Self-Regulated Learning and Psychomotor Skill Development in
Second-Year Veterinary Students

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Submitted in partial fulfillment
of the requirements for the degree of
Masters of Education

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SELF-REGULATED LEARNING AND PSYCHOMOTOR SKILL DEVELOPMENT

Abstract

Previous studies have shown that students who use self-regulated learning strategies have demonstrated improved academic, sport, and medical psychomotor skill mastery. In veterinary education, deliberate practice is currently the educational model for psychomotor skill development in veterinary students. However, with the advent of clinical skills labs, students are expected to self-direct their own development of psychomotor skills, such as suturing, intravenous (IV) catheter placement, and physical exams. Self-directed learning requires the use of self-regulated learning strategies. This research study demonstrates the effect of introducing self-regulated learning theory and deliberate practice theory versus introducing only deliberate theory on the suturing abilities of second-year veterinary students at the Ontario Veterinary College in Guelph, Ontario, Canada. It was theorized that students who use self-regulated learning strategies and deliberate practice to master their skills would out-perform those students who only used deliberate practice. This was not demonstrated with this research and may have been due to the intervention which involved the introduction of these theories to both the test and control group, or to the small group size that resulted from attrition from this research project.

Key Words: self-regulated learning, psychomotor skills, veterinary, suturing
Acknowledgements

I would like to acknowledge and sincerely thank my family for their patience, support, help, and encouragement during the writing and research phase of this Masters thesis. I could not have done it without you.

Thank you to my advisor, Dr. Kamini Jaipal-Jamani for her time, patience and expertise in guiding me through the research and Masters’ process as well as editing all my drafts. Thank you to my committee members, Dr. Xiaobin Li for his assistance with the statistical analysis and review; and Dr. Candace Figg for her time and effort in reviewing my thesis. And to my external examiner, Dr. George Zhou for his recommendations and clarity.

Thank you to Brooke, my research assistant, for all her hard work, enthusiasm, and encouragement.

Thank you to my students, who provide me with inspiration and a passion to learn.

To Dr. Brigitte Brisson, thank you for supporting my research and always wanting to find a better way to educate veterinary students.

Many thanks to Tammy Rowe, who is a mentor and believer in SRL.
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CHAPTER ONE: INTRODUCTION TO THE STUDY

This thesis reports on a quantitative study of the relationship between self-regulated learning strategies and the development of the psychomotor skill of suturing in second-year veterinary students. Psychomotor skills, such as suturing, catheterizing blood vessels, performing physical exams, and performing medical procedures, form the basis of a multitude of clinical skills that veterinary students must perform competently upon graduation. A clinical skill is defined as a combination of a psychomotor skill, a procedure, an understanding of why the procedure is carried out, and an interpretation of the results (Michels, Evans, & Blok, 2012). Competency in clinical skills upholds the integrity of veterinary practice for both patients and clients. Beyond graduation, veterinarians must develop new psychomotor skills and clinical skills as medical and surgical techniques evolve. In recent years, there has been an increased focus in veterinary education on psychomotor skill training, resulting in an emphasis on developing improved psychomotor skill training models and facilities. Much of this literature regarding psychomotor skill development focuses on the need to have learner-centred facilities, how to design such spaces, simulations, model developments and assessments (Rosch et al., 2014; Baillie et al., 2015; Baillie, Dilly, & Crowther, 2015). These new facilities allow the students to self-direct their own learning to acquire psychomotor skills. The veterinary literature recommends that learners use deliberate practice (DP) to improve skill (Scalese & Issenberg, 2005; Baillie, et al., 2015). However, current veterinary education literature has not captured how a student, acting on their own volition, self-directs their own learning within these learner-centered environments with the goal of improving their skills. How effective, then, are veterinary
students at self-directing their own learning and development of psychomotor skills in these learner-centred environments?

**Background of the Problem**

The nature of veterinary medicine involves learning the health and medicine of multiple mammal, avian, and aquatic species. This results in a very demanding course load that encompasses anatomy, physiology, pathology, medicine, surgery, anesthesia, client communications, and clinical skills courses, to name a few (Mikkonen & Ruohoniemi, 2001). The knowledge acquired is both cognitive- and psychomotor-based, culminating in clinical skills used in practice, research, and regulatory medicine. New graduates that enter private practice are expected to have competent, entry-level skills (Hill, Smeak, & Lord, 2012). It is the responsibility of veterinary educators, then, to identify the veterinary knowledge and skills to adequately prepare their graduates for practice (Greenfield, Johnson, & Schaeffer, 2004).

This requirement for competency has become a strong mandate of veterinary colleges in North America. In 2011, the North American Veterinary Medical Education Consortium (NAVMEC) published its ‘roadmap’ to the future of veterinary medicine. The members of the consortium developed five strategic goals, the first being, “Graduate career-ready veterinarians who are proficient in and have the confidence to use an agreed-upon set of core competencies” (NAVMEC, 2011, p. 27). Moreover, the Ontario Veterinary College (OVC) Phase Learning Outcomes (2015) state that graduating veterinarians should have the capability to, “Perform, evaluate and advise on therapeutic approaches/actions, and ensure treatment measures are consistent with the needs of the prevailing circumstance” (p. 4). The competencies discussed in these recommendations
are based on evidence-based medicine, critical thinking skills, and proficient clinical skills.

Do veterinary graduates have these required competencies upon graduation? In a 2011 study from the University of Queensland Veterinary School, only 69% of their graduating class felt satisfied with their current skills, and only 70% felt prepared to start practice (Schull, Morton, Coleman, & Mills, 2011). Likewise, a survey by the Canadian Medical Veterinary Association (CVMA) of its membership of practicing veterinarians indicated that 62% of respondents believed that new veterinary graduates lacking either the confidence and competence was a serious problem, while 14% of the respondents believed that this lack of confidence and competence was a critical problem (Lavictoire, 2003). Additionally, the 2017 Doctor of Veterinary Medicine (DVM) Program Review, (Lissemore, 2017) at the Ontario Veterinary College (OVC) revealed that less than 50% of OVC graduates felt competent enough to perform common medical procedures and minimally invasive surgeries without supervision. Why do our Ontario graduates not feel competent when opportunities to learn and develop these skills are present in the curriculum of veterinary schools? One factor that may play a role in competency development is the structure of the curriculum.

**Current Curriculum Structure**

Different models of veterinary curriculum range from traditional didactic lectures with psychomotor skills labs to develop clinical skills, to problem-based learning (PBL) where the acquisition of knowledge and clinical skills development are much more integrated (Blumberg, 2005). Historically, at the OVC in Guelph, Ontario, Canada, the 4-year undergraduate veterinary curriculum had been traditionally based on a behaviorist
model of teacher-centered lectures with written tests and examinations for the first two years of the program. Starting in the third year of veterinary school, psychomotor skills labs were scheduled to prepare students for performing physical exams and live surgeries. Recent changes in the Ontario Veterinary Curriculum (2015) now integrate courses involving psychomotor skill training earlier into the program (http://ovc.uoguelph.ca/dvm/phase-1 and http://ovc.uoguelph.ca/dvm/phase-2). These first and second-year labs now provide students with the opportunity to develop their psychomotor skills for clinical competency. Objective Structured Clinical Examinations (OSCE’s) are also part of the assessment of some clinical courses to test competency in clinical skills. By integrating more psychomotor skill labs and testing into the earlier years of the veterinary program, opportunities for psychomotor skill development can start sooner, ultimately providing more years of facilitated learning as well as providing an opportunity to bridge learned content knowledge with practical skills earlier in the program. Using this curricular strategy, it is anticipated that the graduating veterinarians will have stronger clinical skills and competencies upon graduation. But simply decompresing course content over a longer time does not address the students’ ability to self-direct their own development of these skills. What learning strategies are promoted to support students’ self-development of competency in psychomotor skills?

**Development of Veterinary Psychomotor Skills**

Over the last decade, programs to develop clinical skills have not only changed in their placement within OVC’s curriculum, but also in their support materials. Humane and ethical consideration of animals is at the forefront of the veterinary profession (Scalese & Issenberg, 2005; Smek, 2007; Valliyate, Robinson, & Goodman, 2012) and
this has resulted in a significant reduction in the use of live animals for practicing and developing psychomotor skills. Now, a variety of teaching models, ranging from cadavers to a spectrum of fidelity simulators, are used in place of live animals. These models and simulations allow for repeated attempts for students to master the psychomotor skills without harming living animals during skill development. Since no live patients can be harmed during their practice, students can work on their skills without instructor supervision (Brydges, Dubrowski, & Regehr, 2010). Skills development is also supported by teaching aids, such as online videos (Baillie et al., 2015) illustrated at https://www.uoguelph.ca/vetsurgery. These aids allow the student to watch an expert model a skill and enables students to watch and review the video at their own pace. Other more traditional resources such as skills instruction guides, textbooks, diagrams, and photographs remain available for student use. Together, then, there are several learning aids to support students’ autonomous practice and development of psychomotor skills.

Traditional psychomotor skills development labs involve instructor-regulated teaching, in which students observe an instructor modeling a skill. The Guide to Veterinary Clinical Skills Laboratories (Baillie et al., 2015) gives a detailed method of teaching these labs and the sequence of modeling psychomotor skills for the students. Once the skill is modeled, students have the opportunity to attempt these skills on a simulator or cadaver, often working in peer pairs or groups. The students can master the skill using deliberate practice (DP), which is defined as repeated, focused practice, improving a defined task using assistance and feedback from the instructor, lab assistants, and peers (Baillie et al., 2015; Ericsson, 2015; McGaghie, Issenberg, Cohen, Barsuk, &
Wayne, 2011). However, the intense veterinary curriculum makes time and human resources for these labs a limiting factor for psychomotor skill instruction. The ideal ratio of instructor to student is 4:1 (Dubrowski & MacRae, 2006) for learning psychomotor skills, which is difficult to achieve when class sizes are large and faculty support is limited. Many of these labs only offer a one-time learning opportunity for the student to acquire the stated learning objectives with an instructor present. It then remains the student’s responsibility to continue to practice and develop psychomotor skill proficiency. Although Baillie et al.’s (2015) Guide to Veterinary Clinical Skills Laboratories gives a detailed method of teaching these labs, it does not go as far as to recommend methods that the student can use to structure or self-direct their own learning to improve these skills in a learner-centered environment.

Although veterinary students are provided with instruction and opportunities to develop psychomotor skills (Baillie, Dilly, & Crowther, 2015) during their veterinary education, it remains that our graduates lack the required clinical skill competence and confidence when entering practice (Lissemore, 2017). Many veterinary schools, including the OVC, are currently developing clinical skills labs to provide students with an opportunity to practice psychomotor skills outside of traditional labs (Dilly, Read, & Baillie, 2017). These spaces – ranging from rooms to entire buildings – house simulators, models, and equipment so that students can come on their own volition, individually or with peers, to practice psychomotor skills. At times, these clinical skills labs are populated by instructors who can give feedback to a student if needed, but often, the students are working without instructor feedback. Consequently, the students need to
self-direct their own learning and development of psychomotor skills in these spaces to achieve the mastery needed for proficient entry-level practice.

**Statement of the Problem**

In 2015, the Principles in Surgery course VETM 3510 in OVC’s second-year instituted labs that allow students to start their skills training in aseptic technique, suturing, and simulated spay surgery a year in advance of previous cohorts. However, there is currently no formal testing of skills in the Principles in Surgery course. The students’ skill level becomes apparent in third-year when they start live-animal surgery – specifically, dog and cat spays and neuters. When these students start live surgery in third-year, as instructor of the course, I have observed that there is some decrease in student stress levels and better procedural knowledge. However, despite having an extra year to develop surgical and suturing skills, students’ surgery times remain the same as previous years, and their surgical skills are on par with cohorts that did not have the Principles of Surgery course as evidenced through the tabulation of scores from formative grading rubrics.

These skill deficits, such as performing three different suture patterns, become apparent to students and instructors during live surgery. Yet, when asked informally about how they could improve their skill levels and surgery times, students reply that they will improve with more live surgeries, or that they should ‘practice more.’ However, they are vague when pressed to define what ‘practice more’ means to them. I have found that students have a difficult time identifying specific aspects of their surgery skills that need improving. For instance, when these goals are determined during facilitated discussion with the instructors, they often require guidance as to which learning strategies
are available to improve their skills. Moreover, the students struggle to define what their learning goals should be when practicing, and what learning strategies they could employ to improve the development of their skills. Their approach to improvement is vague and has no clear plan or direction. Ideally, they should not be waiting until their next live surgery to ‘practice’ – they need to be able to identify their own skill deficits and focus on mastering the skills of performance before their next surgery. Ultimately, students should be able to determine their own learning goals and learning strategies to improve their skills using models and simulators, thereby being better skilled when they perform their next live surgery.

The faculty and instructors overseeing the students perform surgery at OVC grade the students using a rubric with an outstanding, pass, or fail system. Instructor feedback is delivered both verbally during surgery and on a rubric that focuses on the competency for asepsis, instrument handling, procedural knowledge, technical skills, and collegiality. General comments are also written at the bottom of the rubric to address specific concerns or encouragement. When students review the rubric after the live animal lab, they often ask how they can get an outstanding rather than just a pass; here, it is evident that they remain highly focused on their final grade. When the students are asked to self-evaluate their own skills for live surgery, they base it on their outcome performance and that they finished the procedure, and that there were no significant life-threatening incidents during the procedure. Even with the absence of an actual grade and having a rubric to define deficits, our students remain driven by teacher evaluation and performance outcomes rather than by recognizing the mastery skills involved and how to achieve them.
Although the presence of a Clinical Skills lab appears to increase opportunities for students’ psychomotor skill practice, it does not completely address how veterinary students approach this self-directed learning opportunity. There are three possible obstacles that could deter students from getting the most from these opportunities to improve their skills. The first deterrent stems from the curriculum being didactically-based, as this type of andragogy does not promote self-directed learning (Blumberg, 2005). Secondly, students are novices at these skills, and thus approach learning psychomotor skills as novices, which can overwhelm their sense of learning strategies (Zimmerman, 2002). Lastly, in a program that is so outcome-based, students are often more performance driven than focused on the mastery of skills (Artino et al., 2012). For these reasons, it is not enough to just provide a place, equipment, and written or visual instruction on how to perform a psychomotor skill. Instead, students need to recognize themselves as active learners and develop the learning skills to structure and shape their own learning of psychomotor skills. Coming from a didactically-based education, being novices at the required psychomotor skills, and being performance outcome-driven, veterinary students may not have the mindset or strategies needed to succeed in a learner-centered environment. For veterinary students to fully benefit from a clinical skills lab, they need to understand themselves as learners and self-direct their own learning to fully benefit from these facilities.

Our current direction for the mastery of skills is to use DP in these clinical skills labs (Baillie, Dilly, & Crowther, 2015; Scalese & Issenberg, 2005). However, DP relies on instructor feedback (Ericsson, 2015). Will that be enough to guide students in a self-directed, learner-centered environment? As Brydges, Dubrowski, and Regehr (2010)
write, “We must be cautious to ensure that shift towards unsupervised practice is not simply an unreflective drift away from supervised, educator-guided learning” (p. 49).

Self-directed learning requires the mechanism of autonomous learning that is known as self-regulated learning (SRL) (Brydges, Nair, Ma, Shanks, & Hatala, 2012). In research of the psychomotor skill of musical instrument performance, where unsupervised practice is common, both DP and SRL strategies were linked to higher achievement in mastery and performance (Bonnieville-Roussy & Bouffard, 2015). Moreover, in human medicine literature (Brydges, Dubrowski, & Regehr, 2010), there is support for promoting SRL in medical student training where self-directed learning is required. Providing students with an understanding of SRL strategies based on learning goals that they can adopt to support psychomotor skill mastery may, then, offer a framework for students to achieve deeper learning in a self-directed learning environment.

**Purpose of the Study**

In response to our graduates lacking confidence and exhibiting sub-optimal competency at graduation, veterinary colleges are enhancing their clinical skills training facilities and courses to improve undergraduate training and competency. Clinical Skills labs that are provided to students to self-direct their own skill development rely on the students’ own autonomous learning to master their psychomotor skills. But what guidance do veterinary educators provide for their students to become self-directed learners in a learner-centered environment? *Self-regulated learning* is a learner-centered, metacognitive, and social cognitive schema that supports self-directed learning.

The purpose of this study was to determine if instruction in self-regulated learning (SRL) concepts would improve the suturing ability of second-year veterinary students.
Using quantitative methods, a pre-test/post-test control group design was used to compare the suturing skills between two groups of second-year veterinary students. One group was introduced to the theories of SRL and DP; they were encouraged to structure their self-directed development of veterinary psychomotor skills using both SRL strategies and DP. The second group acted as a control and received instruction only in DP. Both groups were introduced to the concept of DP, as this is the current educational practice for clinical skills training and will be explained in the theoretical framework section below.

**Research Questions**

The main question being investigated is: How does the theory of self-regulation influence second-year veterinary students’ psychomotor skills learning at the OVC when they are exposed to the theory and encouraged to use it during their early psychomotor skill training? Specifically, the study will address the question: How does exposure to the theory of self-regulation influence veterinary students’ mastery of suturing skills? The research questions will be investigated through a quantitative experimental pre-test/post-test intervention research design.

**Rationale and Significance**

Veterinary students will become practicing professionals that need to have both confidence and competence to perform different clinical skills and procedures as defined by their professional regulatory body; therefore, they need to be well-prepared and trained before graduating. From the literature of human medical education, there is empirical evidence that using SRL strategies supports the development, transference, and performance of psychomotor skills used in human medicine – specifically, suturing and venipuncture (Brydges, Carnahan, Safir, &Dubrowski, 2009; Sandars & Cleary, 2011).
For instance, medical students that self-guided their psychomotor skill learning using self-regulation strategies retained their skills longer than students who had teacher-lead instruction (Brydges et al., 2012). Moreover, Cleary and Sandars (2011) recommend, “further research to determine how SRL based interventions could be used to support medical education, especially for students that were struggling with clinical skills” (p. 273). There is also a recommendation, in human medical research, to use SRL in intervention studies to determine if it will improve students’ self-regulation and learning (Artino, Cleary, Dong, Hemmer, & Durning, 2014). With the improvements in clinical skills labs and the focus on self-directed psychomotor skill training in North American and European veterinary schools (Baillie et al., 2015; Dilly, Read, & Baillie, 2017), it is an ideal time to see if the advantages of SRL is as important in veterinary medical education as it is in human medical education. The findings of this study will provide evidence of the relationship between SRL and psychomotor skill development in veterinary students, and consequently, will inform veterinary education instructional practices.

**Theoretical Framework**

Two theories pertaining to psychomotor skill development will be reviewed: *deliberate practice* (DP) and *self-regulated learning* (SRL) theory. DP is a theory of skill proficiency that is currently recommended in the *Guide to Veterinary Clinical Skills Laboratories* (Baillie et al., 2015). SRL theory, on the other hand, is currently being explored in medical education to support students’ psychomotor skill development in student-centered clinical skills labs (Brydges et al., 2012). These theories will be
reviewed individually and together to form the theoretical framework that is the basis of this study.

**Deliberate Practice**

*Deliberate practice (DP)* is K. Anders Ericsson’s theory of acquiring and maintaining medical expertise by identifying and understanding what makes a performance superior in an authentic context, and then practicing those skills to improve performance (Ericsson, 2015). Schematically, it is a triad of three representations (see Figure 1). According to DP theory, improving performance requires a specific performance goal (Representation 1), execution of the performance (Representation 2), and monitoring of that performance (Representation 3) that determines mismatches between the first and second representation. This act of monitoring is initially performed by an instructor or mentor who offers immediate feedback for further reiterations of performance. Then this cycle of planning, executing, and monitoring is repeated until the goal is reached. Eventually, the monitoring and analysis of performance is taken over by the learner as they develop the cognitive processes to monitoring their performance (Ericsson, 2004, 2015).
Self-Regulated Learning

SRL is based on two theories: metacognition and social cognitive theory. Here, learning occurs initially from external social factors and becomes more internalized and controlled by the learner until they are fully self-regulating their learning (Zimmerman, 2000). A self-regulated learner understands and controls their learning and learning environment (Schraw, Crippen, & Hartley, 2006). In current educational literature, Zimmerman (2000, 2001, 2002) appears to have the most recognized model of SRL. He

Figure 1. The interconnected representations that form the cycle of deliberate practice. Adapted from Ericsson, K. A. (2015). Acquisition and maintenance of medical expertise: a perspective from the expert-performance approach with deliberate practice. Academic Medicine, 90, 1474.
describes SRL as a cyclical activity that involves three phases: forethought, performance, and afterthought (see Figure 2):

- **Forethought Phase**: Pertains to task analysis (goal-setting and strategic planning) and self-motivational beliefs (self-efficacy, outcome expectations, intrinsic interest/value, and learning goal orientation)

- **Performance Phase**: Self-control (imagery, self-instruction, attention focusing, and task strategies) and self-observation (self-recording and self-experimentation)

- **Self-Reflection Phase**: Involves self-judgement (self-evaluation and attribution) and self-reaction (self-satisfaction/affect and adaptive defensive)

Outline of the Remainder of this Document

Chapter Two that proceeds provides a synthesis of the relevant literature. This will encompass the theory of deliberate practice and self-regulated learning, briefly discussing various SRL theories and then explaining, in detail, B. J. Zimmerman’s self-regulation theory, its phases, and cyclical nature. The review also includes the instructional strategies currently used to teach psychomotor skills and how self-regulation can support this learning.

Chapter Three discusses the methodology which includes the research design, instruments, site and participants, data collection and analysis, and ethical considerations. Chapter Four presents the results of the statistical analysis of the quantitative research data derived from this study and will include the participant voice to provide a deeper understanding of their experiences. Lastly, Chapter Five presents a summary of the findings of this research and its limitations, implications, and recommendations for future application and research.
CHAPTER TWO: REVIEW OF RELATED LITERATURE

This chapter reviews the constructs of self-regulated learning (SRL) and deliberate practice (DP) theory regarding instruction and learning in veterinary clinical skills labs, arguing for skill development to be achieved in a self-directed learning environment. The review begins with a summary of the current state of veterinary practice and a rationale for the need for SRL in the veterinary curriculum. Thereafter, the reasons veterinary students are ill-prepared to achieve greater levels of competencies in the self-directed clinical skills labs, and possible ways to improve their learning skills, is discussed. This is followed by a review of SRL theory, which will include a brief overview of various models of SRL that are encountered in the literature. Then, a more detailed review of B. J. Zimmerman’s model of SRL, its cyclical nature, and the intricate roles of metacognition, social cognitive theory, self-efficacy, and human agency in SRL are explained. The theory of DP is then reviewed, and its similarities to metacognitive regulation explored. Next, the intersection of SRL and DP is examined to determine both the interplay between these two theories and which would be more effective for integration into veterinary clinical skills instruction. Attention is then given to the literature regarding learning a psychomotor skill. Finally, the importance for instructors to understand SRL is examined, and the chapter concludes with a discussion of the importance of promoting SRL in psychomotor skill development.

The Current Status of Psychomotor Skill Training

As the curriculum and facilities at the OVC and international veterinary colleges evolve (Dilly, Read, & Baillie, 2017), veterinary students are being expected to self-direct their own psychomotor skill development beyond the traditional classroom discussion and labs that currently facilitate this learning experience. Though these spaces
make models and simulators available to the student to practice, merely performing the same procedure repeatedly may produce a basic level of mastery – more specifically, it does not empower the learner to achieve higher levels of competence and pursue life-long learning (Duvivier et al., 2011). The veterinary medical literature regarding developing and teaching in these new clinical skills labs focuses on creating instructional ‘how-to’ videos, skill station instructions, and having staff with a dedication to students and teaching (Baillie et al., 2015; Baillie, Dilly, & Crowther, 2015; Dilly, Read, & Baillie, 2017). Some medical educators recommend deliberate practice theory to be structured into clinical skills instruction (Duvivier et al., 2011; Gifford & Fall, 2014; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011). The veterinary education literature has not captured this level of embedding DP into their psychomotor skill instructions, as its human medical education counterparts have done. Rather, the veterinary literature is limited to recommending that students use DP, but does not provide guidance on how to go about its use (Baillie, Dilly, & Crowther, 2015).

DP theory was based on enhancing expertise in highly motivated individuals’ cognitive or psychomotor skills for very specific tasks such as chess, music, and sport, over extended periods of time – for instance, 10 years (Ericsson, 2015). The theory does not take into account novice learners, their level of motivation, self-efficacy, or achieving mastery in shorter time frames. Alternatively, recent literature in human medical education recommends SRL as a means of developing a learner’s self-directed learning of clinical psychomotor skills (Brydges & Butler, 2012; Brydges et al., 2012; Cleary & Sandars, 2011). SRL is a metacognitive and social cognitive schema that supports self-directed mastery of psychomotor skills in novice learners (Kitsantas & Zimmerman,
Self-regulation theory not only sets the learner at the controls of goal-setting and strategy planning and the monitoring of their own progress of cognition and skill (metacognition), it addresses how the learners control their own behavior and environment to learn (social cognitive theory). This theory also considers all levels of development from novice to expert, and the strategies that are the basis of self-directed learning. However, incorporating SRL into existing curricula is challenging for educators and students.

Challenges to Veterinary Students in Self-Directed Learning Scenarios

For veterinary students emerging from a didactic and teacher-centered learning environment, self-directed learning of psychomotor skills can be overwhelming and poorly attained. Self-directed learning requires skilled behaviors and is poorly modeled in teacher-centered learning (Blumberg, 2005). Although students know they must ‘practice’ their skills, is mere practice enough? According to Kneebone and Baillie (2008), merely repeating a procedure is not enough for a student to learn; what is essential is their active engagement in their own learning. Are veterinary students actively engaging in their own learning? In a study from the Veterinary College at the University of Helsinki, Ruohoniemi, Parpala, Lindblom-Ylanne, and Katajavuori (2010) found that veterinary students were not able to assess their own contribution to learning. The authors’ recommendations were to, “explicitly make students aware of their approaches to learning and to support the development of students’ study practices” (Ruohoniemi et al., 2010, p. 286). Students need direction and instructional support to develop into independent active learners in a new learning environment (May & Silva-Fletcher, 2015; Miflin, Campbell, & Price, 2000). In human medical education, problem-
based learning (PBL) curriculum is common and founded on self-directed learning. A body of research in medical education suggests that learners who are effective at SRL – a cyclical, metacognitive strategy embedded in social cognitive theory – succeed in self-directed learning environments (Sandars & Cleary, 2011; Turan, Demirel, & Sayek, 2009; White, 2007). It could be surmised, then, that supporting self-regulation strategies during psychomotor skill development could provide veterinary students with the ability to develop into self-directed learners.

Considering the spectrum of skills development from that of a novice up to an expert provides us with another lens through which to view our students. As instructors, we must appreciate that most students approach psychomotor skills as novices rather than experts. Novices require rules and specific pathways to understand a novel task (Dreyfus, 2004). These rules and pathways are provided in clinical skills labs by a plethora of video, systematic step-by-step skills guides, and illustrations that the learner can access to model the task. Using these learning aids, it is assumed that the learner can advance through the stages of advanced beginner to that of conscious competence, where they still must think their way through a task rather than just doing it automatically (unconsciously competent) (Baillie et al, 2015). However, there are challenges that novices can face in learner-centered environments. According to Zimmerman (2002), novice learners in a psychomotor domain a) can be overwhelmed by the tasks, and tend to only see the outcome goal rather than the hierarchical goals that are required to reach that outcome; b) can have a poor understanding of the learning strategies in a psychomotor domain because they differ from the learning strategies in didactic teaching; c) have difficulty self-assessing their own work, resulting in not appreciating their subtle improvements;
and d) tend to compare their performance with other’s performance, which can result in feelings of poor ability. SRL provides a framework for learners to structure their skill acquisition; by visualizing a task as a hierarchy of goals, recognizing, and selecting learning strategies that are effective, and developing self-observation and evaluation skills to reflect upon their skills (Zimmerman, 2000). Understanding the cycle and strategies of SRL, students, who are novice learners, can then have a framework to approach psychomotor skill training like an expert.

In the competitive and highly academic culture of veterinary medical education, students tend to be performance outcomes-oriented (Zenner, Burns, Ruby, DeBowes, & Stoll, 2005). The focus of deeper learning or skill mastery is based on mastery goals rather than performance outcomes (Artino, et al., 2012). The aim of clinical skills labs is for students to develop mastery of the psychomotor skills needed in practice, which equates to a deeper understanding of the skill technique and an understanding of how that skill may have to adapt in different circumstances (Dreyfus, 2004). Zimmerman (2008) found that students who are encouraged to use SRL strategies during learner-centered activities show an increase in learning goal orientation rather than outcome goal; in other words, they are more motivated and interested in the task and have higher perceptions of their capabilities or self-efficacy. If clinical skill labs provide an environment that is based on mastery goals, then students tend to use mastery processes to achieve them (Artino et al., 2012). As stated by Brydges, Carnahan, Safir, and Dubrowski (2009), “Providing self-guided learners with a process orientation may enhance the efficiency of simulation-based education in the absence of an instructor” (p. 513). Using mastery or learning goals directs a student’s psychomotor development to learn the skill as
accurately as possible rather than just to get to the finished product, performance, or outcome. It should be made explicit to learners developing SRL strategies, then, to recognize the difference between learning goals and outcome or performance goals, and to know that they can choose strategies that support their own learning styles.

**Self-Regulated Learning**

Since learning takes effort and there is a seemingly unlimited amount of information to learn, we effectively self-regulate our learning by choosing what we want to learn (Winne, 2011). Zimmerman (2000) describes *self-regulated learning* as, “self-generated thoughts, feelings and actions that are planned and cyclically adapted to the attainment of personal goals” (p. 14). SRL is not dependent on the learner’s intelligence or level of competence; rather, it is the learner’s own motivation and self-directed learning processes that transforms their intellectual or physical ability into academic or psychomotor skill (Zimmerman, 1998). While learners can self-regulate their learning, they make sub-optimal use of this ability (Brydges, Dubrowski, & Regehr, 2010). Other studies show that learners who are high achievers tend to be skilled at self-regulation; they are strategically mindful of the learning processes involved in all phases of the self-regulation cycle (Cleary & Sandars, 2011). By self-regulating, learners take an active role in the learning process. They determine their own learning goals, use strategies to attain these goals, and then reflect on the effectiveness of their strategies to reach their goals. The outcome of self-regulation is to generate a product of knowledge, and increase understanding and/or mastery, but its true focus is on the process of learning (Zimmerman, 2002).
The literature indicates that SRL supports learning in self-directed learning environments in both veterinary and human medicine (Brydges & Butler, 2012; Ertmer, Newby, & MacDougall, 1996; White, 2007). In intensive learning environments that rely on self-directed learning, the persistence of SRL skills is a variable that reliably differentiates between high and low achievers (Pintrich, 2000). There are similarities between self-directed learning and SRL theories: both are goal-directed learning behaviors, requiring the learner’s intrinsic motivation and metacognitive awareness (Loynes, Magda, & Rikers, 2008). However, the differences between self-directed learning and SRL are based on their theoretical origins, the level of autonomy of the learner, and what they choose to learn; SRL, for instance, is directed more by the instructor or curriculum (Brydges & Butler, 2012; Brydges, Dubrowski, & Regehr, 2010; Loynes, Magda, & Rikers, 2008).

It is important for both the learner and instructor to understand the steps and processes of SRL to improve learning and skill development (Berkhout, Helmich, Teunissen, van der Vleuten, & Jaarsma, 2016). Although the concept of SRL may initially seem to be an intuitive and natural process (Winne, 2011), it is considered to be an adaptive learning strategy that can be developed by students (Loynes, Magda, & Rikers, 2008). It is not readily transferable across contexts because it takes different learning strategies, behaviors, motivations, and environments to learn different things (Cleary, Callan & Zimmerman, 2012; Nilson, 2013; Schunk, 2001; Zimmerman, 1998). Learners may have limited metacognitive strategies to apply to a new learning context, so that they may have limited metacognitive knowledge and skills to know, plan, monitor, or evaluate their learning (Batha & Carrol, 2007; Martini & Shore, 2008; Silver, 2013).
It is important, then, for the learner to understand the steps and processes of SRL so that they do not attribute challenges to learning as a lack of intellect or skill. Rather, in new contexts, they may lack background knowledge, be unfamiliar with different metacognitive strategies, and be deficient at effective self-evaluation within this new context, thus impeding their ability to self-regulate their learning (Zimmerman, 2002). As a mentor, instructor, or facilitator, knowing the SRL cycle can facilitate an understanding of where students are deficient in their ability to learn or develop their skills (Cleary & Saunders, 2011). Cleary and Saunders (2011) explain further that understanding SRL can also provide learners with a better understanding of themselves as learners and can help them to appreciate that different contexts for learning may require new strategies to learn and achieve competency. Brydges and Butler (2012) also suggest that learners in environments which rely on self-regulation should be supported in their development of SRL. As reviewed here, this implies that a learner who has developed effective self-regulation to learn academic material may have difficulty learning psychomotor skills because the motivation, learning strategies, and behaviours to learn these skills are different or unfamiliar to the learner. Learners may appreciate that learning in different contexts can be challenging; however, by understanding the cycle and components of SRL, learners could isolate and address their deficiencies to move forward with their learning in these new contexts.

Models of Self-Regulated Learning

In the current literature, Zimmerman’s (2002) SRL model appears to be the most prevalent, and has withstood theoretical, empirical, and applied tests of SRL (Schunk & Usher, 2013). Zimmerman (2002) describes *self-regulated learning* as a cyclical activity
that involves three phases: forethought, performance, and afterthought. This cycle of SRL begins with a planning or forethought phase which precedes learning. In the *forethought* phase, the learner sets their own learning goals, and determines strategies to achieve them. The second phase is the *performance* or *volition control stage* that involves the active learning of the knowledge and skill; it involves learning and awareness strategies. The final stage, *afterthought*, occurs after learning and is a reflective process that involves self-judgements and attributions of performance (Zimmerman, 1998). This cycle can be reiterated by modifying or changing the original goals and learning strategies. Alternatively, once the goals are reached, the learner can develop new goals to pursue.

Zimmerman’s (1998) SRL model is illustrated in Figure 3 below, and is summarized in the following list:

- **Forethought Phase**: Pertains to *task analysis* (goal-setting and strategic planning) and *self-motivational beliefs* (self-efficacy, outcome expectations, intrinsic interest/value, and learning goal orientation)

- **Performance Phase**: *Self-control* (imagery, self-instruction, attention focusing, and task strategies) and *self-observation* (self-recording and self-experimentation)

- **Self-Reflection Phase**: Involves *self-judgement* (self-evaluation and attribution) and *self-reaction* (self-satisfaction/affect and adaptive defensive) (Zimmerman, 2002).
Butler and Winne (1995), moreover, define *self-regulated learning* as a, “deliberate, judgemental and adaptive process” (p. 246). Their model of SRL involves similar elements to Zimmerman’s model with respect to setting goals and applying strategies and processes to produce learning outcomes. However, they make a distinction between internal and external factors influencing the learner. As part of the internal process, Butler and Winne (1995) emphasize that setting goals involves interpretation of the task and using the learner’s existing domain knowledge and their beliefs about the
task (motivation to do the task). To obtain these goals, the learner applies strategies to produce both mental and behavioral products. Internal feedback occurs as learners self-monitor the effectiveness of their strategies to obtain their goals. This monitoring may alter the learner’s goals and strategies. External factors, conversely, are the feedback a learner can receive from an instructor or a peer, which may or may not conflict with the learner’s perception of their task and their learning strategies. Internal and external feedback, as well as performance outcomes, can influence the learner’s task interpretation, goals, and strategies when they encounter a new learning objective. Butler and Winne’s SRL model is illustrated in Figure 4.


In order to develop a hypothesis based on the founding theoretical principles of a model, it is important to define and adhere to one model for one’s research (Azevedo, 2009; Dinsmore, Alexander, & Loughlin, 2008). The model which I have chosen to base this research on is Zimmerman’s model, as illustrated in Figure 3. The reason I chose this
model is that it is the most prevalent in the literature; not only has Zimmerman written extensively on this subject, there are many others that support his work and model (Schunk & Usher, 2013). Zimmerman’s model has also been used extensively for psychomotor skill development (Cleary, Zimmerman, & Keating, 2006; Kitsantas & Kavussanu, 2011; Kitsantas & Zimmerman, 1996; Zimmerman & Kitsantas, 1996, 1997).

**Theoretical Constructs of Self-Regulated Learning**

Zimmerman’s SRL model embodies the constructs of metacognitive theory and social cognitive theory with its own constructs of self-efficacy and human agency. According to Zimmerman (1995), although metacognitive regulation is the activity that drives many of the learning processes within the cycles of SRL, what differentiates it from only being a purely metacognitive construct are the factors of motivation, self-efficacy, and personal behavior that are inherent in the self-regulation of social cognitive theory. Historically, metacognitive theory and social cognitive theory were developed separately, but as metacognitive theory has become more behavior-based, and social cognitive theory focuses more on cognition, the two theories merge together in SRL, aligning self-awareness and intention to act as core concepts (Dinsmore, Alexander, & Loughlin, 2008).

Where divergence continues to exist between these theories, however, is at the stimulus for learning; the environment or context stimulates self-regulation, and it is the mind of the learner that triggers metacognitive judgements or evaluations (Dinsmore et al., 2008). Kaplan (2008) provides an alternative perspective of SRL, “that metacognitive self-regulation, social cognitive self-regulation, and SRL are subtypes within a multidimensional conceptual space of self-regulated action, allowing changes in self-
regulated actions to be tracked as movement along the dimension” (p. 477). I present these views to reflect the importance of connections between the theories of metacognitive and social cognitive self-regulation with SRL theory. As a personal meta-observation of learning about the topic of SRL, I found it easier, initially, to view them as separate theories. Then, as my understanding of SRL has developed, I now appreciate how integral and entwined both metacognition and social cognitive self-regulation are within the broader SRL theory.

**Metacognition**

*Metacognition* is commonly described as thinking about one’s thinking; it is thinking about what we know and how we learn (Flavell, 1979). Metacognition is a vast topic; therefore, its function in relation to SRL will be the focus of this section. Metacognition can be divided into three parts: metacognitive knowledge (MK), metacognitive regulation or skills (MS), and metacognitive experiences (ME). MK can be further subdivided into a) *declarative knowledge*, knowledge about the self and strategies to learn; b) *procedural knowledge*, knowledge of how to use different strategies effectively and d) *conditional knowledge*, knowledge of when and why to use different strategies to learn (Kincannon, Gleber, & Jaehyun, 1999; Pintrich, 2000). MS involves the skills of planning, monitoring, and evaluation of one’s own learning (Efklides, 2009; Flavel, 1979; Kincannon, Gleber, & Kim, 1999). Lastly, ME are the feelings and emotions that arise from the self-awareness of monitoring one’s learning (Efklides, 2009; Flavell, 1979). Efklides (2008) defines *metacognition* as a representation of cognition; where the learner enriches his or her metacognition knowledge through the task
experience of cognition and metacognition informs cognition by self-regulating ways to learn the knowledge more effectively (see Figure 5).

Metacognition is an integral process of SRL, and functions in each stage of the SRL cycle (Efklides, 2009). Metacognition starts in the forethought phase as an activation of our awareness of what we know (*prior knowledge*) (Pintrich, 2000). Learners need to accurately perceive what the task is and what knowledge – both content knowledge and learning strategies – they have and can use to make them more effective at the task (Winne, 2011). A learner’s strategy planning is based on *metacognitive knowledge*, which is our awareness of strategies that we can use to learn (Pintrich, 2000; Winne, 2001). These can change throughout the learning process, both within and between contexts. To do so, the learner must use metacognition to see when a strategy is working or must be changed to improve comprehension (Schunk & Zimmerman, 1998).

In the second phase of SRL, the performance control or strategic awareness phase, metacognitive functions involve monitoring and control of learning. Metacognitive monitoring in the form of self-observations and self-assessments gives learners information about the gap between their understanding of the task and its goal (Efklides, 2009). By engaging in metacognitive control, learners decide which strategy to use to learn, and whether the current strategy is fulfilling their learning needs (Pintrich, 2000). Being metacognitive, self-observant, and self-aware of their performance, learners may choose a different strategy from their repertoire to improve performance. For Silver (2013), “Metacognition allows students to make decisions about how they learn best by helping them become aware of what they are doing when they are learning” (p. 3).
In the third phase of self-regulation (reflection), learners use the metacognitive functions of self-evaluation and self-judgement of their learning to determine how effective their learning efforts have met their learning goals (Pintrich, 2000). These evaluations and judgements involve comparing task learning to the task learning goals the learner set for themselves. As Pintrich (2000) explains, they may ask themselves if they comprehend what they learned or if they are performing the skill or task optimally. From these self-evaluations and judgements, the learner can ascertain if they have reached their goal, needs to adjust their goal, or can move on to new goals.

Metacognition works throughout each of the SRL phases. These metacognitive skills, such as prior knowledge activation, monitoring, and strategy knowledge and choice, are key functions that are the foundation for the regulation of learning. Using metacognition to learn, either academically or in the psychomotor domain, is an effective way to improve deeper learning and achievement (Silver, 2013). High-achieving
students, gifted students, and experts, for instance, show a greater use of metacognition than lower achievers or novices (Martini & Shore, 2008).

**Social Cognitive Theory**

Zimmerman (1995) based his theoretical framework for SRL on Bandura’s social cognitive theory. Bandura’s (1989) [*social cognitive theory*] states that a learner’s human agency (or action) emerges from a reciprocal triad that includes the environment in which they are learning, their cognitive processes and beliefs, and their behaviors. In social cognitive theory, human agency emerges as an individual who is proactively engaged in their own learning and development by exercising self-regulation; that is, how they choose to interact (behavior) with their environment, how they react to it, and, in part, how they shape it (cognition) (Bandura, 1989; Martin, 2004; Schunk & Usher, 2013). Zimmerman (2000) states, “It is our human ability to self-regulate, the social cognitive theory investigates how we develop our own self-regulated learning” (p. 13).

Through the reciprocal triad of social cognitive theory (environment, cognitive processes and beliefs and behavior) self-regulated learners become self-aware of their performance and adjust to improve their understanding. Social cognitive theory bases learning in social environments and involves observation and interaction with other people where they, “learn knowledge, skills, strategies, beliefs and attitudes” (Schunk & Usher, 2013, p. 5). Within these environments or social contexts, learning can begin with the learner actively engaging in an activity (Schunk & Usher, 2013) or through *vicarious learning*, or watching and then mimicking other people’s actions rather than learning everything anew through trial and error (Bandura, 1989). As learners start to actively perform the skill, they start to recognize themselves trying to copy the action and become
aware of how they are succeeding by comparing their performance with that of the model (Schunk, 1989). As they learn and compare their performance to that of the model, they begin to self-regulate their own personal factors by setting goals for their performance, as well as monitoring and evaluating their performance (Schunk & Usher, 2013). These cognitive processes and beliefs reflect two separate constructs; the cognitive processes involve both cognition and metacognition, whereas the beliefs refer to the learner’s motivation, metacognitive experiences, and affect for the task (Efklides, 2009).

Recognising a need to make changes, the learner modifies their behavior by using different learning strategies to acquire their goal (Schunk & Usher, 2013).

**Human Agency**

Human agency emerges from social cognitive theory’s triad and the reciprocal actions between a learner’s environment, cognition, and behavior. Human agency is our ability to proactively make choices that effect our outcome (Bandura, 1989). Human agency implies that we can make a choice or self-regulate; it puts the ‘self’ in ‘self-regulation.’ Human agency arises from the learner’s participation in sociocultural practices; once they emerge from this practice, it can reciprocally develop both themselves and their society (Martin, 2004). The capability of human agency is exercised as a) self-regulation in forethought and intentionality; b) the learner’s thoughts, feelings, and actions within an environment; and c) their reflection on their actions to further influence action and interaction with the environment (Bandura, 2001; Martin, 2004).

The theory of human agency implies that the learner has control by self-regulating their thoughts, actions, and affect within an environment and can, in turn, shape their learning environment.
Self-Efficacy

For Bandura (2000), “Self-efficacy is a person’s belief in their capability to perform in ways that give them control of events that affect their lives and it forms the foundation of human agency” (p. 212). Self-efficacy influences each construct of the social cognitive theory triad – environment, behavior, and cognition – and therefore, it influences human agency. According to Schunk and Usher (2013), when interfaced with behavior, cognition, and personal beliefs, self-efficacy can influence the choice of learning strategy, effort, and persistence. Reciprocally, if use of these factors enables learners to achieve their goal, then their self-efficacy is increased.

In a social context, if learners are within a social and environmental space that supports their learning and achievement, then their self-efficacy increases, and they may choose to seek out this environment to learn in again (Schunk & Usher, 2013). Self-efficacy determines factors such as our motivation for a task, the feelings we have about the task, and the action we take. This demonstrates, again, that these factors are reciprocal; that is, if self-efficacy is strong, then our motivation to succeed in the task is strong, and if we succeed in the task, this increases our motivation about subsequent tasks (see Figure 6).

Individuals who have strong self-efficacy are not always deterred by failure at a task; for instance, if they strongly believe in their problem-solving capabilities, they are more persistent in their efforts, and have resilient self-belief (Bandura, 1989). Because learning has many challenges, those learners with higher self-efficacy will have the resiliency to overcome the challenges and reach their goals. If these learners overestimate their capabilities, they are intrinsically encouraged to push themselves to reach
goals that may be beyond their reach. They achieve these higher goals by having, what Bandura (1989) describes, as *coping and control efficacy*: the perceived ability to cope and maintain control by minimizing adverse thoughts when there are unfavorable social or environmental factors. This enables learners to maintain their determination to achieve, even when circumstances are not in their favour. Sustaining self-efficacy when there are challenges is important to build resiliency; this delay in self-gratification is important to sustain SRL, as well (Nilson, 2013).

Zimmerman’s Three-Phase Cycle of Self-Regulated Learning

Since I use Zimmerman’s (2000) model of SRL to frame and design the study, I present an adapted model and explain the details of each of the three phases in the section below.

Forethought

The first phase of Zimmerman’s (2000) model of SRL is *forethought*. It can be divided into *task analysis* and *self-motivational beliefs* (see Figure 7).

**Task analysis.** *Task analysis* is also supported as the first step in Butler and Winne’s theory of self-regulation (1995). Correctly interpreting the task can be influenced by the learner’s prior knowledge about the task, and their ability to decipher the expectations that have been set out by an instructor (Butler & Cartier, 2004). The activation of prior knowledge can be automatic, without the conscious effort of the learner; however, learners that are inclined to self-regulate their learning actively retrieve content and metacognitive knowledge from their memory to support their task analysis, goal-setting, and strategy choice (Pintrich, 2000). Task analysis can be further subdivided into *goal-setting* and *strategic planning*. If the task analysis is accurate, then the learner can make more focused goals and determine effective tactics to use to achieve the goals.

**Goal-setting.** A learner’s perception of the task influences the goals that they set for themselves (Ferrari, 1996). A goal defines what the learner would like to accomplish and gives direction to their learning. In the context of SRL, there are two types of goals: i) a learning, proximal, or process goal; and ii) an outcome or performance goal. The *learning goal* is the skill and knowledge that a learner needs to master the task; these should help to focus the learner’s attention on the strategies and processes necessary to
learn and understand the technique to perform the psychomotor skill (Zimmerman & Kitsantas, 1997). Learners that focus on learning goals are more likely to monitor and concentrate on their process of skill acquisition, making adaptive changes to their strategies to learn the technique and self-improve (Cleary & Sanders, 2011; Zimmerman, 2011). Setting and achieving a personal learning goal increases self-efficacy (Schunk & Ertmer, 2000), as, “Learners that set specific, proximal goals for themselves have higher academic success” (Zimmerman, 2002, p. 68). Focusing on learning goals has other benefits, too; the learner is more likely to appreciate an improvement in their skill level faster, while reducing the cognitive load needed to reach the performance outcome. Together, these increase the learner’s self-efficacy (Zimmerman & Kitsantas, 1997).

The outcome goal is the finished product or completed task. Learners that only focus on completing the task are less cognisant of the learning process and strategies to achieve the task. However, Zimmerman and Kitsantas (1997) found that learners who excelled at free basketball throws started with proximal learning goals and, once mastered, their goals would then shift to outcome goals. They out-performed learners that stayed with proximal goals, or learners who only chose outcome goals exclusively. Learning programs that focus on outcome goal structures promote proficiency, which leads to superficial learning rather than deeper learning and adaptive learning behaviors (Artino et al., 2012).
Supporting outcome goals also encourages social comparisons where learners are geared to out-perform classmates. If the outcome goal structure encourages students to avoid displays of incompetence, then the learning remains superficial and is linked to procrastination (Artino et al., 2012; Wolters, 2004). Ideally, when learners are learning a new skill, they should be initially encouraged to choose learning goals rather than outcome goals. Skill mastery level learning environments engage students in adaptive behaviors using SRL (Artino et al., 2012).

When instructing and directing students in acquiring a new psychomotor skill, then, it is important to have them focus on the learning of the skill rather than the ability to perform it. As instructors of psychomotor skills, we should embrace a student’s passion for learning and encourage them to develop learning goals around a psychomotor skill rather than asking them if they can demonstrate proficiency in the skill.

**Strategic Planning.** Once a learner has identified a learning goal, then they need to determine what strategy they can use to learn the skill. The strategy, “is their personal and purposeful process and actions directed at acquiring the skill” (Zimmerman, 2000, p.
17). The strategy that the learner chooses can be based on their own learning style and is not controlled by the instructor. However, strategy choice can be a reason that self-regulation does not cross contexts that easily. As Zimmerman (2000) points out, when learning in a new context, the learner may not be aware of valid strategies to learn in this new situation. It may, therefore, require trying different strategies to determine how they best learn a new psychomotor skill. They may seek feedback from an instructor or peer to determine useful learning strategies, for instance. As they employ strategies to learn and acquire the technique of the psychomotor skill, they can adjust their goals to be more performance-oriented or move on to new goals. Since a learner can adjust their goals to reflect what they have learned or can choose new learning strategies, task analysis becomes a very dynamic process (Zimmerman, 2000).

**Self-motivation.** The second part of forethought is self-motivational beliefs. Positively motivated students do the following: a) they direct their attention to learning processes; b) they use strategies that support their learning; c) they choose tasks that they actively want to practice; and d) they increase their learning effort and are more persistent at mastering the task (Zimmerman, 2011). Zimmerman (2000, 2011) outlines the four different factors that influence a learner’s motivation: i) the learner’s self-efficacy for the task; ii) their outcomes expectation; iii) their degree of intrinsic interest for the task; and iv) their goal orientation.

**Self-efficacy.** Firstly, if the learner has a strong self-efficacy for a task, they believe in their own capability to achieve the goal and are, therefore, more motivated to try to achieve it by working harder, longer, and being more persistent with their efforts
(Schunk & Ertmer, 2000). The learner also self-monitors and shifts to using more
effective strategies when they have high self-efficacy for the task (Zimmerman, 2011).

**Outcome expectations.** Secondly, the learner’s outcome expectations are linked to
their personal beliefs and values, as well as the consequences of choosing to pursue a
task. It fulfills an ‘if-then’ relationship and depends on the learner’s previous experience
with the task and, in this way, does relate to self-efficacy (Winne, 2001).

**Intrinsic interest.** Thirdly, the learner’s intrinsic interest for the task can be
explained in terms of the self-determination theory of intrinsic and extrinsic motivation.
*Intrinsic motivation* develops from the learner’s desire to enjoy and be satisfied with a
task or activity that informs them of their competencies (Zimmerman, 2011). Associated
with intrinsic motivation is *autonomous self-regulation*, “where learners persist at a task
because they can choose and initiate a learning tasks that is interesting or personally
important to them” (Zimmerman, 2011, p. 52). Conversely, *extrinsic motivation* refers to
motivation to learn that comes from a source external to the learner, such as an instructor
that sets a test or a course that must be achieved to acquire a degree. It implies that the
learner does not control the learning outcome (White, 2007). In a study by Legault and
Inzlicht (2013), they determined that brain activity associated with self-regulation and
autonomous (intrinsic) motivation was found to enhance self-regulation by increasing
reactions to performance errors. Since extrinsic or controlled motivation did not cause
these reactions to performance errors, the authors concluded that, “neurologically we are
not able to register the same self-regulatory actions when the motivation comes from an
external source” (Legault & Inzlicht, 2013, p. 135).
**Goal orientation.** Lastly, *goal orientation* refers to why learners want to achieve the goal. If the learner is motivated to master or learn a skill, then they use strategies and monitor their processes to show that they are progressing towards the goal of mastering the skill (Pintrich, 2000; Zimmerman, 2011). Self-motivational beliefs, “have a reciprocal relationship with goals. Goals are a motivational factor for self-regulated learning” (Berkhourt et al., 2015, p. 596). Here, it takes the learner’s motivation to engage in goal-setting and strategy planning, as well as the desire to achieve the goal. By achieving their learning goal using successful strategies, learners will increase their motivation and self-efficacy in a reciprocal fashion and be empowered to pursue similar or higher goals in the future (Zimmerman, 2008).

**Performance**

The second phase of the SRL cycle is performance. This phase can also be called *strategic awareness and behaviors, volition control, or monitoring* (Cleary & Sandars, 2011; Zimmerman, 2000). This is the phase where learning strategies are used to convert information into knowledge. In terms of psychomotor skill learning specifically, it is where the experience of physically performing a skill converts to cognitive knowledge and motor control to correctly execute that skill. There are two important functions that support this conversion: *self-control* and *self-observation* (see Figure 8).

**Self-control.** Firstly, during the performance phase, the strategies that were chosen during forethought are used to implement learning. This involves using self-control to reduce a task down to its essential parts, and re-arranging these parts so that they are meaningful (Butler & Cartier, 2004). Here, metacognitive experiences are involved in strategy selection (Efklides, 2009). If previous experience performing the
psychomotor skill is lacking, then attention to the learning strategies set out by the instructor or peers help may guide the learner in selecting the appropriate strategies for the task. Self-instruction, describing the steps or principles of the movement to one’s self (covertly) or out loud (overtly), and/or visualizing the task (imagery or modelling) are strategies that can aid in learning the skill, while utilizing attention focusing to increase concentration on the task and block out both internal and external distractions (Zimmerman, 2000).

Self-observation and monitoring. Next, *self-observation* is an active process that informs the learner of their personal learning and acquisition of the skill; here, the learner must actively engage in mindfully monitoring their own performance and comparing it to the standard or model in order to recognize their performance strengths and weaknesses. Zimmerman (2000) states that the quality of a learner’s self-observation can be affected by the detail of their observations and what they do with the information they gain from that observation. The effectiveness of self-observation depends, then, on how mindful or ‘in-the-moment’ the learner observes themselves; for instance, learners may not focus on the skill acquisition or can be overwhelmed by or incapable of the focus that is required for such skill acquisition. Their accuracy of observation may also be poor if they are unfamiliar with the skill technique; therefore, this is where their observations can be altered or supported by external feedback. Alternatively, their self-observation can be accurate, but they may have limited strategies available to improve their practice; this is where external feedback can again assist them with making their observation effective (Butler & Winne, 1995). Lastly, learners’ self-observation may be negative or positive and depending on the strength of their self-efficacy for the task, they may be negatively affected by their self-observations (Zimmerman, 2000).

For novice learners, setting hierarchal process steps to divide up the performance task into smaller segments allows the learner to concentrate and observe smaller segments of the skill, thus decreasing cognitive load (Zimmerman & Kitsantas, 1997). If the learner has a model to observe – either prior to performance or while performing the skill – then they have a goal standard to emulate. They can compare their performance directly to the model, observing for accuracy and deficiencies. The model, in turn,
becomes their internal representation for the skill (Winne, 2011). The learner may have to seek external feedback from an instructor, peer, or mentor to guide their experience of self-observation or to help them appreciate what they are observing from their own execution of the task (Butler & Winne, 1995). From the experience and observation of performing the skill, they develop their spatial awareness, force, timing, and coordination (Ferrari, 1996). By observing their own performance and sensing their own movements, learners can develop their own intrinsic feedback by comparing it to what they see modelled (Xeroulis et al., 2006).

When learning psychomotor skills, especially with the aid of video or live demonstrations, learners are better at self-assessment than when self-assessing their academic cognition (White & Gruppen, 2010). Jowett et al. (2007) found that students learning and performing a novel surgical skill – hand-tying square knots – were intrinsically aware of their performance and when it could no longer be improved; the researchers explain that, “when the goal of the self-assessment process is termination of self-regulated practice rather than demonstration of knowledge, trainees are able to accurately assess when it is appropriate to cease practice” (Jowett et al., 2007, p. 241). Developing this individual intrinsic feedback for one’s own learning is important for self-regulation. The learner should be able to form their own self-assessment before external or extrinsic feedback is delivered to them. If they only rely on feedback from a peer or an instructor, then learners do not fully appreciate the importance of self-monitoring their own work.

Self-recording and self-experimentation both support self-observation (Zimmerman, 2000). Writing down or recording one’s observation, for instance, can
clarify and make feedback from self-observation explicit to the learner. Furthermore, using self-experimentation allows the learner to use information from their observations and try to vary different processes to improve the outcome and goal attainment. This increases the learner’s personal control of the learning task, which can motivate their learning (Zimmerman, 2000).

During the performance phase of self-regulation, self-control and self-observation focuses and informs the learner of the effectiveness of their learning. If the learner observes that they are not acquiring the skill, for instance, then they can adjust their psychomotor technique to produce a product closer to their goal or the model. Using these forms of metacognitive monitoring, the learner can determine if they have learned the task correctly, if they could improve their learning by making variances to their technique, or if they need to seek external feedback to understand where their learning is faltering.

**Afterthought**

The third phase of self-regulation is *afterthought* or *self-reflection*. This phase in the cycle is important for the learner to review what they have learned, whether they have achieved their goal, and what they attribute their success or failure to. This includes two sub-categories: *self-judgement* and *self-reactions* (see Figure 9). **Self-judgement.** Beginning with self-judgement, this involves processes of both self-evaluation and attributions.
**Self-evaluation.** Firstly, *self-evaluation* is the process by which the learner compares their skill acquisition to that of their goal or the model. Zimmerman (2000) states that there are four criteria on which a learner can base their self-evaluation. The first is skill mastery; as a novice, it is important that the mastery of a skill is based on a hierarchy of process goals so that the learner can make small incremental improvements to their technique. This allows the learner to self-observe the improvement, thus increasing their self-efficacy and motivation to attain the next process goal. The second criteria is comparing the learner’s performance to their previous performance at the skill, to consequently appreciate the improvement in their performance. The third criteria is social comparison with others performances; this type of self-evaluation could be detrimental to learning if the learner assesses that they are not performing at par with their peers. This often results when the focus of the exercise is on outcomes goals rather than process or learning goals. The final criteria is collaborative evaluation, which occurs.
when a learner is working within a team or group. Their self-evaluation during these events is dependent on their success at performing a role within the team (Zimmerman, 2000). The latter may not specifically relate to learning a psychomotor skill, but as these skills coalesce into team-based clinical skills such as performing surgery, veterinary students may use this self-evaluation to judge their success at performing a skill.

**Attributions.** The second component to self-judgement is *attributions*, or how a learner attributes the cause of their success or failure to reach their goal – which is important to their self-efficacy and how they perceive moving forward (or not) with their learning (Zimmerman, 2000). If a learner attributes failure to themselves, for instance, they could blame the learning failure on their ability, their effort, or their choice of learning strategies. Learners that believe that they have poor ability to learn or perform a skill feel that improvement is beyond their control; this can, in turn, result in low self-efficacy (Zimmerman, 2000). Learners that chose outcome goals rather than process goals tend to make attributions to poor ability (Zimmerman & Kitsantas, 1997). If a learner believes that their poor performance is due to decreased effort or inadequate learning strategies, however, they have the volition to change these factors. They could increase their effort and/or seek or choose different learning strategies. As Zimmerman and Kitsantas (1997) note, “It appears that learners who make attributions to SRL strategies improve their belief in their potential to learn and their intrinsic interest in mastering the task” (p. 35). Learners that make causal attributions to poor learning strategies can maintain high levels of motivation and efficacy until they have exhausted all their available learning strategies (Zimmerman, 2000).
Self-reactions. As the second component of the afterthought phase, *self-reactions* are developed by the learner in response to their level of self-satisfaction and how they adapt their goal hierarchy. A learner’s *self-reaction* refers to their satisfaction or dissatisfaction with their learning by determining how closely it aligns with the learning goals they set for themselves (Zimmerman, 2000). If there is self-satisfaction based on reaching their goals, then this is what increases self-efficacy and motivation for the next task (Pintrich, 2000; Zimmerman, 2000). From their self-satisfaction or dissatisfaction, the learner can make adaptive inferences such as altering their goals, seeking a different strategy to try to achieve their goals, increasing their effort, or abandoning their goals (Zimmerman, 2000). When the learner creates new goals for themselves, it starts the cycle of self-regulation again.

In sum, this section of the literature review has provided an overview of the three phase SRL model adapted from Zimmerman (2000) that will be used in the design of the intervention for enhancing veterinary students’ psychomotor skills in this study. In the next section, the prevailing deliberate practice model used to acquire psychomotor skills in clinical practice is reviewed.

**Deliberate Practice**

*Deliberate practice* is K. A. Ericsson’s (2015) theory of acquiring and maintaining medical expertise by identifying and understanding what makes a performance superior in an authentic context and then practicing those skills to improve performance. Schematically, it is a triad of three representations (see Figure 1). To improve performance, a very defined task or goal is identified; this becomes the learner’s first representation. Then, the task is executed; the actual performance becomes the second
representation. Lastly, the third representation is how this performance is monitored by the instructor, who offers immediate feedback for further reiterations of practice. Eventually, the monitoring and analysis of performance is taken over by the learner as they develop the cognitive processes necessary to monitor their own performance. By recognizing mismatches between the first and second representations using both recognition of patterns during a performance and situational awareness (*focus*), the learner develops the cognitive processes of planning, monitoring, and evaluation in a cyclical fashion to improve their performance to expert level (Ericsson, 2004, 2015). Using DP for a minimum of four hours a day, a learner can reach expert levels in ten years (Ericsson, 2004, 2015; Kirkman, 2013). This theory represents a very long-term commitment to developing expert performance with instructor or mentor feedback.

There are challenges applying this theory to surgical expertise, however, as there is no defined or measureable expert performance outcomes, and surgery is a complex task with many variables such as context, patient co-morbidities, and surgical team members (Kirkman, 2013). The challenge to using this model for novices is that achieving expert levels of performance requires DP to be used over an extended number of years (Baker & Young, 2014) rather than the four years that comprise most veterinary curriculum. Yet, DP theory is repeatedly recommended in the veterinary and human medical education literature as the means to structure psychomotor skill learning for novices in medical and veterinary schools (Baillie, Dilly, & Crowther, 2015; Duvivier et al., 2011; Gifford & Fall, 2014; Kirkman, 2013; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011).

When evaluating DP theory, what stands out is its parallels to metacognition – specifically, metacognitive knowledge and regulation. For instance, Ericsson’s (2015)
cognitive processes mimic metacognitive regulation strategies pertaining to planning, monitoring, and evaluating a performance. Mismatches between the representations are determined by pattern recognition, which can be represented by metacognitive knowledge. In the early stages of training, novices need the support of instructors to help them discern where these mismatches are occurring. When viewed from the perspective of metacognition and learning using metacognitive skills, then, DP becomes applicable to teaching novice learners in a skills acquisition lab when there is an instructor present to provide effective and timely feedback to improve performance. However, it does not account for learners who have to practice without the aid of expert feedback in a self-directed learning environment, such as a clinical skills lab.

**Learning a Psychomotor Skill**

Modeling or demonstration of a skill by an expert is one of the most important steps in learning a skill, as, “Modeling provides the learner with an image of the skill to guide further learning” (Zimmerman & Kitsantas, 1997, p. 29). *Modeling* refers to cognitive, affective, and behavioral changes the learner experiences when they are observing a real or symbolic individual(s) perform a skill or action (Schunk, 2001). According to Ferrari (1996), it is not the modeling itself, but rather, the learner’s perception of the model, that affects how they learn the skill. The learner does this by changing the sounds and images into symbolic code that define the structure and function of the skill. The learner then remembers the skill demonstration as a symbolic code which develops into a cognitive representation of the skill. When a learner performs a skill, they are changing these cognitive representations into action as they try to match the process. It is their perception of the model that becomes their goal (Ferrari, 1996).
Zimmerman and Kitsantas (1997) and Zimmerman (2000) theorize a four-level development of complex psychomotor skill acquisition. Like Ferrari’s (1996) theory, it starts with psychomotor skill observation, then emulation of the skill by the learner which, in time, develops into self-control and, finally, self-regulation. In the observation stage, learning is a social function: learning is initiated by watching and listening to other people as they demonstrate skills (Schunk, 2001). This could be in the form of a live demonstration, digitally with or without auditory input. Typically, the person that is performing the modeling possesses expertise in the subject matter being learned and demonstrates their ability. In fact, George and Doto (2001) state that skill demonstration should be silent so that the image of the skill forms a mental picture for the learner and what it looks like being performed correctly. After the first silent demonstration, the expert repeats the skill but verbalizes, in detail, each step of the technique. Then, the students describe each step of the skill. Using this technique could identify gaps or inaccuracies the learner has between their cognitive representation of the skill and the actual skill, thereby improving their cognitive representation, their task interpretation, and goal structure.

The next phase of psychomotor skill training is imitation, where the learner can attempt to physically perform the skill. Imitation of a psychomotor skill is the most innate way of acquiring a motor skill, such as walking, as at this level, learners are unaware of their own performance of the skill and how or why it is successful (Ferrari, 1996). Zimmerman (2000) uses the term emulation rather than imitation for this stage because imitation implies copying, and emulation implies imitation with the desire to equal or excel beyond the model. To be specific, “Seldom does a learner copy the exact actions of
the model, but rather he or she emulates the general pattern or style of functioning” (Zimmerman, 2000, p. 30); this reflects Ferrari’s (1996) idea of social representations of the skill being based on the learner’s interpretation of the skill that they experience being modeled. Supporting the learner’s emulation of the skill is feedback from the instructors during this stage of training. This would take place in a lab session or clinical skills lab with an instructor present. For both George and Doto (2001) and Zimmerman (2000), feedback from instructors is a key component of the learner’s skill development. This challenge of emulating the skill, with instruction on technique, becomes the first step in, “learning the internal process standards of correct performance” (Zimmerman & Kitsantas, 1997, p. 29).

Using these internal process standards, the learner converts their cognitive representations into conceptual knowledge of the skill. This is the third phase of psychomotor skill development, where the learner is aware of the motor activity and how to change it to accurately perform the skill (Ferrari, 1996). Here, learners need to be aware of how they are technically performing the skill by self-monitoring and detecting mismatches between their mental representation and their performance – which is an important regulatory step in improving skill acquisition in this stage (Zimmerman, 2013). This is Ericsson’s theory of DP and, in fact, Zimmerman (2000) calls this third stage DP in his models of skill acquisition.

Self-regulation is the final phase of skill development that allows the learner the flexibility to make adaptations to their skill technique to account for changes in personal and contextual conditions by varying and adjusting strategies based on outcomes (Zimmerman, 2000). This is where the learner’s cognitive effort shifts from the processes
of monitoring the skill execution to performance outcomes. If the performance outcome is not ideal, as determined by the learner, then they can initiate the cycle of self-regulation to improve their performance. This ability to change their technique to accommodate the context requires a deeper understanding of the skill technique and processes that SRL can inspire. Thus, in sum self-regulation allows learners to adapt their skills to changing contexts and environments.

**Why We Should Promote Self-Regulated Learning in Psychomotor Skill Training**

Promoting self-regulation in psychomotor skill training would benefit the learner in many ways. It can provide a pedagogical framework to guide learning psychomotor skills when switching from didactic learning to skills training. Since this switch requires a change in context and task knowledge, many learners may have difficulty transferring their pre-existing self-regulation skills to psychomotor skill training. Self-regulation theory also provides a framework to understand the difference between a novice’s approach versus an expert’s approach to skill development; a novice a) tends to choose performance goals rather than hierarchal process goals, b) has limited strategy knowledge and choice, c) has limited self-monitoring skills, d) makes ineffective attributions and e) has limited reflective capacity (Zimmerman, 2000). Understanding these limitations and concepts, however, they can understand themselves as novice learners in new contexts.

Self-regulation is strongly associated with increased self-efficacy, motivation, and high academic achievement (Pintrich, 2000). Increasing a learner’s sense of self-efficacy can be very powerful in terms of self-satisfaction and motivation to persist on working to obtain skill mastery. Self-efficacy and motivation also work reciprocally to increase self-
regulation efforts (Pintrich, 2000; Zimmerman, 2000). This would translate into high academic achievement and competency, which is the goal of the veterinary profession.

Metacognition and reflection are integral processes of SRL; as Silver (2013) notes, “Content and procedural knowledge alone are insufficient for persistent and self-directed growth in a learner’s or practitioner’s understanding and expertise” (p. 1). Metacognitive and reflective practice are vital elements of learning and professional practice (Silver, 2013), and integrating self-regulation into psychomotor skill teaching and development that instills metacognitive and reflective practices is vital to deeper learning (Nilson, 2013; Silver, 2013). SRL also supports an understanding of the themes and principles of a psychomotor skill, and, “not just a list of facts or the surface appearance” (Ferrari, 1996, p. 226). This level of deeper learning aligns with Bloom’s Taxonomy (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956) of cognitive domain learning objectives – analysis and evaluation – which are the basis of clinical reasoning. In the psychomotor domain, self-regulation supports the analysis and evaluation of a medical or surgical situation and the adaptation of techniques to align with the changes and challenges of clinical medicine and surgery.

**Promoting Self-Regulated Learning in Psychomotor Skill Training**

There is limited data on veterinary medicine and SRL. In a study by Ertmer, Newby, and MacDougall (1996), for instance, the focus was on case-based instruction in veterinary education rather than psychomotor skill learning. There is, however, recognition of the importance of SRL in human medical education, and particularly in psychomotor skill training. What is, “important to medical educationalists is that specific training to develop self-regulation processes can improve complex psychomotor skilled
performance” (Cleary & Sandars, 2011, p. 875). Woods, Mylopoulos, and Brydges (2011) concur that although SRL is a learner-centered activity, medical educators could become more active in supporting their students’ development of self-regulation. Much of the work in SRL in medical psychomotor skill training involves student training in clinical skills labs where learners work on their own, practicing on simulators in directed or guided self-directed learning. In a study on guided outcomes, Patil et al. (2014) found that if provided with the general steps of SRL, the students using guided SRL surpassed the control group in achieving intended core competencies in the same time period.

Similarly, directed self-regulated learning (DSRL) refers to primarily self-learning on medical simulators with increasing levels of fidelity (Brydges, Dubrowski, & Regehr, 2010). In this study, the learners were encouraged to use various instructional resources – for instance, video demonstrations and written directions – to support their own skill learning on one level of a simulation and when they felt that they had mastered the technique on the simulator, they were able to move to the next level of simulation. When compared to the control group taught by an instructor in a traditional psychomotor skill lab setting, the DSRL group could learn as quickly; however, their skill retention was better after 3 months when retested on the task. Similarly, in a study by Brydges, Carnahan, Safir, and Dubrowski, (2009) learners that self-guided their learning instruction and focused on process goals developed more stable and transferable skills, concluding that instructing learners on using process goals to self-regulate their learning provides a benefit to their acquisition and retention of the psychomotor skill. From the human medical education literature, then, self-regulation is a recognized schema of learner-centered pedagogy which supports improved psychomotor skill training.
From the literature in athletic development, research by Cleary, Zimmerman, and Keating (2006) reveals that training college students in the three phases of self-regulation and self-recording their process goals, strategies, and reflections made a significant impact on their ability to shoot basketball free-throws over students that were not taught the phases of self-regulation and self-recording. The authors concluded that in the early training of novices, explaining the forethought and performance control phase were the most effective phases for improved performance. However, “training in all three phases resulted in the improving motivation for sustained practice” (Cleary, Zimmerman, & Keating, 2006, p. 261). Two important aspects of this study stand out in relation to the current project. Firstly, the students were instructed in the phases of self-regulation, and secondly, they had to self-record in each phase. These factors were attributed to their improved performance over the groups that only practiced the basketball free-throws.

Would this strategy of instruction on the phases of SRL be effective in veterinary psychomotor skill training? Since crossing contexts can disrupt a learner’s self-regulatory processes, would explicitly teaching them about self-regulation and how to use it to their advantage to learn psychomotor skills be an effective way of improving their learning of the skills, as well as improve their sense of efficacy, motivation, self-monitoring, and reflection?

The studies cited above all point to increased academic and psychomotor skill success if instruction or guidance in SRL is provided to the learner. A learner that is adept at SRL in one context does not, however, necessarily carry over these skills to a different context – for instance, academic learning to psychomotor skill learning – since SRL is reliant on the learner’s metacognitive skills, behaviors, and motivation crossing
over into the new learning environment (Cleary, Callan, & Zimmerman, 2012; Nilson, 2013; Shunk, 2001; Zimmerman, 1998). While DP provides the metacognitive skills that a learner needs to succeed in learning psychomotor skills, it does not account for the social cognitive aspects of learning, such as motivation and behavior adaptations to fully self-direct one’s own learning. Hence, the use of both SRL and DP is suggested for improving veterinary students’ psychomotor skills. My research question is to determine if the introduction of the phases, concepts, and application of SRL theory to second-year veterinary students will improve their self-directed mastery of suturing over a four-month period when this skill is transferred to a more sophisticated suture model.
CHAPTER THREE: METHODOLOGY AND PROCEDURE

This chapter will review the research design, methodology, and methods that form the basis of this research project. The purpose of this study was to determine if introducing self-regulated learning (SRL) to second-year veterinary students would improve their ability to self-direct their own psychomotor skills development of a suturing procedure. Drawing on the experimental design and future recommendations from research in sport, psychomotor skill performance in medicine, and veterinary education literature, the justification for this study’s design is discussed. Thereafter, a description of the quantitative, experimental research design implemented, the preliminary tests used to refine the instrument, and the research hypothesis are presented. Then, participant selection, ethical procedures, the instruments, the interventions for the test and control groups, and the data collection procedures are described in detail. Finally, the data analysis procedures used are described.

Research Methodology and Design

The research design implemented in this study stems from similar research and recommendations in the literature on self-regulated learning in sports and human medicine. A few of the pertinent studies influencing the study design will be highlighted.

Prior Studies

Zimmerman and associates (Cleary, Zimmerman, & Keating, 2006; Kitsantas & Zimmerman, 1998; Zimmerman & Kitsantas, 1996, 1997) used the experimental design of pre-test, self-regulated learning interventions (independent variable) and post-test to study the effect of SRL strategies on motoric skills (dependent variable). During these studies, the participants – who were pre-determined to be novices at the particular
motoric skill – were tested for their baseline ability, and then given instruction on skill technique. Immediately following this instruction, each test group was given additional SRL strategy instruction, but the control groups did not receive SRL strategy instruction. Then, each group was given the same amount of time to practice, during which time the participants’ scores of their motoric skill was measured (post-test). These experimental designs for SRL and motoric skill research demonstrate the significantly positive effect of SRL strategies on subsequent performance.

Next, a study on basketball free-throw practice (Cleary, Zimmerman, & Keating, 2006) tested three groups which were given instruction in one, two, or all three phases of SRL (forethought; forethought and performance control; forethought, performance control, and afterthought) as it related to the skill of free-throws. This research design was effective at demonstrating that participants with instruction in both the first and second phases of self regulation performed as effectively as participants that received instruction in all three phases, and significantly out-performed participants in the test group that received no instruction in SRL phases (Cleary, Zimmerman, & Keating, 2006).

Studies on SRL have also been conducted in the medical field. Using the suturing of a simulated wound as the dependent variable, Brydges et al. (2009) employed a pre-test, an intervention involving process goals versus outcome goals, and a post-test consisting of three parts: i) an immediate post-test; ii) a one-week retention post-test; and iii) a transference post-test, where the suturing was performed inside of a simulated abdomen. The pre- and post-tests were video-taped and evaluated by an expert (a surgeon), and rated using an instrument with a 5-point global rating score and a 14-point checklist of skill specific procedures. Assessment of skills by an expert is considered the
gold standard of assessment, although hand-motion detection was also used to assess the participants’ performance. As in the sport-related research, participants using process goals were found to out-perform participants using outcome goals (Brydges, Carnahan, Safir, & Dubrowski, 2009). The added benefit of this latter study is that it considered the transferability of the suturing skill to a contextually higher level of difficulty: suturing deep in a simulated abdomen. This study’s findings support the theory that using self-regulation strategies to learn a skill will allow the learner to adapt that skill in a dynamically changing environment (Zimmerman & Kitsantas, 1997). To be able to perform a skill to high standards is the third stage of Zimmerman’s (2013) social cognitive theory of self-regulation, and similar to the theory of DP. To transfer that skill to a more challenging and contextual scenario is the highest level of SRL; therefore, testing transferability implies that learners are able to adapt their skill to a more challenging context and are more effective at self-regulation.

In a study by Cleary and Sandars (2011), third-year undergraduate medical students who were deemed novices at venipuncture were asked to perform a venipuncture on a manikin simulator, and answer questions related to the different stages of self-regulation – for instance, self-efficacy for the skill, strategic planning, performance control (metacognitive monitoring), satisfaction, and self-evaluative standards. The participants were allowed to make as many attempts as needed. The findings of the study indicate that the SRL cycle was applicable to medicine and was consistent with the SRL studies in other motoric skill domains. The medical students that focused on process goals and strategies, self-monitored their performance, and self-evaluated their
performance techniques out-performed those students who focused on performance outcomes only (Cleary & Sandars, 2011).

The design of the studies reviewed above share many similarities. Firstly, they each employed a pre-test, intervention, post-test design. Secondly, the participants were chosen because they were novices at the motoric or psychomotor skill. Third, the test group interventions focused on introducing the concepts of the three phases of SRL and how they related to the development and mastery of the psychomotor skill (Cleary, Zimmerman, & Keating, 2006). Most of these studies were not longitudinal; they were conducted within one encounter with the participants. However, Brydges et al. (2009) studied the development of suturing skills in medical students, where the intervention involved process goals (test group) versus outcome goals (control); here, part of the post-test was delayed and involved skill transference to a more sophisticated model. Conclusively, these studies cumulatively influenced the research design I employed in the current project.

The Design of the Study

The research design I chose for this study was a quantitative pre-test-post-test control-group experimental design (Creswell, 2014), similar to the design in the studies that were reviewed, as explained above. This choice of design was also supported by the veterinary literature in a study by Williamson et al. (2018), who recommended assessing the net improvement of an educational intervention using a pre- and post-test experimental design, rather than raw performance scores. This quantitative, longitudinal experimental study was used to determine if introducing the concept of SRL to second-year veterinary students would improve their suturing performance. By assessing the pre-
test and post-test performances using a quantifiable instrument that reflected the
procedural and technical skill of a suturing performance, a measurable response to the
intervention could be determined. The dependent variable was the participants’ suturing
performance scores, which measured their ability to perform a suturing exercise that
required the appropriate suture pattern to close an incision in two silicone models,
representing the subcutaneous layer of the abdominal wall of an animal (dog or cat). The
independent variable was a 45-minute instructional intervention discussing the structure
and merits of two types of learning schemas. The test group intervention focused on SRL
and DP; the intervention for the control group focused on DP alone. During the
intervention, students were able to apply these theories while practicing physical exams,
IV catheterization, and intramuscular injections on veterinary simulators.

The research design in this study differs from the design used in the reviewed
studies above by separating the intervention from the post-test by 16-18 weeks.
Zimmerman and Kitsantas (1996, p.73) suggested that long-term skill development
studies were needed to further understand how the self-regulated processes change as
skills develop. Therefore, the intent of doing the post-test after a longer time was to give
the participants more opportunities to apply their intervention training to the many
clinical skills that they would be encountering in their veterinary skills training labs such
as physical exam, IV catheterization and suturing.

During the interventions, each group was given a handout summarizing the
particular educational theory that they were being presented, rather than a cue card to
explain the steps of the procedure; they could keep this handout to use as a reference
during their psychomotor skill development. To provide a platform for self-recording,
both groups were given an electronic activity log to self-record three psychomotor activities during their 16- to 18-week psychomotor skill training. The test group was instructed to use the activity log headings as a guide to record the three phases of SRL that they were consciously applying to their personal skill development. The control group was instructed to use the activity log headings to apply their knowledge of DP when filling out the form during their personal skill development.

The research question guiding this study was: How does instruction in the concept and phases of self-regulated learning to second-year veterinary students influence their mastery of a suturing exercise when this skill is transferred to a more sophisticated suture model after a four-month period?

The research hypotheses were:

1. Second-year veterinary students that are instructed in SRL and DP, when learning veterinary psychomotor skills will obtain a higher performance suturing score and more improvement for the sub-component skills when transferring these skills to a new simulator than the veterinary students that are only instructed to learn veterinary psychomotor skills using DP.

2. Veterinary students instructed in SRL and DP will demonstrate greater levels of self-efficacy and satisfaction with their performance than the veterinary students instructed in DP.

Ethics, Participants, and Curricular Context

Approval for this research was granted from the Brock University Research Ethics Board (Appendix A) and the University of Guelph Ethics Board (Appendix B). This study involved 22 voluntary participants from the second-year class of veterinary
students at the Ontario Veterinary College (OVC), from September 2017 to March 2018. This population was targeted for this research due to their novice level of surgery training at OVC. During their first year of studies in OVC’s curriculum, the students only learn the surgical psychomotor skill of tying a square knot, using surgical instruments, and suture. The instruction for this skill occurs in one lecture, one lab, and is assessed during an Objective Structured Clinical Exam (OSCE). All the students in their second-year of studies at OVC participate in the Principles of Surgery course. This course includes in-class instruction and experiential labs focused on basic suturing techniques, surgery asepsis and preparation, bandaging and surgical procedures, and techniques using simulators. In third-year, students perform live surgeries, specifically, spays and castrations of dogs and cats. These courses provide the basis of the surgical experiential learning opportunities at OVC.

All the students in their second-year of studies at OVC were sent an email by the Research Assistant (RA) detailing the study and the requirements. Since this study would take two hours of their personal time, participation was strictly voluntary. It was made clear to the participants that no part of this research would contribute to their marks at OVC. Approximately ten days after the email was sent out, the RA attended the last ten minutes of a Principles of Surgery course lecture (VETM 3510), which was attended by the entire class of students in the target population. The RA introduced herself to the class and reviewed the study and the requirements. Then, she handed out 40 consent forms (to the first 40 students that approached her, who were eager to participate in the study). The students filled out the forms and returned them to the RA. Once enrolled in the study, each participant was assigned a research ID number by the RA. Only the RA and
Principle Investigator (PI) had access to this list. All email communication for scheduling times of pre-test, intervention, and post-test were between the participant and the RA. The researcher was only aware of the participants’ identities during the interventions. Therefore, the data was blinded to the researcher.

During the research period, there was attrition of participants; this was anticipated for in the study design, since veterinary students have a very demanding course load and tend to be committed to many extra-curricular activities. By the end of the 30-day pre-test period, only 30 students had completed the pre-test. The remaining ten participants, citing personal reasons or lack of time to perform the pre-test (despite the RA’s best efforts to schedule them) withdrew from the research. All 40 participants received a $5.00 Tim Horton’s gift card to compensate for their time in this study, regardless if they completed the research or not. Three more participants were excused from the research when they failed to attend the intervention. Only 22 participants completed the post-test. Therefore, the data used in this study was based on the 22 participants that finished the post-test.

**Pre-test and post-test.** The pre- and post-test was a performance task which assessed the psychomotor skill of suturing a simple continuous pattern in silicone models which represented the subcutaneous layer of an abdominal wall. The same pre- and post-test was designed for many reasons; primarily, however, this psychomotor skill of suturing appears to provide the students with some challenge, as observed in simulation labs and in live animal surgeries – and therefore, it is not an easy skill to master. The researcher had enough expertise to evaluate this suture closure. Pre- and post-test performances could be video-taped and observed by the researcher at an alternate time to the actual suturing performance.
Each pre- and post-test began and ended with the RA asking survey questions (Appendix C and D). The questions pertained to different phases of the SRL cycle and its specific relationship with the context of the suturing exercise. The survey consisted of Likert-type interval scales and open-ended questions. Three questions were asked before the suture exercise, and six questions were asked after the exercise.

During the pre-test, the participants were asked to perform a simple continuous suture pattern with buried knots in a single layer of silicone, which represented the subcutaneous layer of an abdominal wall (Appendix E). This performance was carried out individually in a designated room and video-recorded by the RA (Appendix F).

The post-test was designed to use the same simple continuous suture pattern with buried knots, but applied to a more sophisticated silicone model rendition of all the layers of the abdominal wall, including the linea alba, the subcutaneous, and the skin (Appendix G). The latter practice is in keeping with the theory of SRL where the, “learner has to adapt their cognitive motor skills in a changing environment” (Zimmerman & Kitsantas, 1997, p. 30). Therefore, to test self-regulation over DP, the context of the suturing had to change and, in this case, was more realistically represented by the three layers of the abdominal wall. The survey questions regarding self-efficacy and self-regulation strategies were asked before and after the suturing exercise (Appendix D).

**Closure of the subcutaneous layer of an abdominal wall.** Suturing performance (dependent variable) on a simple continuous subcutaneous pattern was chosen for this research because it is one of the skills students need to perform in live animals during spay surgeries in third-year, and in any abdominal surgery in veterinary practice. Skillful
and time-efficient closure of the abdominal wall following abdominal surgery is necessary to maintain the integrity of the abdominal wall, prevent infection and/or herniation of the abdominal contents, and minimize surgery and anesthesia time. The abdominal wall consists of three layers: the muscle wall, the subcutaneous layer, and the skin. Technically-correct suturing of the subcutaneous layer (the middle layer of an abdominal wall) prevents the accumulation of fluid and aligns the skin edges, preventing tension on the subsequent skin sutures. The researcher had enough expertise to assess this suturing pattern on the models that represented the subcutaneous layer of the abdominal wall. The correct technique to close the subcutaneous is described by Knecht, Allen, Williams, and Johnson (1981), as follows:

The first knot is buried with simple continuous and running sutures. The first pass is begun deep in the tissues and is directed to the deep tissues on the opposite side. The end of the suture should be held toward the open portion of the incision line rather than toward the starting point of the sutures. The needle is passed toward the short end, and a knot is tied deep in the tissues. The same pattern is applied at the opposite end of the incision. Before the last suture is placed, the needle is inserted from superficial to deep in the tissues, and a loop of suture is lifted from the incision line. The needle is then introduced from deep in the tissues to superficial on one side, allowed to cross the incision, and inserted from superficial to deep in the tissue toward the loop. The end of the suture is then tied to the deep end. (p. 56)

The knots on either end of this suture pattern can be challenging to learn, and often confuse students during early practice. Veterinary students need to have proficiency in
this technique prior to performing abdominal surgery in live patients in their third-year of their training.

**Suturing instruction.** The timing of this research experiment was coordinated with the timing of the in-class instruction of this suture pattern. This skill was introduced in lecture, online video, and in psychomotor skill labs during the early fall in the year 2017 in the Principles of Surgery course. Prior to the pre-test, the participants had classroom instruction on this suture technique and had access to videos already posted online by the course coordinator for reference; however, their ability to practice this skill in a lab, with expert feedback, was limited by the timing of the pre-test (October). No extra classroom instruction of suturing was delivered by the researcher. After the SRL intervention, all participants had two simulation labs that involved suturing the subcutaneous layer of a DASIE® (Dog Abdominal for Surgical Instructional Exercises), giving them the opportunity to practice this suture technique and ask for help or feedback from a number of different instructors. They also had their own DASIE® that they could have practiced with on their own time.

**Silicone models.** Silicone models were used for this research. The silicone is durable, it stores at room temperature, and it was easy to visualize the suturing in the videos. Alternative models do exist. The DASIE® is currently the standard of practice for second-year suturing labs; however, the middle subcutaneous layer can tear with suturing and is not available separately to practice as a single layer. A cadaveric model was also considered, as they would present a more realistic experience for the learner; however, a new cadaver would be required for each participant, accurate visualization of the suturing could be challenging, and the cadaveric tissue would have to be saved and evaluated for
triangulation of the data (Williamson et al., 2018). Acquiring, storing, and evaluating the cadavers in a timely fashion would have been limiting factors for this research. Simulated silicone abdominal wall layers are commercially available. However, they tend to have a subcutaneous layer that does not support suturing; moreover, they are expensive, and they do not have an associated stand-alone subcutaneous layer available. The silicone abdominal wall model used for this study is made in-house and has been used for advanced suturing labs for third-year OVC students. Since the layers for this model are poured out of silicone separately, the subcutaneous layer can be produced as a stand-alone model for the pre-test and the three-layered abdominal wall model could be produced for the post-test.

**Videotaping the suturing.** Using a GoPro camera to video capture the suturing performance is an accepted form of image capture in veterinary medicine, as the incremental changes (improvement) in the skills of novices are easier for distinguishing between correct and incorrect technique (Williamson et al., 2018). Research in human medicine has validated videotaping as a means for assessing a procedure and technical performance (Stranc, McDiarmid, & Stranc, 1991). The video capture eliminated the need to have the researcher in the room to evaluate the participant performance, and since there were no identifying features of the participant in the video, the identity of the participants remained blinded to the researcher, thus preventing bias. When viewing the videos for assessment purposes, it is possible to start, stop, and review the video to affirm the quality of the performance. One disadvantage is that the camera position is fixed and provides only one perspective; however, this exercise was simple enough to capture the hand movement of the participant and suture path. It did not capture any vertical
malalignment (eversion) of the sutured incision edges; therefore, having the actual piece of sutured silicone for each participant was a way of evaluating the completed exercise and confirming what was observed or not obvious on the video.

**The instruments.** Two instruments were used in this research study. The first instrument (Appendix H) was a checklist to assess both the pre- and post-test video-taped suturing performances and was developed from instruments used to assess veterinary and human surgical skills. There are various types of assessment instruments in the veterinary and medical education fields. The two types of instruments, with data, that contributed to this research instrument were the binary checklist (Read, Bell, Rhind, & Hecker, 2015), and the Operative Component Rating Score (OCRS), which is task-specific but uses a rubric to score the procedure on a numeric scale (Dath et al., 2004; Williamson et al., 2018). Using a checklist to assess each step of the actual procedural or technical skill provides a better assessment of that skill than assessing the performance outcome alone (Hamstra & Dubrowski, 2005). A checklist instrument allows the procedure to be broken down into individual steps that can be assessed as a binary function – for instance, *yes* or *no* answers to qualifiers such as, ‘uses the correct suture path; superficial to deep and then deep to superficial.’

The operative component rating score (OCRS) also breaks down the procedure into segments, but not as detailed in the steps as a checklist -- for instance, it will simply qualify, ‘simple continuous suture line’ – but it also uses a rubric-like, numerical range grading system rather than the *yes* or *no* binary system of a checklist. For this research instrument, using a range of scoring rather than a yes-no assessment allowed for the observation and recognition of errors and corrections to be built into the assessment.
The descriptive scale for the research rubric were: 0 = unsuccessful; 1 = unsuccessful correction; 2 = successful correction; and 3 = successful on the first try. By combining the two types of assessment instruments, this research instrument allowed for the detailed assessment using a checklist and the range in performance using a rubric to mark, thereby accounting for perfect procedural and technical skill as well as students’ recognition of errors and attempts to correct them (thus reflecting the metacognitive skills of SRL).

The second instrument was a SRL microanalysis instrument that combined open-ended questions and Likert-type interval scores reflecting the different elements of each stage of the SRL cycle. The questionnaire (Appendix C and Appendix D) assessed the students’ self-regulation immediately before and after they performed the suturing exercise. The questionnaires were developed using the principles of self-regulated learning microanalysis (SRLMA), which investigates the dynamic processes of self-regulation a learner can utilize during a specific, contextualized learning task (Cleary, Callan, & Zimmerman, 2012). Various other evaluation methods have been utilized to capture aspects of a learner’s self-regulation. Two examples are the Motivated Strategies and Learning Questionnaire (MSLQ) and the Learning and Study Strategies Inventory (LASSI); however; these assessment tools rely on the retrospective responses of students, are not context-specific, and rely on a composite score (Cleary, Callan, & Zimmerman, 2012). In contrast, SRLMA is, “a highly specific or fine-grained form of measurement that targets behaviors and processes as they occur in real time across authentic contexts” (Cleary, 2011, p. 330). The SRLMA combines features of self-reports and structured interview questions, where the questions are administered to the learner during a genuine
learning task to determine whether they are, in fact, using self-regulation to structure their learning (Cleary, 2011; Cleary et al., 2012; Cleary & Sandars, 2011). This feature allowed the questionnaire questions to relate specifically to the suturing exercise and be delivered to the students at the time of the suturing exercise.

SRLMA is structured to follow the three phases of Zimmerman’s model of self-regulation: forethought, performance, and self-reflection. Although not all phases have to be included within the microanalysis, incorporating all three phases into the microanalysis gives a more detailed understanding of the learner’s grasp and use of self-regulation during an authentic learning task (Cleary, Callan, & Zimmerman, 2012). The questions can be focused in specific phases and sub-processes, but it is important to examine the learner’s cognition in all three phases of the cycle to determine where they excel and where they falter in their self-regulation (Clearly, 2011). The questioning can be divided further to include the sub-process of each phase, such as goal-setting in forethought or self-judgement in the self-reflection phase.

SRLMA questions are situated around a defined task with a specific beginning and ending, are administered while the learner is actively partaking in the defined task, and are delivered to them during each phase, or right after the phase as is the case with performance (where an interruption would disrupt the performance of self-regulation) (Cleary, Callan, & Zimmerman, 2012). Cleary (2011) states these questions are, “structured assessment probes that are designed to evaluate an array of cyclical phase processes of self-regulation at strategic moments during a specific activity” (p. 331) and are not dependent on the participant’s memory. Asking microanalytic questions during the learning activity minimizes errors and biases that can occur in retrospective studies.
and captures the participants’, “cognitions, behaviors and affective processes in the moment” (Cleary et al., 2012, p. 4).

In this study, I chose to evaluate the students’ SRL in each of the three phases. Within the forethought phase, the questions pertained to self-efficacy, goal orientation, and task analysis. The first three questions were asked immediately prior to the suturing exercise and questions 4-9 were asked after the suturing exercise:

- **Question 1 – Self-Efficacy:** Do you believe you are capable of learning the three parts of this suturing exercise today: the first buried knot, the simple continuous line, and the final buried knot? This question utilized a Likert-type interval scale of 0 to 10, where 0 = completely incapable and 10 = completely capable

- **Question 2 – Goal Orientation:** What is your learning objective in practicing this suturing exercise today?

- **Question 3 – Strategy Use:** What strategies do you use to learn suturing?

- **Question 4 – Use of Mastery vs. Performance Goals:** While you were suturing, can you tell me: What is your self-talk during this suture pattern; that is, what were you telling yourself? Did you identify any problems with any part of our technique, yes or no?
  - If yes: Did you adjust your technique to try and correct the problems(s), yes or no?
  - If yes, If you adjusted your technique, what did you do? Expand a little bit more. How did the adjustments help?
• **Questions 5 and 6 – Self-Satisfaction:** Using a scale of 0 to 10, where 10 is *completely satisfied* and 0 is *completely dissatisfied*, how satisfied are you with achieving your learning objective: practicing this suture pattern during today’s exercise? What criteria did you use to judge your degree of satisfaction?

• **Question 7 – Attribution:** Why do you think your subcutaneous closure turned out the way it did?

• **Question 8 – Self-Efficacy to Transfer to Skills to a Live Animal:** On a scale of 0 to 10, where 10 is *completely capable* and 0 is *completely incapable*, to what level do you believe you can perform an acceptable closure of the subcutaneous layer of a live animal?

• **Question 9 – Adaptive Inferences (Setting New Goals):** What are your next steps in learning this subcutaneous closure?
  
  o If *practice*, the RA was asked to prompt them to elaborate on this term: Since you said *practice*, please define what this means to you.

In sum, I chose this method of SRL evaluation because it follows Zimmerman’s (2000) three-phase model of SRL, and it targets each phase of the cycle as well as the sub-processes of SRL. By recognizing these sub-processes and developing questions for specific processes of interest, this analysis can capture a learner’s individual cognitions about his/her suturing, in real time, as he/she performs a sutured subcutaneous closure.

**The intervention.** The intervention was a 45-minute session for each group. Each of these sessions started with a PowerPoint (PP) presentation by the researcher. The focus of the presentation for the control group was on veterinary simulators and DP theory to
develop psychomotor skills (Appendix I). The test group, on the other hand, had a presentation on SRL phases and DP using veterinary simulators to develop their psychomotor skills (Appendix J). After the initial presentation, the participants had the opportunity to work with veterinary-based simulators (matched for both groups) to practice technical skills. After these activities, the researcher engaged the participants in further discussion regarding how they could employ their particular learning theories presented in the PP to improve their learning with simulators.

At the beginning of each intervention, each group member was provided with a handout/cue card (Appendix K and L) to summarize the importance of simulators in learning and their particular learning theories. They could keep these handouts and refer to them during their personal skills development. At the end of the interventions, each participant was emailed an activity log (Appendix M) to a) track three different psychomotor skills that they encountered in their subsequent veterinary training prior to the post-test, and b) to record the time they spent doing that skill development.

**Pilot studies.** Various parts of this study were developed over time with students from first-, third-, and fourth-year as part of their curriculum; the participants in this study specifically were from the second-year cohort. This was the target population for the research because second-year students were just introduced to this suture pattern at the beginning of their academic year, and had not yet performed live surgery in veterinary school.

The instrument was modeled from a rubric assessment of a simple interrupted knot tying used to assess first-year students during an OSCE. This rubric was used to assess 240 students in two years of testing. It assessed instrument handling, knot
placement, and knot integrity. Since it only made use of a global rating score, however, it did not adequately capture the distinct actions involved in creating a suture, tying a knot, or the specific instrument handling techniques, nor did it account for how many errors a student made or if they corrected such errors. For this research, improvements were made to this assessment tool by making it into a checklist (Appendix H) that included all the salient features and technical skills needed to create the specific knots, the continuous suture line, and instrument handling.

The pre-test silicone models were developed at OVC for use in a third-year formative OSCE to test suturing and knot tying ability (the single layer of silicone) prior to live surgery. This involved 120 students. From this trial, it was determined that constant observation of the suturing was necessary to capture the nuances of the suture technique, and that evaluation of the sutured silicone alone was not enough to evaluate a student’s suturing ability. Video capture of the student suturing would also be necessary to appreciate all the detail involved in their technique and ability. The post-test silicone three-layer abdominal wall model has been used for two years in advanced suturing labs for third-year students (240 students in total); with this, students appreciate the realistic look and malleability of the silicone while they practice their suturing.

The interventions were developed from instructing fourth-year students (110 students over three years) in DP and SRL during a surgery elective in their final year of veterinary school. This fourth-year surgery elective was modeled after the students’ third-year spay and neuter surgery labs, providing an opportunity for the students to master familiar surgical procedures from their previous studies. Working in small groups with the researcher, the students would begin their week working through the first phase of
SRL, reviewing their goals and strategies for improvement for the elective. During the three days of surgery, they had the opportunity to self-monitor and self-control their learning efforts. After the last day of surgery, the researcher and students reflected on their ability to reach their goals or re-evaluate their goals for future learning. The researcher found that introducing an activity log, where students spent time writing down their goals and strategies, their self-observations, and their reflections, invested more students in working through the SRL cycles as they performed and mastered techniques through the week of surgery.

The survey questions and Likert-type interval scale questions were developed from the summary of work in Cleary, Callan, and Zimmerman (2012). The questions were altered to reflect the context of suturing the subcutaneous layer. These questions were reviewed by Tammy Rowe, a Learning Strategist at Wilford Laurier University, and minor modifications were then made to align with the sub-processes of Zimmerman’s (2000) SRL cycle (personal communication, August, 2017).

**Research Procedure**

This study took approximately two hours of the participants’ time, divided into three separate events; this time was outside of curricular classroom and lab hours. It involved a pre-test (30 minutes), an intervention (45 minutes), keeping an activity log (15 minutes), and a post-test (30 minutes). None of the suturing exercises or the data collected contributed to the students’ grades at OVC.

**Pre-test.** The participants were asked to participate individually in a 30-minute interview and suturing exercise. These sessions were coordinated between the participant and RA, and were facilitated and led by the RA. The participant was asked to sign up for
a time slot and attend the session. The RA offered multiple session times and an effort was made to accommodate the veterinary curriculum schedule, respecting the timing of exams and tests and not scheduling sessions during class time, for instance. These sessions were performed in a room set up for this study (Appendix F); it provided privacy and seclusion away from other labs and activities, yet it was easily accessible to the participants. The RA was stationed outside the room during the times the participant was working alone on the suturing exercise and ran each session according to the research protocol. During each session, the RA asked the participant to verbally answer a set of interview questions before and after carrying out the suturing exercise. The participant was made aware that the GoPro camera was recording their verbal answers and videoing the suturing exercise, as stated in the invitations to join the study and the consent form.

Each half-hour session began with the RA explaining the suturing exercise. The exercise was to suture an incision made in a silicone subcutaneous tissue model (Appendix E), wearing opaque exam gloves, using the suture material (Monocryl 2-0) and the surgical instruments provided (needle drivers, forceps, and sharp-blunt suture scissors). The RA explained that the participant should attempt to close the incision with a simple continuous suture pattern, consisting of a buried knot, simple continuous throws, and ending with a buried knot. The RA made it explicit that this exercise was about practicing the knots and the suture line. The participants were informed that they could correct mistakes if they wished, that there was no penalty for not completing the intended suture pattern, and that this suture exercise and the verbal answers would not contribute to any course grades. The participant was instructed to write their individual research study ID number on the silicone with the Sharpie pen provided (for anonymous
identification of the silicon and suturing exercise). After explaining the suturing exercise, the RA asked the participant the first three questions from the Pretest questionnaire (Appendix C). The participant was asked to answer aloud, and these answers were recorded by the GoPro audio. The participant was given the option of not answering any of the questions if they did not wish to answer.

Once the participant had finished verbalizing their answers, the RA informed the participant that they would leave the room and return 7 minutes before the end of the session to ask the remainder of the questions. Once the RA had left the room, the participant proceeded with the suturing exercise, which was being video-recorded by the GoPro. The GoPro camera was positioned to only capture the image of the participant’s gloved hands and the suturing of the silicone model. The identity of the participant was not apparent on video-tape.

Seven minutes before the half-hour session was completed, the RA knocked on the door and re-entered the room. The RA asked the participant to stop the suturing exercise, and then proceeded to ask the last six questions from the pretest questionnaire (Appendix C). The participants were given the option of not answering any of the questions if they did not wish to answer. The GoPro audio recorded the participant’s verbal answers. Once the participant had finished answering the questions, they were excused from the session. The RA collected the labelled sutured silicone model and keep it in a sealed manila envelope for later analysis by the researcher.

**The intervention.** The intervention occurred 30 days after signing the consent forms. At this time, only 30 of the original 40 participants had completed the pre-test. This cut-off date was determined by the beginning of the curricular labs where the suture
pattern would be performed in the lab, which would create an unfair advantage for the participants performing the pre-test after the lab. The remaining 30 participants were randomly divided into two groups of 15 students, creating a test group and a control group. Each group attended a 45-minute presentation after school hours.

The control group attended a 45-minute presentation regarding DP and simulation in veterinary medical training. The presentation involved a take-away summary sheet (Appendix I) on the discussion topics, a PP presentation (Appendix J), participants’ trialing of different simulators, and a group discussion about applying DP principles when using simulators. The PP presentation a) presented the concept of DP; b) reviewed the importance of simulators from an ethics and competency perspective; and c) showed images of different simulators that are available and being developed. Then, the participants were invited to come to the front of the room to work with simulators for IV catheterization, intramuscular injection models, and a Rescue Critter® for physical exam. After using the simulators, the researcher and participants discussed how these simulators could support their DP and skill development and were encouraged to discuss simulators that they thought would help with their veterinary education. Each participant was asked to keep an activity log (Appendix M) of their DP practice of three activities over the next 20 weeks of their clinical skills labs. The log was sent to them digitally by the RA. They were advised that they were welcome to discuss the concept of DP and simulators amongst the people in their control group, but not with anyone outside of their group. Then, they were invited to leave the intervention.

For the test group, there was a 45-minute presentation on self-regulation, DP, and simulation in veterinary medical training. The presentation involved a take-away handout
summarizing the PP presentation (Appendix L), a PP presentation (Appendix J), students’ trialing of the veterinary simulators, and group discussion about applying the SRL cycle and DP principles when using simulators. This PP presentation a) reviewed the stages of self-regulation, including the forethought phase, practice/learning phase, and afterthought phase; b) explained that novices learn differently than experts, and how SRL can support novices learning like experts; c) introduced the concept of DP; e) reviewed the importance of simulators from an ethical and competency perspective; and f) showed images of different simulators that are available and being developed. Then, the participants were invited to come to the front of the room to work with simulators for IV catheterization, intramuscular injection models, and a Rescue Critter® for physical exam. After using the simulators, the researcher and participants discussed how these simulators could support their SRL, DP, and skill development. Each participant was asked to keep an activity log (Appendix M) where they recorded their use of the SRL cycle and their goals, strategies to learn, and reflections over the next 16 weeks of their clinical skills labs. The log was sent to them digitally by the RA. They were advised that they were welcome to discuss the concept of SRL, DP, and simulators amongst the people in their test group, but not with anyone outside of their group. Then, they were invited to leave the intervention.

**Post-test.** The post-test occurred approximately 16 weeks after the intervention and took the same format as the pre-test. The participants were asked to participate individually in a 30-minute interview and suturing exercise. These sessions were coordinated and run by an RA after each participant finished their last Principles of Surgery (VETM 3510) simulated spay lab. The participants signed up for a time slot and
attended the session they registered for; multiple sessions were made available by the RA and did not occur during class time, while also respecting the participants’ exam-burdened schedule. These sessions were performed in the same room as the pre-test.

During their session, each participant was asked to verbally answer a set of interview questions before and after carrying out the suturing exercise. The participant was made aware that the GoPro camera would be recording their verbal answers and videoing the suturing exercise, as stated in the invitations to join the study and the consent form.

The half-hour session began with the RA explaining the suturing exercise. The exercise was to suture an incision made in a silicone abdominal wall model, where the middle layer was the subcutaneous tissue layer. The model was attached to an 8-inch diameter aluminum duct that gave the incision more of a natural opening. It was also covered with a laparotomy sheet to increase the surgical context of the model (Appendix F). Participants were asked to wear opaque exam gloves, using the suture material (Monocryl 2-0) and the surgical instruments provided (needle drivers, forceps, and sharp-blunt suture scissors). The RA explained that the participant should attempt to close the incision with a simple continuous suture pattern, consisting of a buried knot, simple continuous throws, and ending with a buried knot. The RA made it explicit that the exercise was about practicing the knots and the suture line. The participants were informed that they may correct mistakes if they wish, that there is no penalty for not completing the intended suture pattern, and that this suture exercise and the verbal answers do not contribute to any course grades. Before the suturing exercise began, the RA asked the participant the first three questions from the posttest questionnaire (Appendix D). The participant was asked to answer aloud, and these answers were
recorded by the GoPro audio. The participant was given the option of not answering any of the questions if they did not wish to answer.

Once the participant was finished verbalizing their answers, the RA informed the participant that they would leave the room and return 7 minutes before the end of the session to ask the remainder of the questions. Once the RA had left the room, the participant could write their individual research study ID on the piece of silicone (for anonymous identification of the silicone and suturing exercise). The participant could then proceed with the suturing exercise, which was being video-recorded by the GoPro. The GoPro Camera was positioned 25 cm above the silicone model, capturing only the image of the participant’s gloved hands and the suturing of the silicone model. The actual identity of the participant was not apparent from the video, thereby remaining anonymous to any observer. Seven minutes before the half-hour session was completed, the RA knocked on the door and re-entered the room. The RA asked the participant to stop the suturing exercise. The RA then proceeded to ask the last six questions of the posttest questionnaire (Appendix D). The participants were given the option of not answering any of the questions if they did not wish to answer. The GoPro audio recorded the participant’s verbal answers. Once the participant had finished their post-test questions, they were reminded to submit their completed digital log to the RA via email and were then excused from the session. The RA collected the labelled sutured silicone model and keep it in a sealed opaque bag for later analysis.

**Data Processing**

Quantitative data was collected by scoring each participant’s suturing exercises from the pre- and post-tests, which were captured on the GoPro digital video and scored
using the scoring instrument (Appendix H). The second source of quantitative data was the Likert-type interval scores from the questionnaires (Appendix C and D) that the RA asked each participant during the pre- and post-test. The verbal questions were not coded for this research; however, samples of answers were examined to add student voice to the research results. The return of the activity logs (Appendix M) was poor; only 6 of the 13 control group participants returned the logs, and only 3 of the 9 test group participants returned theirs. Excerpts from these logs were added to results for student voice.

**Video Data**

Each video recording on the GoPro was transferred to a hard drive by the RA. At the completion of the pre-test and after the intervention, the hard drive was given to the researcher. The researcher viewed each suturing exercise video on her personal 13-inch Acer Aspire IV laptop computer (there was no audio associated with this portion of the video). Each participant’s suturing exercise performance was graded individually using the instrument (Appendix H), which was a checklist for quantifying the accuracy of each step of the suturing technique.

The researcher was able to stop and restart the video as needed to appreciate the details of this process, including the number of throws used to form a knot, or the pathway of knot formation. Once the video was finished and the technique was graded, the silicone used by the participant was removed from the manila envelope to reveal the finished product. This provided a three-dimensional view and assessment of the functionality of the finished suturing product: for instance, did the edges of the incision align, or did the knots truly bury? This evaluation was also part of the assessment and
completed the checklist. The checklist generated the numerical data for this quantitative study.

**Data Analysis**

Data were analysed using Statistical Program for the Social Sciences (SPSS). All pre- and post-suturing performances were scored with the checklist (Appendix H) and the scores were inputted into SPSS. The Likert-type interval scores from Question 1, 5, and 8 from the questionnaires (Appendix C and Appendix D) were tabulated and inputted into SPSS to determine reported self-efficacy and satisfaction level of the participants’ suturing exercises.

Initially, all the data were tested for normality to determine the distribution pattern of the data. The difference between the total performance scores of the control and test group data was compared for the pre-test and then for the post-test. This was done using a Mann-Whitney U test, as the data distribution was non-parametric. Then, the individual pre-test and post-test scores for each individual part of the suturing exercise was compared within each group, test group and control group, using either a paired t-test or the Wilcoxon Sign Rank test. The effect size was calculated for the test group total score.

**Reliability, Validity, and Limitations**

The methodology utilized in this study would suggest that any improvement in the participants’ performance between the pre- and post-test would be due to the intervention. However, various threats to internal and external validity may have affected the results. Because the intervention was a presentation of concepts rather than specific rules, it may be interpreted and used by each participant differently. Also, due to the
chosen longitudinal nature of the study, threats to internal validity such as history and maturation could affect the participants’ outcomes. *History* refers to events that can occur over time that unwittingly affect the outcome of the results beyond the test intervention, and *maturation* refers to the maturing and change in the participants during the experimental time period (Creswell, 2014). Academic work load, personal stressors (personal or family illness, for instance), or a disproportionate amount of extra time or opportunities to practice their clinical skills outside of scheduled labs are examples of history and maturation that could have affected the post-test. *Diffusion of the treatment*, where discussion regarding the test intervention and the control intervention between the two groups of participants (Creswell, 2104), could have also occurred, although the researcher specifically requested that no discussion regarding the interventions occur between groups. *Selection* refers to pre-existing characteristics of participants that may influence the results (Creswell, 2014); since the selection of participants was based on them self-selecting to volunteer their time and energy for this research, this can be considered an unequal probability of selection, since those participants may have had more time available or have been more motivated to participate than the general population of students (Fowler, 2009). To try to control this threat, however, the groups were randomly devided into the two groups: control and intervention. Moreover, the students that persisted in this study may have been very high-achieving students, as no attribution to grades was gained by participating in this study. High-achieving students may already be very adept at self-regulation, as studies suggest (Cleary & Sandars, 2011; Pintrich, 2000). Therefore, performance improvement may not be due to the intervention, but rather, due to participants’ innate motivation and skills. Lastly, the pre- and post-test
were suturing; this suturing exercise may not reflect improvement in other psychomotor skills that the participants would have learned in that year, such as IV catheterization, bandaging, or asepsis. Hence, these threats to internal validity could have changed the final performance of the participant and not been a direct effect of the intervention.

*External validity* refers to extrapolation of the data to a population’s characteristics and the setting of the research (Creswell, 2014) – and in this study, there are limitations to the extrapolation of the data to other populations and settings. These include the voluntary sample of participants from a single class of second-year veterinary students. The class was chosen because of the level of suturing instruction that was anticipated that they would learn that year. Therefore, no first-, third-, or fourth-year students were included. Moreover, this study was only based on one year (OVC 2020 graduating class) and not multiple years (cohorts). It was in only one veterinary college in Ontario, Canada, as well, so the results may not be generalizable to other populations. For these reasons, the results may not be directly extrapolated to other Veterinary Colleges in Canada or globally.

This research was designed and undertaken to determine if second-year veterinary students would self-direct their learning and perform a suture pattern more effectively after being instructed in SRL and DP than their cohorts who had only been instructed in DP. The results of this investigation will be presented in the succeeding chapter, Chapter Four.
CHAPTER FOUR: PRESENTATION OF RESULTS

The purpose of this thesis was to determine if instruction in self-regulated learning (SRL) concepts would improve the suturing ability of second-year veterinary students. To investigate this hypothesis, a quantitative, true experimental design using a pre-test/intervention/post-test method, involving a test group and a control group, was performed. The response rate for this research study was underwhelming; the response rate for the test group was 45%, and 65% for the control group. The quantitative data assessed for this study was the suturing performance scores from the video-taped suturing exercises and the survey questions (Likert-type interval scores) of each participant before (pre-test) and 16 weeks after (post-test) the intervention. The participants were from the second-year veterinary class at the Ontario Veterinary College (OVC). The analysis of the data involved independent t-tests, Mann-Whitney U tests, paired t-tests, and Wilcoxon Signed Rank tests to determine the statistical difference in suturing performance, self-efficacy, satisfaction, and self-efficacy for skill transfer to a live animal both between the two groups and within each group from pre-test to post-test. The qualitative data were selectively analysed, and quotes were included in this chapter to provide student voice to the results.

Suturing Exercise Scores

The suturing performance scores were tabulated from the Scoring Checklist for the Suturing Exercise (Appendix H). The videos of the pre- and post-test suturing exercise were observed and scored on this checklist for each participant. The checklist included assessment scores to be generated for each sub-component of the exercise – including burying the initial knot, simple continuous suture, and burying the final knot –
as well as assessment scores of the suturing in the actual silicone model and the participant’s instrument handling. A total score was calculated by adding these five sub-components together. The data was derived from the sub-component scores and the total score.

**Preanalysis**

It was determined that there was no difference in pre-test total suturing performance scores between the control group and the test group. Table 1 provides the median, mean, standard deviation, and standard error of the mean for the pre-test performance scores. The distribution was non-parametric, so a Mann-Whitney U test was used to determine the analysis of variance, at a significance level of 0.05. The results of this test – U = 39.5, *p* = .209 – indicated that the distribution of scores was the same for the pre-test suturing performance scores between the control and test group. Therefore, there was no significant difference of the pre-test performance scores between the control group and the test group. This indicates that the participants regardless of group, were at the same skill level at the pre-test.

Table 1

*Descriptive Statistics for Total Suturing Performance Scores of Pre-Test for Control Group and Test Group*

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Median</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control Group</strong></td>
<td>13</td>
<td>25.0000</td>
<td>27.923</td>
<td>10.259</td>
<td>2.845</td>
</tr>
<tr>
<td><strong>Test Group</strong></td>
<td>9</td>
<td>27.0000</td>
<td>33.000</td>
<td>10.689</td>
<td>3.563</td>
</tr>
</tbody>
</table>
Hypothesis 1

The first hypothesis of this study was that second-year veterinary students who are instructed in SRL and DP when learning veterinary psychomotor skills will obtain a higher total suturing score when transferring these skills to a new simulator than the veterinary students that are only instructed to learn veterinary psychomotor skills using DP. Table 2 provides the median, mean, standard deviation, and standard error of the mean for the post-test performance scores of the control and test group. The distribution was non-parametric; therefore, a Mann-Whitney U test was performed at a significance of 0.05. The result of this test – U = 57.5 and p = .948 – indicate that the distribution of scores was the same between the control group and the test group. Therefore, there was no significant difference between the total suturing performance of the control and the test group. A Cohen’s d test also produced a factor of 0.017, thus indicating that the effect size was minimal. These findings do not support the second hypothesis that the intervention of instructing participants in SRL and DP would result in higher suturing performance levels than participants instructed in only DP. These results indicate that the SRL intervention did not result in significantly better suturing performance.

Table 2

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Median</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control Group</strong></td>
<td>13</td>
<td>41.000</td>
<td>41.539</td>
<td>11.738</td>
<td>3.255</td>
</tr>
<tr>
<td><strong>Test Group</strong></td>
<td>9</td>
<td>53.000</td>
<td>41.778</td>
<td>15.522</td>
<td>5.174</td>
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</tbody>
</table>
Further analysis was conducted on the subcomponents of the suturing exercise within each group. These sub-components consisted of a) burying the initial knot; b) the simple continuous throws; c) burying the final knot; d) the overall appearance of the subcutaneous layer closure of the silicone model; and e) proper surgical instrument handling during the exercise. Each sub-component was graded numerically. The overall suturing performance of the subcutaneous layer in the silicone model was tabulated by adding together all the sub-components for each participant. The sub-components were compared between pre- and post-test within both the control and test group using paired t-tests and Wilcoxon Signed Rank tests, depending on the normality of their distribution. The results, including the descriptive statistics, are included in Table 3 and Table 4.

These results indicate that the participants in the control group did improve their overall performance when tested to a significance level of 0.05, p = .003. The control group participants significantly improved their performance of burying the initial knot, burying the final knot, and the appearance of the closure on the silicone model. The test group did not have an overall improvement in performance. The only sub-component that showed significant improvement by the test group was burying the final knot. There was no significant improvement with burying the first knot. Their pre-test score was relatively higher than the control group’s pre-test score; however, when tested with an independent t-test, there was no significant difference between their pre-test scores for burying the first knot. The test group did not show improvement in the appearance of the silicone. In summary, the control group showed significant improvement of three sub-components of the suturing exercise as well as the total performance score, whereas the test group
demonstrated improvement in only one sub-component (burying the final knot) of the suturing exercise and not the total performance.

There was no improvement for either group in the sub-component of instrument handling. Both groups scored very high (perfect score of 6 for the skill), which indicates that their previous training in instrument handling was effective in both the pre- and post-test. The control group did have a slight decrease in their post-test score from their pre-test score, which may be the result of the challenges of the increase in fidelity of the model; however, this was not statistically significant.

Table 3

*Paired t-Test and Wilcoxon Signed Rank Test Results for the Pre- and Post-Test of the Control Group*

<table>
<thead>
<tr>
<th>CONTROL GROUP (Sub-Component variables of Suturing Performance Variable)</th>
<th>N</th>
<th>Mean</th>
<th>S.D</th>
<th>Statistic al Test</th>
<th>Paired Sample Differences</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Initial Buried knot</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Paired t-Test</td>
<td></td>
</tr>
<tr>
<td>Pre-Test</td>
<td>13</td>
<td>5.7692</td>
<td>3.58594</td>
<td>Paired t-Test</td>
<td>-4.30769</td>
<td>4.67947</td>
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<tr>
<td>Post-Test</td>
<td>13</td>
<td>10.076</td>
<td>3.97559</td>
<td>Wilcoxon Signed Rank Test</td>
<td>.83179</td>
<td>.41735</td>
</tr>
<tr>
<td><strong>Simple Continuous Line</strong></td>
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<td></td>
<td></td>
<td></td>
<td>Wilcoxon Signed Rank Test</td>
<td>.579</td>
</tr>
<tr>
<td>Pre-Test</td>
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<td>1.41421</td>
<td>Wilcoxon Signed Rank Test</td>
<td>.25773</td>
<td>.31256</td>
</tr>
<tr>
<td>Post-Test</td>
<td>13</td>
<td>8.3077</td>
<td>1.31559</td>
<td>Wilcoxon Signed Rank Test</td>
<td>.71037</td>
<td>.41735</td>
</tr>
<tr>
<td><strong>Final Buried Knot</strong></td>
<td></td>
<td></td>
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<td>Wilcoxon Signed Rank Test</td>
<td>.013</td>
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<td>3.8462</td>
<td>4.65199</td>
<td>Wilcoxon Signed Rank Test</td>
<td>.25773</td>
<td>.31256</td>
</tr>
<tr>
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<td>13</td>
<td>9.3077</td>
<td>7.04018</td>
<td>Wilcoxon Signed Rank Test</td>
<td>.71037</td>
<td>.41735</td>
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<tr>
<td><strong>Assessment of Silicone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Paired t-Test</td>
<td></td>
</tr>
<tr>
<td>Pre-Test</td>
<td>13</td>
<td>2.5385</td>
<td>2.69615</td>
<td>Paired t-Test</td>
<td>-2.53846</td>
<td>2.69615</td>
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<tr>
<td>Post-Test</td>
<td>13</td>
<td>5.0769</td>
<td>2.84199</td>
<td>Wilcoxon Signed Rank Test</td>
<td>.25773</td>
<td>.31256</td>
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<tr>
<td><strong>Instrument Handling</strong></td>
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<td></td>
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<td></td>
<td>Wilcoxon Signed Rank Test</td>
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<td>.27735</td>
<td>Wilcoxon Signed Rank Test</td>
<td>.25773</td>
<td>.31256</td>
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<td>.83205</td>
<td>Wilcoxon Signed Rank Test</td>
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<td><strong>Total Performance</strong></td>
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<td>Wilcoxon Signed Rank Test</td>
<td>.003</td>
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<tr>
<td>Pre-Test</td>
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<td>27.9231</td>
<td>10.25883</td>
<td>Wilcoxon Signed Rank Test</td>
<td>.25773</td>
<td>.31256</td>
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<tr>
<td>Post-Test</td>
<td>13</td>
<td>41.5385</td>
<td>11.73751</td>
<td>Wilcoxon Signed Rank Test</td>
<td>.25773</td>
<td>.31256</td>
</tr>
</tbody>
</table>
Table 4

*Paired t-Test and Wilcoxon Signed Rank Test Results for the Pre- and Post-Test of the Test Group*

<table>
<thead>
<tr>
<th>TEST GROUP (Sub-Components of the Suturing Performance Variable)</th>
<th>N</th>
<th>Mean</th>
<th>S.D</th>
<th>Statistical Test</th>
<th>Paired Sample Differences</th>
<th>95% Confidence Interval of Difference</th>
<th>t</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Buried Knot</td>
<td>9</td>
<td>7.22</td>
<td>4.16</td>
<td>Paired t-test</td>
<td>-1.222</td>
<td>3.898</td>
<td>1.774</td>
<td>.981</td>
<td>8 .374</td>
</tr>
<tr>
<td>Simple Continuous Line</td>
<td>9</td>
<td>8.67</td>
<td>1.00</td>
<td>Wilcoxon Signed Rank test</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Buried Knot</td>
<td>9</td>
<td>5.11</td>
<td>5.862</td>
<td>Paired t-test</td>
<td>-6.000</td>
<td>7.280</td>
<td>-11.506</td>
<td>.404</td>
<td>2 .472</td>
</tr>
<tr>
<td>Assessment of Silicone</td>
<td>9</td>
<td>4.0</td>
<td>3.0</td>
<td>Paired t-test</td>
<td>-1.000</td>
<td>3.354</td>
<td>-3.578</td>
<td>1.578</td>
<td>8 .397</td>
</tr>
<tr>
<td>Instrument Handling</td>
<td>9</td>
<td>5.33</td>
<td>1.323</td>
<td>Wilcoxon Signed Rank test</td>
<td>.180</td>
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<tr>
<td>Total Performance</td>
<td>9</td>
<td>33.00</td>
<td>10.689</td>
<td>Paired t-test</td>
<td>-8.778</td>
<td>12.921</td>
<td>-18.710</td>
<td>1.154</td>
<td>8 .076</td>
</tr>
</tbody>
</table>

**Likert-Type Interval Scale Scores**

During the pre- and post-test, the participants were asked to answer survey questions from the questionnaires (Appendix C and D) before and after they performed the suturing exercise. The participants’ answers to these questions were captured on the audio of the GoPro and transcribed by the RAs. The purpose of these questions was to capture the participants’ self-efficacy or capability beliefs for performing each section of the closure (initial knot, simple continuous, and final knot) before they did the suturing exercise, as well as their satisfaction with their suturing ability and their belief in their capability to transfer their skills to a live animal after the suturing exercise.
Hypothesis 2

The second hypothesis pertained to the participants’ own capability beliefs and their performance satisfaction: the participants in the test group (SRL and DP) would have higher self-efficacy and satisfaction with regards to the exercise than the control group (DP). The analysis of these Likert-type interval scale scores involved paired t-tests and Wilcoxon Signed Rank tests on the pre- and post-test data within each group (see Table 5 and Table 6), and Mann Whitney U tests on the scores between groups (see Table 7).

As indicated by the data analysis of the Likert-type interval scale scores, both the participants in the control and test groups had statistically significant increases in their self-efficacy for each of the three parts of the suture exercise, their satisfaction with their performance, and their belief in their capability to transfer this skill to the live animal surgery. However, there was no significant difference between the groups for any of the self-assessed Likert-type interval scale scores questions. This does not support the second hypothesis that only the test group would have significantly higher levels of self-efficacy, satisfaction, and beliefs in the transferability of this skill to live animals than the control group.

Factors that could have affected the results of this study are the small numbers of participants that actually finished the whole study, and the skewed, disproportionate group sizes (control group: n = 13; test group: n = 9). The distribution of the data was non-parametric for many of these tests and the resulting analysis by the Wilcoxon Signed Rank tests and Mann Whitney U tests.
Table 5

*Paired t-Tests and Wilcoxon Signed Rank Test for the Control Group’s Self-Assessed Likert-Type Interval Scale Scores for Self-Efficacy of the 3 Parts of the Suture Exercise, Satisfaction, and Transfer Capability*

<table>
<thead>
<tr>
<th>CONTROL GROUP</th>
<th>N</th>
<th>Mean</th>
<th>S.D</th>
<th>Statistical Test Used Based on Distribution</th>
<th>Paired Sample Differences</th>
<th>95% Confidence Interval of Difference</th>
<th>T</th>
<th>Df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Self-Assessed Likert-Type Interval Scale Scores for Self-Efficacy of the Three Parts of the Suture Exercise, Satisfaction, and Capability)</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Initial Buried Knot</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test</td>
<td>13</td>
<td>4.808</td>
<td>3.509</td>
<td>Paired t-Test</td>
<td>-3.5385</td>
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<td>-5.3407</td>
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<td>-4.278</td>
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</tr>
<tr>
<td>Pre-Test</td>
<td>13</td>
<td>8.154</td>
<td>1.405</td>
<td>Wilcoxon Signed Rank test</td>
<td>.018</td>
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<tr>
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<td>Final Buried Knot</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test</td>
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<td>4.385</td>
<td>2.959</td>
<td>Paired t-Test</td>
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<td>2.511</td>
<td>-4.8638</td>
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<td>-4.804</td>
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<td>7.731</td>
<td>1.165</td>
<td></td>
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<td>-7.093</td>
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<td>Satisfaction with Finished Suture Line</td>
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<td></td>
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</tr>
<tr>
<td>Pre-Test</td>
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<td>6.192</td>
<td>1.750</td>
<td>Paired t-Test</td>
<td>-1.9231</td>
<td>1.656</td>
<td>-2.9240</td>
<td>-.9221</td>
<td>-4.186</td>
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<td>1.0439</td>
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<tr>
<td>Capability of Closing SC on Live Animal</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test</td>
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<td>3.462</td>
<td>2.3670</td>
<td>Paired t-Test</td>
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<td>1.883</td>
<td>-4.7537</td>
<td>2.4771</td>
<td>-6.920</td>
</tr>
</tbody>
</table>
Table 6

*Paired t-Tests and Wilcoxon Signed Rank Test for the Test Group’s Self-Assessed Likert-Type Interval Scale Scores for Self-Efficacy of the Three Parts of the Suture Exercise, Satisfaction, and Transfer Capability*

<table>
<thead>
<tr>
<th>TEST GROUP (Self-Assessed Likert Scores for Self-Efficacy of the Three Parts of the Suture Exercise, Satisfaction, and Capability)</th>
<th>N</th>
<th>Mean</th>
<th>S.D</th>
<th>Statistical Test</th>
<th>Significance</th>
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<tr>
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Table 7

The Mann Whitney U Test Results for Each Survey Category Between the Control and Test Group

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<th>Survey Category</th>
<th>Mann Whitney U Test p-value</th>
<th>Mann Whitney U-value</th>
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<td>Post-Test Initial Knot</td>
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<td>Post-Test Subcutaneous Suture Line</td>
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<td>Pre-Test Capability</td>
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<td>Post-Test Capability</td>
<td>.794</td>
<td>54.5</td>
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Survey Answers Representing Student Voice

Although it is beyond the scope of this study to present an extensive analysis of the qualitative data, the survey questions designed to reflect specific aspects of the phases of the SRL cycle were examined for student voice. A general overview of how control and test participants reflected aspects of SRL is presented here.

For Question 2 – “What is your learning objective in practicing this suturing exercise today?” – the test group tended to have very specific learning objectives in both the pre- and post-test, so any influence of the test group intervention is difficult to determine. Defining specific learning goals helps to focus self-regulated learners on strategies, such as self-monitoring, to learn that task and improve (Cleary & Sandars, 2011; Zimmerman, 2011; Zimmerman & Kitsantas, 1997). The control group tended to have post-test goals that were less specific, such as more practice. This could imply, then, that the test group focused their goals on specific aspects of the suturing exercise more so than the control group (see Figure 10).
Question 2: “What is your learning objective in practicing this suturing exercise today?”

Test Group Participant #32
Pre-Test: “Learn how to start by burying the knot.”
Post-Test: “To practice burying the final knot.”

Test Group Participant #24
Pre-Test: “I would like to know how to bury a knot.”
Post-Test: “I want to be able to successfully bury the end of the knot and to not have it visible as I finish closing.”

Control Group Participant #29
Pre-Test: “Just become a bit more familiar with the suturing technique and the instruments and eventually learn how to bury a knot.”
Post-Test: “Just getting more practice with the suture pattern and like, kind of making it automatic-the technique.”

Control Group Participant #15
Pre-Test: “To get practice in suturing.”
Post-Test: “Um I want to be able to do a buried knot and you know a simple continuous that actually closes the incision cause I’ve had trouble with that. I mean I think I have the technique down but I haven’t been really able to oppose the tissues very well.”

Control Group Participant #9
Pre-Test: “To learn how to do it-practice it a bit more I guess”
Post-Test: “To hopefully do it correctly”

Figure 10. Test and control responses to Question 2.

Question 3 asked, “What strategies do you use to learn suturing?” For this question, the participants in both groups mentioned new ways to improve their learning, such as seeking feedback from peers or instructors in labs. There appeared to be no difference between the two groups. Both groups considered new learning strategies which aligns with SRL more than DP, so this may be more of an innate SRL rather than an affect of the intervention.

Question 4 was asked immediately after the suturing exercise was finished, and explored the performance phase of SRL. In this phase, both the SRL learner and the DP learner should be self-monitoring to convert the experience of physically performing the
suturing skill into cognitive knowledge and motor control to correctly execute the skill. In
addition, the SRL learner should be reducing the skill to hierarchal steps and focusing
their attention on learning the skill, using strategies such as self-instruction and
visualization to do so. Ideally, the goal should be to master the techniques of the skill and
not be focused on the outcome of the performance. Examples of responses from both
groups are shown in Figure 11.
Question 4: “What was your self-talk during this suture pattern, what were you telling yourself? What aspects of the suturing were you thinking about? Did you identify any problems with any part of your technique? If yes - did you adjust your technique to try and correct the problem? What did you do to initially adjust your technique? How did your adjustment help?”

Test Group Participant #21:
Pre-Test: “What I was telling myself during the whole process? To relax and to take it one step at a time. If I had a slip knot I would try to unrelease the knot and try again, it helped a little bit-I didn’t get it right all the time.”
Post-Test: “I was thinking about making sure my first knot was actually buried, that I was taking a good bite out of the tissue, then I was making sure I was keeping it at evenly spaced out and enough pressure was pulled to make sure it was tight and then attempting to do a final knot. Sometimes I would not take a good enough chunk so I would take it back out and do another one. Sometimes I noticed I was doing a granny knot so then I would undo my knot and then re-do it. It seemed to come out okay so it helped out well.”

Test Group Participant #32:
Pre-Test: “I guess at the beginning that you start like closest to the surgeon and you go superficial to deep, deep to superficial. And then you kind of follow that all the way around. But going into burying the knot I just tried my best to keep everything deep.”
Post-Test: “Restarting the knot, how fast to go, start on the side of the surgeon and you go deep to superficial, opposite side, superficial to deep and then you tie your knot. Then you have to do one more tie deep to superficial on the side of the surgeon to bury. The end knot, I still need to work on that. It is very confusing. I thought I knew what I was supposed to be doing but it didn’t bury as nicely as I thought it would. I was mainly just tying sutures at the end and tried to pull evenly on them to try and help bury them. It helped a little.”

Control Group Participant #8
Pre-Test: “Deep to superficial, superficial to deep just over and over again. And then remembering that my last-my like ending knot has to be one more tie than the first one. So initially I noticed that the tissue wasn’t closely opposed so I figured that was because my spacing for the bites were too far apart-so I just started making my-taking bites that were closer together. It helped a lot. I noticed that after that point, the tissues were a lot closer together than previously.”
Post-Test: “Um, so I was thinking about my knots and trying to think that I was actually forming a square knot verse just a loop. Trying to keep my spacing even so there was no little dips and folds in it. Also, to be consistent in my spacing and the amount of knots or ties that I did. Um, so when I first tried the starting knot I didn’t pull my square knots tight enough so as a result it came loose and when I cut I cut it too short so I had to start again. In terms of spacing as well, towards the middle I noticed that some of my bites I was taking were too close together and as a result there was little dipits in the pattern so I started spacing them out a little bit more.”

Control Group Participant #16
Pre-Test: “Um, I was pretty nervous, so I was like make sure that the bites were kind of similar in size each time. I kept having issues coming up like knots showing up when they shouldn’t be or slip knots and trying to figure out how to get them undone. And just general being nervous about it. Yes, I definitely noticed I was getting a few slip knots, um and then I tried to adjust and also got some random knots where they shouldn’t be because the string would get tangled and then I noticed that I was holding the instruments wrong at first and I adjusted that as well. So I think changing my grip definitely helped me to use the needle drivers better and I was able to better if guess get through the silicone an then just adjusting the knots made it better knot security at the end.”
Post-Test: “I was thinking about getting over the subcutaneous layers and not breaking through the skin and making sure that it was closed but not completely closed over. Just making sure my bites are fairly evenly apart. Yes-so I did notice that some of my knots were getting slip knots and it was also not-the suture wasn’t tight enough so it was coming undone as soon as I was doing it so that might be because of the thickness of the suture. I did adjust the way that I was doing my knots-make sure that they weren’t slip knots and watching that my knots went all the way down. And I tried to pull as tightly as possible to get my knots to stay but they still kept opening up. Um again so the tightening didn’t help as much as I had hoped but watching my knots go down and working a bit more slowly did help.”

Figure 11. Test and control responses to Question 4.
In the post-test, the test group showed an increase in SRL strategies associated with performance such as hierarchal steps and self-instruction, as well as mastery based objectives. This is apparent with Test Participant #9, whose pre-test answers were vague in regards to self-talk when stating, “What I was telling myself during the whole process? To relax and to take it one step at a time.” Their self-talk became very detailed in the post-test, however, reflecting that,

I was thinking about making sure my first knot was actually buried, that I was taking a good bite out of the tissue, then I was making sure I was keeping it at evenly spaced out and enough pressure was pulled to make sure it was tight. (Test Participant #9)

This is also seen with Test Participant #32: their pre-test demonstrated general suture patterns, but their post-test answers defined more self-talk, self-monitoring, and hierachial goals, stating, “The end knot, I still need to work on that. It is very confusing. I thought I knew what I was supposed to be doing.”

The control group used self-monitoring and mastery goals consisently in their pre- and post-test. For instance, Control Participant #8 self-monitored and adjusted bite sizes in the simple continuous bites as their mastery goals in the pre-test, stating, “So initially I noticed that the tissue wasn’t closely opposed so I figured that was because my spacing for the bites were too far apart-so I just started making my-taking bites that were closer together. It helped a lot.” In their post-test, Control Participant #8 reflected that they were, “Trying to keep my spacing even so there was no little dips and folds in it. Also, to be consistent in my spacing.” Likewise, Control Participant #16 also demonstrated consistant self-monitoring and mastery orientation during the pre- and post-test, as
evidenced by their dedication to monitoring slip-knot formation and making adjustments:

“Um again so the tightening didn’t help as much as I had hoped but watching my knots go down and working a bit more slowly did help.” It was rare that the overall performance outcome was the objective for either group; for instance, only one test participant mentioned grades in their self-talk during the pre-test, stating, “I was surprisingly nervous and shaky so I was like it’s fine. It’s not like graded or anything, take your time” (Test Participant #39). The post-test responses by the test group show a trend towards using more SRL strategies such as hieracheal goals. From both the SRL and DP views, then, it is important that the participants chose mastery goals over performance goals even in their pre-test, indicating that they innately chose mastery goals before the intervention.

Question 6 – “What criteria did you use to judge your degree of satisfaction?” – is part of the afterthought or self-reflection phase of SRL where participants self-evaluate their learning and performance. Ideally, the SRL learner will base their judgement of incremental improvement in their mastery of the skill, rather than only on the outcome or in comparison with others. In this study, both groups tended to base their judgement of satisfaction on criteria based on skill mastery in both the pre- and post-test (see Figure 12). In the pre-test, the test group tended to use performance goals and vague criteria, such as the overall look of the finished product or, “How easily the movements came to me I guess” (Test Participant #30); however, in the post-test, they did appear to change their satisfaction criteria as they used to more specific skill based criteria. This is seen when Test Participant #24 states, “I liked the fact that I was able to bury both knots and you can’t see them at the top. I feel that I followed all the correct steps to bury.”
For the control group, there was a tendency to not focus on the criteria of mastery skills. In the pre-test, the criteria used by to judge satisfaction often focused on vague criteria such as their previous or lack of practice, evidenced by statements such as, “The fact that I practiced it” (Control Participant #9) and, “based on the video of me doing the suture properly because it doesn’t help to do something improperly” (Control Participant #15). In the post-test for the control group, the criteria remained vague and performance-based, such as, “How successful I was at achieving it”. (Control Participant #15). These shifts in judgement criteria from vague to specific aspects of mastery for the test group suggests that the intervention in SRL could have influenced the test participants to judge their success on more specific aspects of mastery than the control group.

**Question 6:** “What criteria did you use to judge your degree of satisfaction?”

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Pre-Test:</strong> “One was how well I buried the knot and kind of just overall what the suture looks like....yep.”</td>
</tr>
<tr>
<td><strong>Post-Test:</strong> “I liked the fact that I was able to bury both knots and you can’t see them at the top. I feel that I followed all the correct steps to bury but I just wasn’t as close to properly closing as I would like to be.”</td>
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</tbody>
</table>

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Pre-Test:</strong> “How easily the movements came to me I guess.”</td>
</tr>
<tr>
<td><strong>Post-Test:</strong> “Um, how well I followed the theoretical instructions of this pattern, how well apposed the subcutaneous layer is and how well my knots held together.”</td>
</tr>
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</table>

<table>
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<tbody>
<tr>
<td><strong>Pre-Test:</strong> “The fact that I practiced it”</td>
</tr>
<tr>
<td><strong>Post-Test:</strong> “I am happy with everything except the last knot.”</td>
</tr>
</tbody>
</table>

<table>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Test:</strong> “Um again it was based on the video of me doing the suture properly because it doesn’t help to do things improperly-to keep practicing it if you’re doing something the wrong way.”</td>
</tr>
<tr>
<td><strong>Post-Test:</strong> “How successful I was at achieving it.”</td>
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*Figure 12. Test and control responses to Question 6.*
Attribution of participants’ suturing exercise performance was captured in Question 7: “Why do you think your subcutaneous closure turned out the way it did?” In the pre-test, it was common for both groups to respond with vague attributions for their level of performance, many of them making the attribution to needing more practice, as illustrated in Figure 13. Although these pre-test responses were not directed to specific areas of the suture exercise, neither were they directed to lack of their ability, which supports their positive self-efficacy. In the post-test, the test group made more attributions to specific aspects of their suture exercise, such as improving their final buried knot. The control group participants, however, remained focused on the concept of more practice and potential optional learning strategies.

The final question (Question 9) was to determine if the participants were making any adaptive inferences or conclusions about how to improve their performance in future reiterations of this suture exercise. Ideally, they should be setting specific goals for their next practice in their post-test, as re-evaluating goals was discussed in both interventions since it is part of DP and SRL. However, both groups contained more participants that had vague goals rather than specific goals (see Figure 14). The test group did have 2 participants that had very specific goals in both the pre- and post-test, who were therefore not influenced by the intervention. There were a few participants in both groups that reported a vague goal in the pre-test and a focused goal in the post-test, but this was not highly represented in either group. This implies that the test group, despite identifying specific attributions of poor mastery in Question 7, did not transfer this information into making new goals in the reflection phase.
Question 7: “Why do you think your subcutaneous closure turned out the way it did?”

Test Group Participant #21
Pre-Test: “Because I need more practice.”
Post-Test: “I don’t know how to do the end burying knot.”

Test Group Participant #24
Pre-Test: “It’s not great cause I wasn’t really sure how to bury the knot before. I haven’t practiced that much. I’ve always had trouble with this pattern just to kind of make it look kind of even so yah I guess that is why.”
Post-Test: “Well I followed the steps for burying a knot so I wasn’t successfully able to get the knots to stay in the subcutaneous. As for the tightness, I wasn’t pulling as hard and thinking about the tightness of the knots I was mostly focusing on burying the knot.”

Control Group Participant #1
Pre-Test: “I need to practice more. I’m not very good at it yet.”
Post-Test: “I would like to practice on cadavers. I want to know what the real thing feels like.”

Control Group Participant #29
Pre-Test: “Probably because I need more practice,”
Post-Test: “I think it just shows that you just need to keep repeating it and that you need more and more practice to get better.”

Control Group Participant #15
Pre-Test: “Because I’m not very skilled at it.”
Post-Test: “I mean the first part I think turned out good because I know what technique I was doing but then end part I just kinda got a little confused and tangled up. I actually did get tangled up in it, I had to untangle my suture so yeah—it wasn’t the best but I tried.”

Figure 13. Test and control responses to Question 7.
Figure 14. Test and control responses to Question 9.

The return of the Activity Log was poor, as only 6 of the 13 control group participants and 3 of the 9 test group participants sent them back, despite numerous reminders by the RA. For the activity logs that were returned, the interpretation of the instructions to, “Fill this out for any of the psychomotor skills you encounter” was interpreted by some participants as any psychomotor skill, and thus resulted in entries
pertaining to knitting, rug hooking, and playing the piano. In general, it was noted that a few participants from each group set specific goals such as bury a knot, ensure even bite width of suture pattern, or improve the mastery of other continuous suture patterns. Learning strategies often cited practicing on their DASIE® and watching the online training videos. One control participant went into detail on the learning strategy:

First watch a video for burying a knot, start to finish, then replay the portion where they end. Next try one on my own and analyze what I need to work on, then watch the video again focusing on the area that needs improvement, then try again. (Control Participant #8)

This statement is rich with metacognitive skills to improve their mastery. Of the three test participants, two had specific learning strategies reflecting metacognitive skill: for instance, Test Participant #39 wrote, “being aware of proper hand position assessing bite depth and distance between suture” and Test Participant #33 indicated, “mark out even bites with a marker to follow in order to gain better muscle memory between bites.”

The Reflections section of the Activity log was also poorly filled out by both groups. They managed to write down the time estimate component, but rarely filled out any information pertaining to attributions or adaptive inferences. Only one of the six control participants wrote in the Reflections column with the same response for each of their three skills: “Approximately 60 minutes to learn the technique initially and now countless hours of practice have been dedicated to it” (Control Participant #29). Only one of the three test participants wrote any reflections, and it was more specific to the goal of improving suture placement; their reflection was, “continue on the suturing skill with greater awareness of where I should focus my attention while practicing” (Test
Participant #39. Since the Activity Log return rate was a mere fraction of the participants, and the nature of the psychomotor skill was often misinterpreted, this data was not assessed beyond these quotes.

In the next chapter, I will discuss the results and elaborate on possible reasons for these outcomes. The results will be analysed in light of current research.
CHAPTER FIVE: SUMMARY, DISCUSSION, AND IMPLICATIONS

In this final chapter, I will summarize the reasons for conducting a thesis study in self-regulated learning (SRL) and the development of psychomotor skills in veterinary students. I will review the methods used to collect the data, and briefly reiterate the results that were obtained from the data analysis. A discussion will follow that considers different ways the results can be interpreted and relates this study’s findings to the current literature. The implications of this study, and how it affects practice, will be reviewed, followed by future recommendations for further study.

Summary

Veterinary educators continue to find ways to improve the competency of their graduates (Baillie, Dilly, & Crowther, 2015; Baillie et al., 2015), and at OVC, a new clinical skills lab is currently being developed to give students an opportunity to self-direct their own practice of the psychomotor skills needed for veterinary practice. With a didactically-based curriculum, the archetypical performance orientation of the students, and their novice psychomotor skills status, self-directing their own practice can be poorly achieved. This is currently the concern with veterinary students at OVC, as evidenced by students’ difficulty in understanding their own skill deficits and how to improve them when preparing to perform live animal surgery in third-year surgical exercises. One possible solution to support their self-directed practice is to introduce the students to the concept and application of SRL. Using this student-centered schema of learning has been demonstrated to improve academic learning, sport-related psychomotor skill development, and human medical clinical skill performance (Brydges & Butler, 2012; Cleary, Zimmerman, & Keating, 2006; Cleary & Sandars, 2011; Kitsantas &
Zimmerman, 1998). Since psychomotor skill development in veterinary medicine shares similar features to these activities, it was hypothesized that learners that applied SRL strategy to their psychomotor skill development could improve their performance of these skills.

This was a quantitative, experimental pre-test/intervention/post-test design study. The independent variable was an intervention that introduced the test group participants to the concept of SRL and DP, and their consequent application for practice on veterinary simulators used to develop their psychomotor skills. The control group participants were introduced to DP only, and its application for practice on veterinary simulators used to develop their psychomotor skills.

The dependent variable was the participants’ scored performance of a simple continuous suture pattern performed on a silicone model. The silicone model used for the pre-test was a single layer of silicone that represented the subcutaneous layer of tissue where this suture pattern is routinely performed in the live animal. The model for the post-test was on a silicone model that had representative layers for the whole body wall (muscle, subcutaneous, and skin); the participants were only required to suture the subcutaneous layer. The increase in silicone model fidelity was to increase the difficulty of the application of the pattern, ideally to stimulate students to self-regulate their skill to a more challenging model. The post-test was conducted 16 to 20 weeks after the intervention to introduce longevity into the study.

Both the pre-test and post-test suturing exercise were video-taped for each participant. Before and after the suturing exercise was undertaken by the participant, the RA asked a series of questions that were developed as a SRLMA (Cleary, Zimmerman, &
Keating, 2006) to provide an idea of how these participants felt about their learning and performance of their suturing skills. These video-tapes were analyzed by the researcher, and produced three sets of data. The first set of data was produced by grading the video-taped suturing exercise of each participant using a checklist with an operative component rating score to quantify their performance. There were five sub-categories and a total performance score (a sum of the five sub-categories). The second set of data were the results from the Likert-type interval scale from the surveys conducted before and after each suturing exercise. The third set of data were the transcribed verbal answers to the questions on the survey. These were examined, but not analysed by rigorous qualitative methods; rather, they were presented to illustrate student voice.

The statistical analysis of the data involved comparing the differences in pre-test and post-test suturing performance scores and Likert-type interval scale scores that involved self-efficacy, capability, and satisfaction with learning questions between the groups; this was done using independent t-tests and Mann-Whitney U tests, as well as differences between pre-test and post-test results within the groups using paired t-tests and Wilcoxon Signed Rank tests. Pre-analysis of the suturing performance scores show that all the participants were at the same level of skill development in the pre-test. Despite the introduction of SRL strategies during their intervention, the test group did not out-perform the control group when both groups had to repeat the suture exercise on a higher fidelity model. In fact, when considering their total performance score, they performed at the same level; this did not support the first hypothesis, which predicted the test group would out-perform the control group. Further analysis revealed that the control group significantly improved on their total suturing performance and on three sub-
components of this suturing exercise: burying the initial knot, burying the final knot, and the appearance of the silicone. The test group only demonstrated improvement in the sub-component of burying the final knot. Burying the final knot is the most cognitively and technically demanding part of the entire suturing exercise, so it was reassuring to see that both groups improved significantly at this skill. Neither group improved their instrument handling significantly, but both groups scored very high in the pre- and post-test, so it was not expected that there would be improvement with this skill.

From the Likert-type interval scale data, both the control and test group showed significant increases in their self-efficacy of their capability to perform the three sub-components of their suturing exercise, their satisfaction with their performance, and their belief in their capability to transfer this skill to a live animal surgery when comparing pre-test to post-test scores. It was hypothesized (hypothesis 2) that the test group would score significantly higher than the control group, but this was not evident in this research.

From the analysis of the translated verbal survey question responses, a positive trend emerges. The test group post-test results demonstrated that the SRL intervention had an impact on how the test group participants made more specific learning goals in the forethought phase, used more SRL techniques such as self-talk, hierachial goal structures, and self-monitored, while the post-test control group responses were only based on self-monitoring. Both groups favoured mastery orientation rather then performance orientation in the performance phase, and this is ideal and reflects both SRL and DP. In the post-test, the test group used more specific skill criteria on which they based their satisfaction, where the control group continued to use vague criteria in the post-test. Although the test group reported more specific attributions, such as a poorly buried knot,
in their post-test, they did not transfer this information as an adaptive inference by setting these as new goals for further practice. While some transfer of SRL skills were observed in the responses to the survey questions, the data is not robust enough to warrant making causal inferences.

**Discussion**

There was no statistically significant difference between pre-test suturing scores of the control and test group. This indicates that all the groups were matched for their level of performance at the beginning of the study. For this suturing exercise, all the participants were at the novice level.

The test group intervention – involving an introduction, using a PowerPoint presentation, to both the cycle of SRL and DP and their application to psychomotor skill development using veterinary simulators – did not statistically, improve students’ suturing performance on a higher fidelity model. The control group, which was introduced to the single theory of DP and its application to psychomotor skill development using simulators, did show an increase in suturing performance. However, there was no significant difference between the post-test total performance scores between the control and test group. Reasons for the latter result could be related to factors of the intervention, attrition of participants resulting in the small sample size, and the difference in the size of the control and test group, the stage of learners’ psychomotor skill development. Each of these possibilities will be reviewed here.

**Intervention**

The intervention for the test group (SRL and DP) may have been one reason the students did not demonstrate a significantly superior suturing performance or report
higher self-efficacy and satisfaction in the surveys than the control group (only DP). The interventions were matched for a time of only 45 minutes each to control for the total time the students had to spend in the study; yet, the test group intervention had the addition of the SRL cycle within this 45-minute time period. This resulted in a lot of information being presented to students, and may have introduced cognitive overload, where the participant’s working memory was overwhelmed by the new concepts being presented and they, therefore, did not have enough time to process this information (Weidman & Baker, 2015) before having to apply the theory to the veterinary simulators and their practice.

The introduction of SRL content into the test group intervention also reduced the time spent on using the simulators and the discussion of the application of the SRL schema to both practice and mastery of veterinary psychomotor skills. Rather than just knowing about SRL, the key to its success as a learning schema is understanding the SRL cycle and it’s application to learning in a specific context (Cleary, Callan, & Zimmerman, 2012). In this study, the context was learning veterinary psychomotor skills using veterinary simulators. Therefore, if the participants were overwhelmed by the content of the 45-minute intervention, and did not have the working memory or the time needed to apply the concepts to the simulators available at the intervention (despite a brief discussion about how they could apply the cycle to learning on these simulators), then this could be the reason that they did not adopt the SRL cycle into their development of psychomotor skills.

Another possible contention with the intervention was that it was not context-specific enough for suturing. The intervention included applying the broader concepts of
SRL to all psychomotor skills. When considering the work of Zimmerman and Kitsantas (1996, 1997), Kitsantas & Zimmerman (1998), and Cleary, Zimmerman, and Keating (2006), the strategic feedback for their novices was specific to the skill set that they were learning: either dart-throwing or basketball throws. During either the test or control interventions in the current study, however, there was no suturing exercise present; this was intentional, so that the students would try to apply the strategies to multiple simulators encountered in their psychomotor skill training, since this has been effective in similar contexts (Cleary, Callan, & Zimmerman, 2012). So, the contexts of putting an IV catheter into a model leg, giving injections into simulators, or performing a physical exam on a manikin (all available activities during the intervention) may not have represented close enough contexts for SRL of suturing – but they did represent the ‘close enough’ contexts for DP concepts to be effective for learning. Not having an actual suturing exercise present at the interventions also prevented a limited number of students from practicing suturing, when others may not have had the opportunity to do so in the short time frame of the intervention.

Extending the time of the intervention to an hour or dividing the intervention into multiple researcher-participant interactions to reinforce and support the application of these theories was considered; however, adding more participant time was considered a deterrent for student participation due to the intensity of the veterinary curriculum in second-year. Even keeping this research capped at two-hours of participant time resulted in a high attrition rate of the participants.
Attrition and Small Sample Sizes

The higher than expected attrition rate resulted in a less then ideal sample size and uneven group sizes. The smaller sample size resulting from the high nonresponse rate creates a bias in the statistical analysis and resulting inferences, so that the results are not representative of the population (Fowler, 2009).

The RA reported that 40 students were very eager and willing to sign up, but after a month of offering a multitude of times to perform the pre-test, only 30 students completed this activity and the rest were excused from the study (with their $5.00 Tim Hortons gift card). Of the 30 remaining participants, only 27 (divided into test and control group) actually attended their respective intervention meeting. The interventions were carefully scheduled to avoid major tests and assignments and offered a pizza dinner (with consideration for dietary restriction). The post-test, held over a two-month period to give the students time for major tests and exam, still resulted in further attrition of another seven participants. Although some attrition was expected (10 participants), the final number of participants that finished the pre-test, intervention, and post-test was only 22. The resulting small groups sizes and the difference in test group (n = 9) and control group (n = 13) sizes at the end of the study also affected the data analysis, making trends and findings impossible to extrapolate to the general population.

Participants

Another consideration for the total performance improvement in the control group (DP and simulation) could be the result of the skill level of the learners involved in this study. This population of students were novices at suturing, as determined by the pre-test. At the time of the pre-test, they had listened to lectures on suturing and had access to
video instruction, but had no curricular psychomotor skill lab time dedicated to suturing a suture pattern with the degree of complexity as the simple continuous suture line. They were in the observation phase of motor skill learning (Zimmerman, 2002), where they were learning by observing a model: in this case, the videos. When considering a perfect suturing exercise performance score of 63, the mean score for the control group was 27.9 and the test group was 33, meaning that neither group was performing the exercise well.

As their training progressed over time (four months), participants had the opportunity to practice suturing this simple continuous line in curricular labs with feedback from instructors, and on their own volition, either practicing on their own DASIE® or during extra-curricular activities such as surgery club; this would represent the emulation stage (Zimmerman, 2002). Their next step in skills development was the deliberate practice stage, with emphasis on self-monitoring and self-evaluation (Zimmerman, 2002), so learning and applying this theory during their curricular training was a natural progression after the emulation of their skills development. Considering the control group and test group both achieved similar post-test performance mean scores – 41.5 and 41.8, respectively – neither group were averaging close to a perfect score of 63.

Once a level of mastery and automation is achieved, a learner should employ SRL if challenged with a more difficult task involving the skill (Zimmerman, 2002), which is why the fidelity of the model was increased. It would be difficult to define automation of a skill without seeing multiple performances, or having a global rating score to evaluate the ease of performance along with the checklist for accuracy of performance. A global rating score was not included in the assessment of this study, as it would require more than the researcher to evaluate the videos and was thus beyond the scope of this research.
study. Even with the increase in model fidelity, the DP control group performed as well as the SRL and DP test group. Greirson (2014) states that the fidelity of a model should be based on challenges to information processing, so it is possible that the singular layer of silicone and the abdominal wall model did not challenge information processing enough to inspire SRL, and the learners were able to achieve their level of performance based on their deliberate practice skills alone. The real change in fidelity and challenge to information processing occurs when these students start to perform live surgery, and perhaps this is where the self-regulation skills of the test group should be evaluated.

Considering the results of participants’ self-assessments of self-efficacy for the three parts of the subcutaneous suture closure (initial knot, simple continuous, and final knot), their satisfaction with their performance and how capable they felt to transfer this skill to a live animal, both groups showed statistically significant changes for each step within their own group – thus indicating that the participants self-assessed themselves as becoming more capable by the post-test. There was no difference in self-assessment between the groups, so the intervention of SRL did not increase the test group’s confidence beyond that of the control group. This could reflect the short duration of the intervention or the level of learning that the participants were currently in, being the deliberate practice stage of their psychomotor skill development. The fact that they all believed that they were improving could be a result of their few attempts at this suture pattern during labs, and also the incremental gains made after a few more attempts at completing this suture pattern.

The effect of the intervention, however, did reflect in their survey answer responses. Both groups were mastery-oriented and improved at identifying learning
strategies, but they had difficulty identifying goals and making adaptive inferences, self-evaluating, and clearly defining areas of their suturing that detracted from their overall performance. Setting goals, self-evaluating, and analysis (reflection) are fundamental activities of DP (Ericsson, 2004); therefore, neither group demonstrated an improved understanding from either intervention regarding how this cycle supported their learning. Interestingly, even in third-year, the students (after they have performed live animal surgery in their surgical exercises course) still have difficulty defining what they have to ‘practice more’ when asked what they can improve on after each surgery. In particular, they have difficulty identifying specific areas of their performance that need improvement or making adaptive inferences, just as the second-year students did; and, this appears to detract from their ability to set new learning goals for themselves.

Making the transition to SRL can be difficult coming from an environment of didactic learning (Berkhout et al., 2016; White, 2007), as it does not just represent learning; it represents being self-aware of one’s learning (Brydges & Butler, 2012). This meta-level of learning awareness may be overwhelming for learners that are just in the early stages of skills development. Factors that may have contributed to the failure of the SRL group to surpass the DP group could be related to the intervention, and included factors such as cognitive overload for the participants in the test group, limited time to apply and discuss their SRL and DP strategies when practicing on the simulators, and lacking specific learning strategies to improve suturing performance. The attrition rate of participants, resulting in a small number of results and a disparity in size between the control group and test group, will decrease the ability to extrapolate these results to the population of the class. And finally, the novice level of participants in suturing made DP
the natural stage of development; the expectation of learners self-regulating their learning may be premature for the models used and the stage of skills development they are currently in (emulation and deliberate practice stage).

**Limitations of this Study**

The limitations of this study are the intervention and the greater than expected attrition of participants, thus resulting in a small sample size. The intervention was too short and limited in its ability to demonstrate adequate application of the SRL cycle to learning various psychomotor skills. The attrition of participants was beyond what was expected, and resulted in small group numbers and a difference in the post-test group sizes. The goal of the study was to have 30 students participate, which would have represented 25% of the class (population); some attrition was expected, so 40 participants were invited to join the study. A larger number of participants than expected did not finish the study, resulting in a response rate of 55% for the study: the response rate for the test group was 45%, and the response rate for the control group was 65%. Since so few finished the post-test, the statistical analysis is unlikely to represent the population (Fowler, 2009). As well, this study involved a representative group from only one class of veterinary students.

**Implications of this Research**

The effectiveness of SRL in improving both academic and psychomotor skill performance has been shown in numerous studies (Cleary & Sandars, 2011; Cleary, Zimmerman, & Keating, 2006; Ertmer, Newby, & MacDougall, 1996; Kitsantas & Kavussanu, 2011; Kitsantas & Zimmerman, 1998; Zimmerman & Kitsantas, 1996; Schunk & Ertmer, 2000). The fact that this study failed to demonstrate this effect is most
likely related to the intervention. The idea of delivering SRL strategies in a relatively
generic, tidy package is not effective for students to engage in or develop into self-
regulated learners. In a recent study of veterinary students’ use of metacognitive
strategies, Root Kustritz and Clarkson (2017) found that simply introducing a
metacognitive activity (in this study, exam wrappers) into the curriculum did not inspire
the students to actively plan, monitor, or adapt their exam study habits or achieve higher
exam grades. In fact, their study found that students often recognised poor study habits,
but never changed them from one exam to the next (Root Kustritz & Clarkson, 2017). A
similar finding was voiced by students in this study, where they would list the same
problems with their technique in both the pre- and the post-test surveys. Root Kustritz
and Clarkson (2017) recommend that metacognitive strategies be incorporated into the
learning outcomes of courseware. Similarly, SRL should be specifically delivered for
each psychomotor skill lab to contextualize the strategies and identify the challenges to
learning for each skill.

If SRL strategies – such as choosing a personal goal of practice, ways to self-
monitor and evaluate during the execution of the skill, and reflecting on the next steps to
take in personal skill development – were listed as a lab objective for each lab, then the
students could start to develop this cycle for themselves. It would also require educating
instructors in SRL and having them support this cycle with each student as they give
feedback. Instructors should also be aware of the theory of self-efficacy so that they can
support students’ self-efficacy, as this is tied to motivation to learn and continue to learn
(Schunk & Ertmer, 2000). Engaging students in SRL during labs, so that they are
recognising difference in their performance and directing their goals, could provide the
self-efficacy and motivation to go to the clinical skills lab to improve their skills on their own volition. If their practice were more goal-directed, then they could see improvement faster.

**Future Research**

Embedding SRL strategies, such as task analysis (goal-setting and strategy planning), self monitoring, and self-control, into learning objectives for a psychomotor skills lab is an important step in the development of SRL strategies; thus, researching best methods for this should be a priority. To support these objectives, making instructors aware of SRL and how to support student-centered learning using the SRL cycle could be explored. The connection between the instructor and student by recognising and valuing the student’s self-efficacy for a task will strengthen the student’s motivation and strategic behaviors, thereby promoting student-centered learning in a self-directed learning environment, such as a clinical skills lab. Future studies in the genre of veterinary education could involve promotion of SRL cycles in all second-year labs as part of the learning objectives for each lab, as this is the students’ year of novice learning based on observation, emulation, and deliberate practice. The test for SRL could be in their third-year of study when experiential learning has ‘higher stakes’ in live animal surgery. Although an actual test of suturing may be more difficult to assess, a more rigidly enforced activity log could reflect students’ thoughts of their own SRL. If activity log comments were related back to the formative grading on the rubric, then possible inferences between self-reported self-regulation strategies could be made regarding success in live animal surgery.
Conclusions

At the onset of this study, veterinary students were considered to have limitations to engage in self-directed learning because their curriculum was so didactically-based; they were very performance-oriented rather than mastery oriented and, in the context of veterinary-based psychomotor skill development, they were novices. It appears that participants did struggle with the concept of applying SRL cycle strategies to their psychomotor skill development, and that embedding this cycle right into the learning objectives for psychomotor skill labs could be more effective than presenting the SRL concept and its generalized application in a one time presentation.

Moreover, the participants in this study did seem to be focused on mastery of their skills rather than overall performance. This may have been due to the very focused task of the suturing exercise rather than an entire procedure, such as ovarianhystorectomy in a cat or dog. When considering the different approaches to learning between novice and experts, this study presented a very focused aspect of performance to master. Helping veterinary students to see a pathway from novice to competent mastery – or beyond, to expert levels – is to demonstrate ways that they can control their own learning and development. They need the skills to develop themselves as learners as much as they need to know how to suture an abdomen closed.
**References**


Greenfield, C. L., Johnson, A. L., & Schaeffer, D. J. (2004). Frequency of use of various procedures, skills and areas of knowledge among veterinarians in private small animal exclusive or predominant practice and proficiency expected of new veterinary school graduates. *Journal of the American Veterinary Medical Association, 224*(11), 1780-1787.


self-regulated learning across diverse disciplines: A tribute to Barry J.


Appendix A

Brock University REB Approval

[Image of Brock University REB Approval Certificate]

The Brock University Bioscience Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 8/16/2017 to 8/1/2018.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 8/1/2018. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at http://www.brocku.ca/research/policies-and-forms/research-forms.

In addition, throughout your research, you must report promptly to the REB:

a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
c) New information that may adversely affect the safety of the participants or the conduct of the study;
d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved:

Sandra Peters, Chair
Bioscience Research Ethics Board

Note: Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.
Appendix B

University of Guelph REB Approval

The members of the University of Guelph Research Ethics Board have examined the protocol which describes the participation of the human participants in the above-named research project and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement, 2nd Edition.

The REB requires that researchers:
- Adhere to the protocol as last reviewed and approved by the REB.
- Receive approval from the REB for any modifications before they can be implemented.
- Report any change in the source of funding.
- Report unexpected events or incidental findings to the REB as soon as possible with an indication of how these events affect, in the view of the Principal Investigator, the safety of the participants, and the continuation of the protocol.
- Are responsible for ascertaining and complying with all applicable legal and regulatory requirements with respect to consent and the protection of privacy of participants in the jurisdiction of the research project.

The Principal Investigator must:
- Ensure that the ethical guidelines and approvals of facilities or institutions involved in the research are obtained and filed with the REB prior to the initiation of any research protocols.
- Submit an Annual Renewal to the REB upon completion of the project. If the research is a multi-year project, a status report must be submitted annually prior to the expiry date. Failure to submit an annual status report will lead to your study being suspended and potentially terminated.

The approval for this protocol terminates on the EXPIRY DATE, or the term of your appointment or employment at the University of Guelph whichever comes first.

Signature: [Signature]

Date: September 19, 2017

L. Valls
Chair, Research Ethics Board-NPES
Appendix C

Pre-Test Survey Questions

Questions asked before suturing began:

1. “Using a scale of 0-10, where 10 is ‘completely capable’ and 0 is ‘completely incapable’, do you believe you are capable of learning the 3 parts of this suturing exercise today? Please indicate a number for:
   The first buried knot:
   The simple continuous line:
   The final buried knot:

2. “What is your learning objective in practicing this suturing exercise today?”

3. “What strategies do you use to learn suturing?”

Questions asked after the suturing was finished:

4. “While you were suturing, can you tell me: what is your self-talk during this suture pattern, that is what were you telling yourself?”
   “Did you identify any problems with any part of your technique, yes or no?”
   IF ‘yes’: “Did you adjust your technique to try and correct the problem(s) Yes or No?” If they indicated ‘no’ then move to question #5.
   IF ‘yes’: “If you adjusted your technique, what did you do? Explain a little bit more.”
   “How did the adjustment help?”

5. “Using a scale of 0-10, where 10 is completely satisfied and 0 is completely dissatisfied, how satisfied are you with achieving your learning objective, practicing this suture pattern during today’s exercise?”

6. “What criteria did you use to judge your degree of satisfaction?”

7. “Why do you think your subcutaneous closure turned out the way it did?”

8. “Using a scale of 0-10, where 10 is completely capable and 0 is completely incapable, to what level do you believe you can perform an acceptable closure of the subcutaneous layer of a live animal?”

9. “What are your next steps in learning this subcutaneous closure?” If they respond with the word ‘practice’ the following question is asked: “since you used the word ‘practice’ please define what this means to you?”
Appendix D

Post-Test Survey Questions

Questions asked before suturing began:

1. “Using a scale of 0-10, where 10 is ‘completely capable’ and 0 is ‘completely incapable’, do you believe you are capable of learning the 3 parts of this suturing exercise today? Please indicate a number for:
   - The first buried knot:
   - The simple continuous line:
   - The final buried knot:

2. “What is your learning objective in practicing this suturing exercise today?”

3. “What strategies do you use to learn suturing?”

Questions asked after the suturing was finished:

4. “While you were suturing, can you tell me: what aspects of the suturing were you thinking about?”
   “Did you identify any problems with any part of your technique, yes or no?”
   IF ‘yes’: “Did you adjust your technique to try and correct the problem(s) Yes or No?” If they indicated ‘no’ then move to question #5.
   IF ‘yes’: “If you adjusted your technique, what did you do?”
   “How did the adjustment help?”

5. “Using a scale of 0-10, where 10 is completely satisfied and 0 is completely dissatisfied, how satisfied are you with achieving your learning objective, practicing this suture pattern during today’s exercise?”

6. “What criteria did you use to judge your degree of satisfaction?”

7. “Why do you think your subcutaneous closure turned out the way it did?”

8. “Using a scale of 0-10, where 10 is completely capable and 0 is completely incapable, to what level do you believe you can perform an acceptable closure of the subcutaneous layer of a live animal?”

9. “What are your next steps in learning this subcutaneous closure?” IF they respond with the word ‘practice’ the following question is asked: “since you used the word ‘practice’ please define what this means to you?”
Appendix E

Single layer silicone subcutaneous model with 3-inch incision used in the pre-test.
Appendix F

Room and Set Up for the Pre- and Post-Test, Showing the Mounted GoPro
Appendix G

The Silicone Abdominal Wall Model Used in the Post-Test

The linea alba has been sutured closed (simple interrupted) as this was not a layer the participants were asked to close. The model is now ready to have the subcutaneous layer closed by the participants.
Appendix H

Scoring Checklist for Suturing Exercise

<table>
<thead>
<tr>
<th>Task</th>
<th>Total Per Task</th>
<th>Task</th>
<th>Total Per Task</th>
<th>Task</th>
<th>Total Per Task</th>
<th>Task</th>
<th>Total Per Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Burying the Initial Knot</td>
<td></td>
<td></td>
<td></td>
<td>Burying the Final Knot</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>a) Follow the prescribed pattern, (surgeon side) superficial-deep, (far side) superficial-deep</td>
<td></td>
<td>b) Ties the knot without half hitch or slip knot</td>
<td></td>
<td>c) Ties the trailing end with the correct (loop)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>b) Ties the knot on the correct side of the suture.</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>c) Ties 6 throws in the knot.</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Ties the first knot on the correct side of the suture.</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e) The next throw is deep to superficial on the surgeon’s side.</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Simple Continuous Suture</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) Uses the correct suture path; superficial-deep, deep-superficial.</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>b) Sutures far side to near side, pointing needle towards surgeon.</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>c) Takes even bites, with enough tissue.</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burying the Final Knot</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) Follow the prescribed pattern, (far side) superficial-deep, (surgeon side) superficial-deep</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Creates and maintains the deep loop</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) The next bite is superficial to deep</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) The trailing end comes out between the two loops</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e) Ties the trailing end with the correct (loop)</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>f) Places 7 throws</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>g) Ties knot without half hitch/slip knots</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assessment of Suturing in the Silicone</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) The first knot is buried</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) The incision edges are apposed</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) The final knot is buried</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Instrument Handling</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) Holds needle drivers correctly, thumb, 4th digit</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Holds forceps correctly, pencil grip</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time from start of the first knot to the end of the last knot</td>
<td></td>
<td>How many attempts?</td>
<td></td>
<td>How many attempts?</td>
<td></td>
</tr>
</tbody>
</table>
Appendix I

PowerPoint Presentation for Control Group
Why do we use simulators instead of animals?

- ANIMAL WELFARE-MORAL AND ETHICAL REASONS
- COMPETENCY-BASED EDUCATION
- SUSTAINABILITY

What types of simulators are there?

- Low to high fidelity
- Devices - task trainers (laparoscopy boxes)
  - computer-based simulators
- Scenario-based simulations
- Virtual reality-haptic systems

The Haptic Cow

https://www.youtube.com/watch?v=q1FkTXnftCg
**Why do Simulators and Simulation Improve Skill Acquisition?**

- Experiential - you actually get to experience the psychomotor skill
- Contextual - they represent a ‘real-life’ skill and scenario
- Repeatable - you can repeat the skill more than once
- Standardized - same to similar experience for everyone
- Feedback - from instructors, more experienced peers, review of literature/video.
- Often learning in a low pressure environment

**DOES PRACTICE MAKE PERFECT??**

- It depends on the type of practice....

- Simply repeating a task over and over again will only improve performance so far.

- Simple repetition may make the performance seem automated and effortless but how do you improve beyond that?

**DELIBERATE PRACTICE**  

Deliberate Practice is more effective at improving skill

It involves:
- Goal-directed practice
- Executing the task
- Monitoring the task you are performing
  - being aware of inaccuracies and either correcting them or getting feedback from an experienced mentor.
WHAT TYPE OF SIMULATIONS OR SIMULATORS HAVE YOU USED?
- DASIE®
- COMMUNICATIONS LABS
- SURGICAL ASEPSIS LABS

WHAT TYPE OF SIMULATOR WOULD HELP YOU LEARN?

IV CATHETERIZATION
- SIMPLE TAPING TASK SIMULATOR
- DOWELING SIMULATOR
- 3-D PRINTED LEG SIMULATOR
**INTRAMUSCULAR INJECTION TRAINER**
- SILICONE INJECTION PADS
- SILICONE INJECTION PADS MOUNTED ON CANINE OR FELINE SKELETON

**MANIKIN SIMULATORS**
- RESCUE CRITTERS
- SYNDACERS IN THE FUTURE
  [Image: http://www.thehomerzine.com/Horbie/AlbertaTheDog/AlbertaTheDog.html]

**LAPAROSCOPY TRAINING**
- TRAINING BOX
INTUBATION MODELS

- SILICONE DOG HEAD

WORKING IN 3 GROUPS, PLEASE DISCUSS AREAS OF PSYCHOMOTOR SKILL DEVELOPMENT WHERE YOU THINK DELIBERATE PRACTICE ON FOLLOWING SIMULATORS WOULD HELP YOUR LEARNING.

- Group 1- PHYSICAL EXAM ON A MANIKIN
- Group 2- IV CATHETERIZATION ON A SIMULATOR
- Group 3- INJECTIONS USING DIFFERENT INJECTION PADS

PLEASE CONSIDER WHAT YOU HAVE THOUGHT ABOUT AND LEARNED FROM TODAY’S PRESENTATION.

APPLY IT TO YOUR LEARNING OF PSYCHOMOTOR SKILLS HERE AT OVC.

IN A FEW DAYS YOU WILL BE EMAILED A ONE PAGE LOG TO FILL OUT OVER THE NEXT FEW MONTHS. IT SHOULDN’T TAKE MUCH MORE THAN A FEW MINUTES EACH TIME YOU FILL IT IN. PLEASE EMAIL IT BACK TO BROOKE GALLOWAY, MY RESEARCH ASSISTANT, AS SOON AS POSSIBLE AFTER YOUR POSTTEST IN LATE FEBRUARY, EARLY MARCH.

THANK YOU FOR COMING IN TODAY AND PARTICIPATING IN THIS STUDY
Appendix J

PowerPoint Presentation for Test Group

- How do you decide what to learn?

- Do you determine strategy to use for learning?

Do you believe that you have the ability to develop and implement a plan of action to obtain a desired performance level?

Making Practice Matter

FORETHOUGHT Phase

PLANNING

Self-efficacy
• How are you self-observing your learning technique?

DOES PRACTICE MAKE PERFECT??

• It depends on the type of practice....

• Simply repeating a task over and over again will only improve performance so far.

• Simple repetition may make the performance seem automated and effortless but how do you improve beyond that?

Deliberate Practice is more effective at improving skill than just repeatedly performing a task.

It involves: 1. Task-directed practice
            2. Executing the task
            3. Monitoring the task you are performing
            - being aware of inaccuracies and either correcting them or getting feedback from an experienced mentor.
WHILE YOU ARE LEARNING....
Are you using **Self-control**?

[Image of a dog holding a bone in its mouth with a link to a website: http://www.tssavon.ch/]

- How do you reflect on your results, during or after a PRACTICE SESSION?

[Image of a cat looking into a mirror with a link to a website: https://www.jennyhobkirk.com/tororo-crystal-ball-and-secrets-pull-10-of-15/]

**Making Practice Matter**
APPLICATION OF TASK STRATEGIES:
- Attention
- Focusing
- Self-talk
- Imagery

PRACTICE/LEARNING /PERFORMANCE
Phase

**Making Practice Matter**
SELF-SATISFACTION

ATTRIBUTION **

SELF-EVALUATION

- Poor Performance?
THINK STRATEGY USE
AFTERTHOUGHT Phase

**MAKING PRACTICE MATTER**
The
SELF-REGULATED LEARNING CYCLE
• Does this cycle of learning seem intuitive to you?

• Is it applicable to learning psychomotor skills such as IV catheterization, physical exam or surgery?

• How do SIMULATORS in veterinary medicine help us with practice and learning psychomotor skills?
  • They allow learning to be:
    • Experiential
    • Contextual
    • Repeatable
    • Standardized
  • Occurs in a learning environment that is low stress and where feedback from peers or mentors can be available.
  • ‘MISTAKES’ are OK

• ONE OTHER THING TO CONSIDER....
  ARE YOU CURRENTLY
  A NOVICE OR AN EXPERT
  at veterinary psychomotor skills?

  Why is it important to make this distinction?
<table>
<thead>
<tr>
<th>NOVICE</th>
<th>EXPERT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>Set hierarchical goals</td>
</tr>
<tr>
<td></td>
<td>*set process goals that advance to outcome goals</td>
</tr>
<tr>
<td>Strategy</td>
<td>Good understanding of strategies to achieve goals</td>
</tr>
<tr>
<td>Self-monitoring</td>
<td>Strong self-observers</td>
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<tr>
<td></td>
<td>Self-evaluate their performance in comparison to their own goals</td>
</tr>
<tr>
<td>Attribution</td>
<td>Make STRATEGY attributions rather then ABILITY attributions.</td>
</tr>
<tr>
<td>Reflection</td>
<td>Good at detecting subtle progress</td>
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</table>

• How can novices use self-regulated learning to be more effective learners? ????

• Let's find out 😊

• LET'S THINK ABOUT HOW THE SELF-REGULATED LEARNING CYCLE
APPLIES TO PRACTICING AND
LEARNING PSYCHOMOTOR SKILLS
  • PHYSICAL EXAM ON A MANIKIN-Group 1
  • IV CATHETERIZATION ON A SIMULATOR-Group 2
  • INJECTIONS USING DIFFERENT INJECTION PADS-Group 3

MAKING PRACTICE MATTER

WORKING IN GROUPS OF 5, PLEASE DISCUSS EACH PHASE OF THIS CYCLE AS IT WOULD RELATE TO LEARNING A VETERINARY PSYCHOMOTOR SKILL.
WRITE DOWN WHAT YOU WOULD BE THINKING OR ASKING YOURSELF IN EACH PHASE. THESE WILL BE SHARED WITH THE WHOLE GROUP.
SELF-REGULATED LEARNING AND PSYCHOMOTOR SKILL DEVELOPMENT

- PHYSICAL EXAM ON A MANIKIN:

- FORETHOUGHT:

- PRACTICE:

- AFTERTHOUGHT:
• IV CATHETERIZATION ON A SIMULATOR

• FORETHOUGHT:

• PRACTICE:

• AFTERTHOUGHT:

• INJECTIONS ON AN DIFFERENT INJECTION PADS

• FORETHOUGHT

• PRACTICE

• AFTERTHOUGHT

THANK YOU FOR COMING TODAY

• PLEASE CONSIDER WHAT YOU HAVE LEARNED AND THOUGHT ABOUT TODAY

• APPLY IT TO YOUR LEARNING OF PSYCHOMOTOR SKILLS HERE AT OVC

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Appendix K

Take-Home Handout for the Control Group

Why do Simulators Improve Skill Acquisition?

- Experiential—you get to experience the psychomotor skill
- Contextual—they represent a ‘real-life’ skill
- Repeatable—you can ‘practice’ the skill more than once
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- Usually learning in a low-pressure environment

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Appendix L
Take-Home Handout for the Test Group

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## Appendix M

### Activity Log

**ACTIVITY LOG**

Research participant ID number: __________

<table>
<thead>
<tr>
<th>Skill #1</th>
<th>Where am I now?</th>
<th>Goal</th>
<th>Learning Strategy(s)</th>
<th>Reflections</th>
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<th>Reflections</th>
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<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Skill #3</th>
<th>Where am I now?</th>
<th>Goal</th>
<th>Learning Strategy(s)</th>
<th>Reflections</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Time spent on learning this skill: ______ (minutes)</td>
</tr>
</tbody>
</table>

After Event #3, please email this completed Activity Log back to the Research Assistant, Brooke Galloway at vgallowa@uoguelph.ca.