseline Questionnaire

* Required

What is your subject code? *

Please provide a score for your baseline endotracheal intubation experience *
  
  o 0 - Not experienced
  o 1
  o 2
  o 3
  o 4
  o 5 - Somewhat experienced
  o 6
  o 7
  o 8
  o 9
  o 10 - Very experienced

Please provide an estimate of the number of times you have performed intubation in the past on a patient: *

Please provide an estimate of the number of times you have performed intubation in the past on a simulator: *

Please provide an estimate of the number of times you have seen an intubation performed in the past on a patient: *

Please provide an estimate of the number of times you have seen an intubation performed in the past on a simulator: *
Please rate how motivated you are to learn intubation today. *

- 0 - Not motivated
- 1
- 2
- 3
- 4
- 5 - Somewhat motivated
- 6
- 7
- 8
- 9
- 10 - Very motivated
Appendix 2: Endotracheal Intubation Global Rating Scale

GLOBAL RATING SCALE OF PROCEDURAL PERFORMANCE

Please circle the number corresponding to the candidate's performance.

<table>
<thead>
<tr>
<th>Respect for tissue and airway anatomy</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequently used unnecessary force on airway or caused damage by inappropriate use of equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Careful handling of airway but occasionally caused inadvertent damage to tissue but occasionally</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consistently handled airway appropriately with minimal damage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time and motion, instrument handling</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many unnecessary, awkward moves, with frequent stops</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficient time/motion, but some unnecessary, awkward moves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear economy of movement and maximum efficiency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow of Procedure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequently stopped procedure and seemed unsure of next move</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrated some forward planning with reasonable progression of procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obviously planned course of procedure with good flow from one move to the next</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge of Procedure and Equipment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficient knowledge. Requires specific instruction for most steps of procedure and for equipment to be used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knew all important steps of procedure and used appropriate equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrated great familiarity with all steps of the procedure was very familiar with equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OVERALL PERFORMANCE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very poor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearly superior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3: SAS Coding

Intubation Time Data

data Time;
   infile '/folders/myfolders/sasuser.v94/Time.csv' dlm=',' firstobs=2;
   input Group Support Instructor Subject_Code Pretest_AVG Pottest_AVG Retention_AVG Transfer_AVG PFL_AVG INS_TOT EXP_TOT;
run;

data TimeRMES;
   infile '/folders/myfolders/sasuser.v94/Time.csv' dlm=',' firstobs=2;
   input Group Support Instructor Subject_Code Pretest_AVG Pottest_AVG Retention_AVG Transfer_AVG PFL_AVG INS_TOT EXP_TOT;
   score=Pretest_AVG; test=1; output
   score=Pottest_AVG; test=2; output;
   score=Retention_AVG; test=3; output;
run;

proc mixed data=WORK.Time method=ML;
   Class Support Instructor;
   Model PFL_AVG=Support|Instructor;
   lsmeans Support|Instructor / adjust=bon;
run;

proc mixed data=WORK.Time method=ML;
   Class Support Instructor;
   Model Transfer_AVG=Support|Instructor;
   lsmeans Support|Instructor / adjust=bon;
run;

proc mixed data=WORK.TimeRMES method=ML;
   Class Support Instructor Subject_Code test;
   Model score=Support|Instructor|test / solution DDFM=BETWITHIN;
   repeated test / Subject=Subject_Code(Support Instructor);
   lsmeans Support|Instructor|test / adjust=bon;
run;
**GRS Data**

data GRS;
    infile '/folders/myfolders/sasuser.v94/GRS.csv' dlm=',' firstobs=2;
    input Group Support Instructor Subject_Code Pretest_AVG Pottest_AVG
    Retention_AVG Transfer_AVG PFL_AVG INS_TOT EXP_TOT;
run;

data RMES;
    infile '/folders/myfolders/sasuser.v94/GRS.csv' dlm=',' firstobs=2;
    input Group Support Instructor Subject_Code Pretest_AVG Pottest_AVG
    Retention_AVG Transfer_AVG PFL_AVG INS_TOT EXP_TOT;
    score=Pretest_AVG; test=1; output
    score=Pottest_AVG; test=2; output;
    score=Retention_AVG; test=3; output;
run;

proc mixed data=WORK.GRS method=ML;
    Class Support Instructor;
    Model PFL_AVG=Support|Instructor;
    lsmeans Support|Instructor / adjust=bon;
run;

proc mixed data=WORK.GRS method=ML;
    Class Support Instructor;
    Model Transfer_AVG=Support|Instructor;
    lsmeans Support|Instructor / adjust=bon;
run;

proc mixed data=WORK.GRS method=ML;
    Class Support Instructor;
    Model INS_TOT=Support|Instructor;
    lsmeans Support|Instructor / adjust=bon;
run;

proc mixed data=WORK.RMES method=ML;
    Class Support Instructor Subject_Code test;
    Model score=Support|Instructor|test / solution DDFM=BETWITHIN;
    repeated test / Subject=Subject_Code(Support Instructor);
    lsmeans Support|Instructor|test / adjust=bon;
run;