A CRITICAL REAPPRAISAL OF SELF-LEARNING IN HEALTH PROFESSIONS EDUCATION: DIRECTED SELF-GUIDED LEARNING USING SIMULATION MODALITIES

by

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Abstract

Context: Self-learning (i.e., students learning independently) and clinical simulation are essential components in contemporary health professions education (HPE). Self-learning is discussed often, yet the concept is seldom the target of rigorous study. Likewise, simulation modalities are abundant, though educational theory that guides their use in HPE remains elusive.

Objectives: This dissertation investigates the effects of directed self-guided learning (DSGL) on novice health professions students’ skill acquisition, retention, and transfer in the context of simulation-based education. The objective is to explore how the combination of external direction and student self-guidance influences: students’ cognitive and metacognitive processes, students’ interactions with the learning environment and available resources, and how students learn in different DSGL contexts.

Methods: Three research studies used randomized, controlled experimental designs to address five hypotheses. All studies included a performance assessment one-week after the initial practice session that evaluated skill retention and/or skill transfer. Data analysis employed univariate and multivariate analyses of variance and correlational techniques.

Results: Regarding students’ cognitive and metacognitive processes, the data show a relation between DSGL and goal-setting. The results suggest that self-guided students benefit when they are directed to set goals related to performance processes, rather than performance outcomes. Regarding the learning environment, when students are directed to practice on simulators that
increase progressively in fidelity (i.e., realism) they self-guide their advancement between those simulators effectively and display successful skill transfer. Finally, self-guided students that controlled their learning progression and learning sequence selected the theoretically most appropriate practice schedule (i.e., progressive learning). Students in this latter group seemed able, surprisingly, to direct their own self-guidance.

Conclusions: This dissertation adds support to the hypothesis that self-guided students benefit due to their autonomy in controlling practice conditions to meet their own learning needs. Thus, the question of whether or not DSGL is effective, becomes how best to augment the DSGL experience. The instructional design of elements such as goals lists and task structuring (e.g., progressive increases in simulator fidelity) represent techniques that an educator can use to fulfill the role of director in a student’s SGL.
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List of Abbreviations

ANOVA – analysis of variance
CL – checklist
CPF – challenge-point framework
DOPS – direct observation of procedural skills
DSGL – directed self-guided learning
GRS – global rating scale
HPE – health professions education
HPS – human patient simulator
ICSAD – imperial college surgical assessment device
ICC – intraclass correlation
IPPI – integrated procedural performance instrument
IV – intravenous
KP – knowledge of performance
KR – knowledge of results
MANOVA – multivariate analysis of variance
OSCE – objective structured clinical examination
OSATS – objective structured assessment of technical skills
PBL – problem-based learning
SCM – simplifying conditions method
SP – standardized patient
SDL – self-directed learning
SRL – self-regulated learning
SGL – self-guided learning
VR – virtual reality
ZPD – zone of proximal development
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CHAPTER 1: GENERAL INTRODUCTION

Health professions education (HPE) has historically used apprenticeship training strategies in which students learn from experienced clinical educators. Clinical educators are often content experts who analyze a task or problem and create a plan on how to teach students at various levels of knowledge and ability. While task-analysis is a necessary skill, educators must also analyze students’ level of understanding and performance characteristics (Irby, 1992; Irby, 1994; Wood, Bruner, & Ross, 1976). Combining task- and student-analyses, clinical educators can tailor instruction and training interventions to students’ needs (Irby, 1994; McMorris & Hale, 2006). The most effective clinical educator will analyze the task and the student accurately. However, it is the unfortunate case that clinical educators do not have enough time to do so for every student. Therefore, alternative training strategies must be developed to close the inevitable gaps of apprenticeship training.

1.1. Self-Learning and HPE

Learning can be defined as the process by which an individual’s skills, knowledge, and/or attitudes change. In this introductory section, the general term ‘self-learning’ will be used to describe the scenario in which a student learns independently. As the section continues, additional terms and historical factors will be introduced and used to show how this generic definition of self-learning has evolved in HPE. To date, self-learning has been hailed as an effective educational strategy that can help reduce the demands on clinical educators (ACGME, 2002). Health professions students are exposed to many contexts where they engage in self-learning. While these opportunities are traditionally available for learning cognitive skills (e.g., textbook learning), self-learning is now becoming a viable approach for the learning of clinical technical skills (e.g., suturing and knot-tying) (Jowett, LeBlanc, Xeroulis, MacRae, & Dubrowski, 2007). However, more work is needed to understand the
utility of self-learning for students practicing clinical technical and non-technical skills (e.g., practitioner-patient communication) because a recent systematic review suggests that students and clinicians do not accurately self-assess their level of ability in these domains (Davis, Mazmanian, Fordis, Van Harrison, Thorpe, & Perrier, 2006). If we cannot rely on students to accurately self-assess their learning progress and levels of ability, then the emphasis on self-learning in HPE may be misguided. Clearly there is a need to address this disconnect between rhetoric and practice in the HPE context.

HPE research studies typically investigate self-learning in the macro-instructional conditions of students’ daily education and training. Kennedy, Regehr, Baker and Lingard (2005), for example, discuss the validity of progressive independence, whereby students are given increasing autonomy in their daily clinical responsibilities as their expertise increases. Studies of progressive independence suggest that students and supervisors work collaboratively to achieve a proper balance between autonomy and guidance (Kennedy et al., 2005). Clinical educators must recognize that the concept of progressive independence is relevant not only to students’ clinical responsibility, but to all aspects of clinical training (Gofton & Regehr, 2006).

Relatively few studies have concentrated on self-learning in micro-instructional conditions, for example when students learn a clinical skill using simulation modalities (i.e., simulators). Simulation can be defined as an instructional process that substitutes real patient encounters using live actors, artificial models and/or virtual patients for the purpose of learning and/or assessment (Gaba, 2004). The recent purchase and use of simulators in the HPE curriculum has created ample self-learning opportunities. In particular, simulation centres offer students the context and technology to practice clinically relevant skills repetitively and safely. Though this expansion in learning possibilities is promising, research that creates and
evaluates self-learning interventions in simulation-based education is lacking. A recent systematic review of nursing simulation research, for instance, showed that only 13% of eligible papers referenced learning theory (Kaakinen & Arwood, 2009). Faculty appear to be using simulation in a teacher-centred rather than a learner-centred manner, a strategy that must shift if simulation is to be effectively used to enhance students’ conceptual learning. Kaakinen and Arwood’s (2009) findings highlight the need for this shift, which applies broadly to the field of HPE and supports the focus of this dissertation: to clarify the study of self-learning in the micro-instructional context of simulation-based education.

One contributing issue to the self-learning research gap is a problem of definition. In the education literature the umbrella term of self-learning has been developed into two specific lines of inquiry: self-directed learning (SDL) and self-regulated learning (SRL). Definitions of SDL and SRL and issues associated with the two terms are provided in Table 1.

Regarding SDL, Garrison (1997) discusses how researchers have traditionally defined the construct in terms of external control and facilitation, rather than with the student’s internal cognitive processing and learning in mind. Problem-based learning (PBL), for example, is often described as an educational approach that creates opportunities for students to be self-directed as they develop, refine and share knowledge in a particular field of study. While this emphasis on external management of the learning process is not present in all descriptions of SDL, the majority of research and educational applications of SDL theory has been skewed in that direction (Garrison, 1997). In addition, a systematic review of medical education manuscripts published between 2000 and 2004 (Ainoda, Onishi & Yasuda, 2005) found that only 8% of articles defined SDL explicitly. Researchers who fail to define a term force readers to derive their own definitions (Schunk, 2008). Leaving out a definition can be a perilous approach as definitions can become muddled quickly. Even when researchers define SDL
explicitly, the definition often suffers from a lack of theoretical perspective and, ultimately, does little to inform how to use the concept to design and test educational interventions. For present purposes, a small follow-up to Ainoda et al. (2005) used OVID Medline to search for articles from 2004-2009 using: ((self-direct* or self-regul* or self-guid*) and learning). Of the 426 results, 100 abstracts referred to health professions students in an experimental context. Inspection of the 100 abstracts revealed that 61 articles mentioned SDL and/or SRL with no reference to theory, and 31 articles referenced scales or inventories, adult learning theory, and other theories that lack extensive empirical evidence (Ende, 1995; Norman, 1999). Only eight articles named an established theory (e.g., cognitive load theory) and outlined its use for the study of SDL or SRL. This follow-up highlights the continued theoretical gap in the study of SDL and SRL in HPE.

Regarding SRL, it could be argued that researchers interested in this definition of self-learning have produced a much broader empirical evidence base than that of SDL (e.g., Zimmerman & Schunk, 2001). SRL researchers traditionally concentrate on student characteristics and how students cognitively and metacognitively respond to different educational interventions. Researchers pay less attention, however, to how SRL theory can contribute to the design of learning environments (Loyens et al., 2008). Comparing the SDL and SRL literature, one can see that the two research traditions not only differ in terms of terminology preferences, but also differ in where the emphasis is directed when studying how students learn independently – SDL focuses on external control and facilitation, whereas SRL focuses on how students internalize knowledge and skills.

This dissertation aims to argue that SDL researchers’ emphasis on external control and facilitation and SRL researchers’ emphasis on how students respond and adapt to independent learning should not be mutually exclusive. That is, the present series of studies on self-learning
in the context of simulation-based education demands consideration of the student, the educator and the learning environment.

Table 1: Overview of self-learning terminology used in this dissertation.

<table>
<thead>
<tr>
<th>Definition</th>
<th>Self-Directed Learning (SDL)</th>
<th>Self-Regulated Learning (SRL)</th>
<th>Directed Self-Guided Learning (DSGL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>a scenario in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes (emphasis added; Knowles, 1975).</td>
<td>a scenario in which a student self-generates thoughts and behaviours that are systematically oriented toward the attainment of learning goals (Schunk, 2001).</td>
<td>a scenario in which students are active motivationally, behaviourally, and metacognitively in their own learning process (Zimmerman, 1989), and that involves collaboration with instructional agents, who help direct the student but do not set the conditions for practice and learning exclusively.</td>
</tr>
<tr>
<td><strong>Issues</strong></td>
<td>Used widely in the HPE literature to describe far too many concepts (Ainoda et al., 2005). Assumes that as human’s develop so too does our ability to self-direct our learning (Knowles, 1975). Lack of empirical evidence to support adult learning assumptions (Norman, 1999). Assumption that students can diagnose learning needs and formulate effective goals without help goes against the self-assessment literature and is particularly dangerous in a field like HPE.</td>
<td>SRL theory concentrates on student characteristics, rather than on design features of the environment (Loyens, Magda &amp; Rikers, 2008). Description of the interaction between cognitive, behavioural and environmental characteristics is considered only for the student and the educator’s role is not always considered.</td>
<td>Is a new term necessary? Is DSGL sufficiently different from SDL or SRL?</td>
</tr>
</tbody>
</table>

1.2. A Critical Reappraisal of Self-Learning in HPE

Traditional definitions of SRL focus on the individual student and pay less attention to students’ interactions with peers, teachers and environments. Knowles’ (1975) definition of
SDL appears to consider these external factors, but as outlined above SDL has been fraught with problems of definition and a lack of rigorous empirical support (Norman, 1999). Rather than viewing self-learning as an all-or-none activity with respect to collaboration with an educator, this dissertation defines self-learning as falling on a continuum with self-guidance and other-guidance at the two extremes (Hadwin, Wozney, & Pontin, 2005; Kaplan, 2008; see also Figure 1). Due to the identified shortcomings of the SDL and SRL literature, this dissertation introduces a novel model of self-learning – directed self-guided learning (DSGL). DSGL refers to a scenario in which students are active motivationally, behaviourally, and metacognitively in their own learning process (Zimmerman, 1989), and that involves collaboration with instructional agents, who help direct the student but do not set the conditions for practice and learning exclusively. Importantly, this new model gives the student and the ‘director’ equal responsibility for optimizing the DSGL process. Therefore, the DSGL model has two vital components: 1) an active and engaged student who is committed to learning and 2) a director who draws on learning theory to create an educational experience that enhances the student’s success in self-guided learning (SGL). As students shift along the continuum from self-guided to other-guided (Figure 1), their control over learning changes and so does their ability to select the content for learning, to choose and employ different learning strategies, and to evaluate their learning needs (Loyens et al., 2008). While this new conceptualization of DSGL borrows heavily from the SRL literature, the explicit incorporation of the environment and the instructional agent creates a new perspective. In sum, the general aim of this dissertation is to explore DSGL in simulation-based education.

Please note that in this dissertation there is no intention to design a theoretical model with diagrams that attempt to describe DSGL and the complex interactions that accompany the process. Instead, a staged approach will be followed to understand how certain components of
DSGL (i.e., practice conditions, goal-setting, effects of gradual changes in task structure, comparisons between different DSGL approaches, and the behaviours that surface in a DSGL environment) can be manipulated and tested.

Figure 1: Depiction of the self-guided — other-guided learning continuum. Marked along the continuum are SRL, PBL as one application of SDL, as well as the ideal for the new model of DSGL.

1.3. Overview

Recently, the recommended format for a dissertation has been broadened to include the ‘paper format’. Used here, this dissertation is organized as a series of self-contained chapters representing submitted and published manuscripts in the HPE literature. Framed by an in-depth literature review that provides a common background, three subsequent chapters each
contain a manuscript that reports the results of a particular study. Because the three manuscripts touch upon slightly different aspects of the overall dissertation, a transition section is provided at the beginning of each chapter to assist the reader in forming links between them.

The literature review chapter (Chapter 2) provides a scholarly review of the background to this dissertation. The dissertation is framed within literature that addresses the basic science domains of psychology, kinesiology and motor learning and the applied fields of educational psychology, instructional design and HPE. The review aims to reveal a history of research that may allow contemporary HPE researchers to reappraise and refocus the self-learning research agenda. Links between theories of learning and simulation modalities are discussed with particular focus on clinical skill training.

The research aims and hypotheses chapter (Chapter 3) frames the general aims of the dissertation and outlines the specific hypotheses about the nature of DSGL. Hypotheses are stated explicitly along with a brief discussion of how each manuscript addresses the aims.
CHAPTER 2: LITERATURE REVIEW

2.1. Simulation as an Educational Tool in HPE

Joe arrives for his weekly practice session at the local simulation centre.

In today’s class, all students will practice suturing on an artificial skin
pad. A clinical educator demonstrates several techniques and then visits
with Joe to see how his practice is advancing. After one-hour of practice
and one or two visits from the educator, Joe’s formal practice of suturing
is complete and subsequent classes will focus on other skills such as
casting and laparoscopic skills.

This example represents present day simulation-based education – the educator has
limited time to provide Joe with the feedback he needs, and Joe often leaves wondering about
his performance level. The problems that Joe and his peers face are not uncommon. What
follows is a brief history of simulation in HPE and an elaboration on three perspectives that
address how simulation can be used to advance the learning of health professions students.

2.1.1. Simulation history and typologies

Simulation modalities have a long legacy of educational use. Examples include flight
simulators for airline pilots and astronauts, war games for soldiers and disaster management
experiences for nuclear plant personnel. Historically, simulation has been used in these
settings for training and evaluation purposes. In HPE, the use of simulation modalities has
varied, with some specialties conducting more research and using the technology for more
purposes than others. Nevertheless, over the past two decades simulation has quickly become a
favored tool for health care professionals’ training and assessment (Aggarwal & Darzi, 2006;
Keebeone et al., 2004; Reznick & MacRae, 2006). Simulations can be experienced in self-
guided and group learning contexts, depending on the desired learning objectives. For the purpose of this dissertation, simulation is defined as the replication of a task or an event for the purpose of teaching and/or evaluation (Gaba, 2004).

A wide variety of simulators are used in HPE, thanks in part to the rapid increase in technological innovations in the fields of computer science and engineering. Though a common classification system is absent, several authors have created their own simulator typologies (Decker, Sportsman, Puetz, & Billings, 2008; Reznick & MacRae, 2006). The range of simulator types includes part task trainers, computer-based programs, virtual reality, high-fidelity human patient simulators, standardized patients and the Integrated Procedural Performance Instrument (IPPI).

Part task trainers are inanimate bench models or mannequins made from synthetic materials to replicate a specific anatomical region of the body. Typically, part task trainers are used to train a solitary skill (e.g., suturing) that has been isolated from a complex task (e.g., suturing with patient interaction). Computer-based and web-based simulations offer students the opportunity for discovery learning of human physiology or pharmacology either independently or in groups (Decker et al., 2008; Maran & Glavin, 2003). Virtual reality simulators are an offshoot from the gaming industry and provide students with realistic graphics and multiple patient cases (e.g., insert intravenous catheters on young and old patients). High-fidelity human patient simulators (HPS) are computerized mannequins that look like real patients and are programmed to respond physiologically and (somewhat) behaviourally to students’ actions (Decker et al., 2008). High-fidelity HPS’ allow students to work in teams to manage patients and offer unique opportunities to practice emergency situations such as cardiac arrest. Standardized patient (SP) simulations involve a paid actor or volunteer portraying a patient (Decker et al., 2008). Standardized patients allow the student to
practice skills such as communication, patient interviewing and physical assessment. Finally, an IPPI simulation combines a part-task trainer or piece of medical equipment with a SP, which allows students to practice invasive procedures while also practicing communication and other ‘non-technical’ skills.

Each simulator type can be associated with a range of advantages and disadvantages. Generally speaking, part task trainers are inexpensive and reusable though issues include student acceptance and the restriction of training to simple skills (Decker et al., 2008; Reznick & MacRae, 2006). Virtual reality and computer-based simulations usually provide objective evaluations of student performance, are reusable and easy to setup, but some are not ‘user friendly’ and they are often costly to purchase and maintain (Reznick & MacRae, 2006). The human patient simulator (HPS) offers a realistic training mode that is interactive for the student and is also reusable. However, educators typically do not take the time to design informative patient cases for the HPS and the initial/maintenance costs are prohibitive for many institutions (Decker et al., 2008; Reznick & MacRae, 2006). Standardized patients (SPs), due to their immersive qualities, have become accepted as a gold standard training and assessment tool. Issues with SPs include student and actor responses to the roles (e.g., suicidal patients), difficulties replicating invasive procedures, and the cost- and time-intensive process required to design and implement SP simulations. Finally, IPPI simulations are beneficial because the student can practice invasive procedures while also interacting with the SP to create a realistic patient encounter. However, IPPI simulations are very cost- and time-intensive and require expertise in scenario design, student assessment, and the training of SPs.

2.1.2. Simulation-based education

When working in the clinical environment, students must place patient needs ahead of their own learning needs (Kennedy et al., 2005; Kneebone, 2003). Calls for educational
alternatives that provide a student-centred focus have led to a shift in how simulation is used in HPE. Benefits of simulation include the ability to learn about rare events, repetition of cases and experiences (i.e., deliberate practice), and learning from errors without harm to patients (Beyea, von Reyn, & Slattery, 2007). Additional advantages of simulation include the ability to learn in a self-paced manner (Beyea et al., 2007), to apply theory to practice prior to clinical experience (Rauen, 2004), and to provide remediation for students (Haskvitz & Koop, 2004). While the potential benefits of simulation are numerous, these positive aspects draw attention away from how educators can integrate simulation into contemporary curricula. That is, lists of benefits do not allow educators to answer the what, when, who, where and how of simulation-based education.

Simulation is not education, simulation enables education. Medical simulation pioneer David Gaba stresses that simulation should be viewed as an educational approach, not a technology (Gaba, 2004). Clearly, however, people at all levels of administration, education and research have been seduced by technological opportunism. That is, technologies, rather than innovations in instruction and learning theory, have driven educational change (Kneebone, 2005; Winne & Stockley, 1998). New simulators are purchased annually, yet lie under-utilized due to the lack of faculty who are aware of the educational principles that underpin simulation (Maran & Glavin, 2003). Advances in technological innovation have surpassed advances in instructional design and researchers must acknowledge and address this problematic disconnect.

Advocates of a theory-based approach to using simulation in HPE are common (Decker et al., 2008; Kneebone, 2005; Kneebone et al., 2004; Maran & Glavin, 2003). Few advocates, however, subsequently test the effectiveness of their proposed blend of theory and simulation. Some suggest that this lack of research may be due to the time- and resource-intensiveness of
developing patient simulations (Radhakrishnan, Roche, & Cunningham, 2007). Research is certainly a time-intensive process, but researchers interested in promoting simulation-based education must address the lack of theoretically-driven work in this domain. Some scholars who have proposed and completed research on their simulation approaches will be discussed below.

2.1.3. Integrated Procedural Performance Instrument (IPPI)

Recently, Kneebone and colleagues (Kneebone et al., 2006; Kneebone, Bello, Nestel, Yadollahi, & Darzi, 2007; Nestel, Kneebone, & Kidd, 2003) developed an approach to simulation-based education that aims to give technical skill and professional behaviour equal value during training. Many training approaches involve reducing procedural skills to part-skills (e.g., psychomotor, cognitive or communication skills) and teaching students each skill separately. Kneebone et al. (2006) believe students will benefit most if they practice an integrated set of procedural skills in an authentic context. Assigning such a critical role to context, Kneebone et al. (2006) identify concepts from cognitive and constructivist psychology (Bruner, 1996; Tharp & Gallimore, 1988; Vygotsky, 1978) as their theoretical basis. IPPI designers believe that a highly contextualized simulation experience will allow students to generate knowledge and meaning that will be transferrable to real patient encounters (Nestel et al., 2003).

Kneebone et al.’s (2006) IPPI approach achieves the desired sense of realism by combining SPs with simulators or pieces of medical equipment. As the student performs a procedure, the fully briefed SP creates a patient encounter that is highly realistic. Expert clinical raters assess student performance either in real-time, from behind mirrored glass, or from a videotape. The SPs may also provide feedback to the student. Kneebone et al. (2006) suggest that this type of simulation emphasizes the need for students to concentrate on
technical, interpersonal and communication components when preparing for a patient
encounter. SPs may also be trained to provide real challenges for the student, such as how to
calm a combative or drunk patient when completing a procedure. Contextualized practice in
IPPI scenarios is meant to improve skill transfer to the clinical setting and to consistently
challenge students, which often does not happen if practice is limited to chance patient cases
(Kneebone et al., 2006; Nestel et al., 2003). Initial research on the IPPI approach indicated that
it is a feasible training method that was well-received by both students and faculty (Kneebone
et al., 2006; Kneebone et al., 2007).

Typically, the IPPI is an examination in which the student performs in a number of
scenarios and receives ratings and feedback at the end of the day. The IPPI protocol makes use
of a variation of the assessment method called the Direct Observation of Procedural Skills
(DOPS; Appendix V). DOPS was developed and is now used in residency training by the
Royal College of Physicians in the United Kingdom. Using the DOPS, a rater assesses several
components of performance including interpersonal skills, technical ability, communication
skills, situational awareness and patient safety. DOPS is typically used in workplace
assessment of procedural skills performed on real patients. Kneebone and colleagues use the
DOPS for their IPPI scenarios to emphasize that even in a simulation students should use an
integrated approach to skill performance.

Specific psychometric testing of DOPS is limited in the literature, though recent studies
suggest the tool has strong reliability (Wilkinson, Crossley, Wragg, Mills, Cowan, & Wade,
2008). While there is a need for further psychometric testing, DOPS has been accepted as a
tool with good face validity and reliability because it was developed using the large evidence
base on global ratings of procedural skills in surgery and medicine (Norcini & McKinley,
2007; Wilkinson et al., 2008). Because the IPPI designers use a modified DOPS form, it will
be referred to as the IPPI rating tool in this dissertation. Additional studies on the entire IPPI approach have verified the psychometric properties of IPPI scenarios for training technical (LeBlanc et al., 2009) and communication skills (Moulton et al., 2009). Based on these positive findings, the IPPI approach and IPPI rating tool will be used in this dissertation to evaluate students’ ability to transfer the skills they learn in a DSGL setting.

2.1.4. Simulator fidelity and ‘Dynamic fidelity’

The term simulator in the HPE context is often linked to the term fidelity, which refers to how closely a simulator replicates reality (Alessi, 1988). Most HPE researchers typically study whether a simulator’s fidelity should be high or low when teaching clinical skills. In opposition to this comparative approach, Alessi (1988) suggests that one fruitful method may be to link simulator fidelity to the student’s level of ability. Specifically, Alessi (1988) suggests that fidelity can be increased as students progress through a training regime, an approach that he calls ‘dynamic fidelity’ and which draws from principles of the spiral curriculum (Bruner, 1996) and elaboration theory (Reigeluth, 1992).

Within the dynamic fidelity approach, Alessi (1988) suggests that low-fidelity and high-fidelity simulators each have their best uses. Low-fidelity simulators may result in substantial performance gains because they focus on a few critical elements in a simplified manner, allowing students to understand how all elements can be integrated (Thiagarajan, 1998). Conversely, high-fidelity simulators may not suit novice students because high-fidelity often means high-difficulty, which can overload students’ cognitive abilities (Alessi, 1988). A combination of low-fidelity and high-fidelity simulators may be most suitable for simulation-based education. Several authors have advocated for a graduated use of simulation, particularly when it comes to simulators that differ in fidelity. Most have echoed Alessi (1988) and recommend a progressive learning approach to training with increasing levels of simulator
fidelity and difficulty as the student’s abilities improve (Kneebone et al., 2004; Maran & Glavin, 2003).

In the HPE literature, researchers typically compare low-fidelity with high-fidelity simulators. Many researchers suggest that low-fidelity simulators’ lack of realism will prevent skill transfer to clinical practice (Seropian, Brown, Gavilanes, & Driggers, 2004). Others believe that “in order to implement simulation for teaching, learning and assessing practical skills it must reflect reality, which is referred to as fidelity” (McCallum, 2007, p. 826). This particular definition of fidelity may be misunderstood because it implies that fidelity only describes simulations that are most realistic or highest in fidelity. Unfortunately, this misconception is widespread. A recent literature review of ‘all randomized controlled trials and quasi-experimental trials’ carried out between 1969 and 2003 limited eligible studies to those using high-fidelity simulation only (Issenberg, McGaghie, Petrusa, Lee Gordon, & Scalese, 2005). Conversely, one recommendation for evaluating the overall purpose of simulation is that “…high-fidelity simulators cannot be regarded as ‘better’ than low-fidelity simulators and the choice of degree of fidelity is merely an issue concerning the objectives of the learning process” (Thiagarajan, 1998, p. 37). Indeed, research in medical education has shown that high-fidelity and low-fidelity simulators can have equally positive impacts on learning for novice students (Grober et al., 2004; Matsumoto et al., 2002; Sidhu, Park, Brydges, MacRae, & Dubrowski, 2007). Once more the rhetoric in HPE does not match the evidence base, which demonstrates the need to further investigate the educational use of simulators that differ in fidelity.

Rather than use Alessi’s (1988) term ‘dynamic fidelity’, the more general phrase ‘progressive learning’ will be used to describe a simulation-based training approach with incremental increases in simulator fidelity. Concepts like progressive learning must be
continuously scrutinized before, during and following their application to educational design. An example of researchers moving quickly from theory to curricular design is the ‘strong’ link proposed between SDL theory (Knowles, 1975) and the use of simulation. Maran and Glavin (2003, p. 23), for example, state that “…this process of experience followed by reflection illustrates how simulation addresses many of the principles of adult learning and can contribute to the experiential learning cycle.” Maran and Glavin (2003) are not the only authors to make such statements that are intuitive, yet lack clear empirical support. Designers of PBL curricula used many principles of adult learning theory and experiential learning.

Decades later, systematic reviews of the literature suggest that PBL is no more effective than traditional training procedures (Koh, Khoo, Wong, & Koh, 2008; Williams & Beattie, 2008). Progressive learning may not be as substantial an innovation as PBL, but it deserves the same level of scrutiny. Preliminary evidence for the utility of progressive learning is available (Alessi, 1995; Dubrowski, Park, Moulton, Larmer, & MacRae, 2007; Quinn, Peña, & McCune, 1996). Although the evidence base is building, this dissertation will test the progressive learning approach in an effort to confirm its efficacy in simulation-based education.

2.1.5. Proficiency-based training

Researchers who support the progressive learning approach do not state explicitly which parameters educators should use to control student’s progress. Presently, many training programs assume that most students become proficient by the end of a fixed amount of practice time. Shortcomings of this duration-based format include its prescriptive nature and that it usually produces students with highly variable abilities. In response to this dilemma, Gallagher et al. (2005) conceptualized the proficiency-based training approach, which draws on the limited attentional capacity model from the psychology literature. According to this model, students experience many demands on their attentional resources when they enter a
new training environment. In the operating room, for example, students must monitor technical
technical skill demands, instructions from the lead surgeon, emotional responses and decision making
demands. During the initial stages of training in such an environment, the novice student’s
attentive capacity will likely be exceeded and little learning will result. Gallagher et al.
(2005) suggest that proficiency-based training may help students to balance these attentional
demands and achieve an educational benefit.

Proficiency-based training involves progress from less to more demanding simulated tasks
only after students achieve pre-defined criteria (Aggarwal et al., 2006; Gallagher et al., 2005).
Subsequently, some students may complete aspects of their training sooner than others
(Issenberg et al., 2005). Therefore, proficiency-based training is designed to help the student
achieve his maximum potential by ensuring that his training proceeds at an individually
appropriate rate. Simulation works quite well in proficiency-based curricula because
simulators often contain their own performance metrics and assessment systems, which can be
used to define the proficiency criteria. Researchers must avoid setting the criterion level too
high because students may never reach it and they must avoid setting the criterion too low to
prevent students from developing an inferior skills set. Once an appropriate criterion is
selected, proficiency-based training should provide students with specific, challenging and
attainable goals to guide their learning.

Recently, a number of researchers in surgical education have used simulation to test the
proficiency-based training strategy (Stefanidis et al., 2005; Stefanidis, Korndorffer, Markley,
Sierra, & Scott, 2006). Findings have typically supported the use of simulation in proficiency-
based training for technical skills such as suturing and knot-tying (Goova et al., 2008; Scott,
Goova, & Tesfay, 2007). As well, feasible and cost-effective proficiency-based curricula are
now common place in laparoscopic skills training (Scott et al., 2008; Stefanidis et al., 2005;
Stefanidis et al., 2006; Stefanidis, Korndorffer et al., 2006). Currently, testing of the proficiency-based model is limited to technical skills in surgery. To address this research gap, future studies should investigate proficiency-based training of technical and non-technical skills. In this dissertation, students’ capacity to acquire an integrated set of clinical skills (e.g., technical and non-technical) using the proficiency-based training method will be tested.

2.1.6. Synthesis

In this dissertation, simulation is regarded as an educational tool that can improve current training methods in HPE. Theoretically driven research of simulation-based education has been sparse and deserves further attention. Moreover, many studies test one simulator type in one context with little or no follow up. Research is needed to extend the generalizability of recent theory-based educational interventions such as the IPPI, progressive learning and proficiency-based training approaches. Studies that include a variety of simulator types are also necessary as there are likely benefits associated with training regimes that provide a broad range of practice scenarios to students.

In addition, more psychometric data should be generated to test the reliability and validity of different assessment tools when evaluating performance in simulation-based education. This dissertation will use previously developed and validated measures including the global rating scale (GRS) and checklist (CL) components of the objective structured assessment of technical skills (OSATS) examinations (Martin et al., 1997), hand motion analysis (Reznick & MacRae, 2006) and will aim to produce further data on the IPPI rating tool.
2.2. SRL Theory

Joe realizes that beyond his formal simulation centre experience he will need to practice on his own. He will have the opportunity to practice during his limited interactions with patients and by using the 24-hour practice room available at the simulation centre. However, he wonders what the best approach will be to learning suturing and other skills independently.

Particularly relevant to Joe’s predicament is SRL theory. In line with current student-centred activities in HPE, SRL theory promotes giving students some control over their practice conditions. Therefore, SRL theory may represent a framework that researchers can use to improve simulation-based education research.

SRL encompasses any context where the student displays personal initiative, perseverance and adaptive skill (Zimmerman, 2001). When combined, the concepts of ‘self’ and ‘learning’ can assume various meanings depending on the researcher’s epistemology. It is of no surprise, then, that SRL is viewed from a number of theoretical perspectives (Zimmerman, 2001). All perspectives commonly assume that students are capable of actively regulating their cognition, motivation or behaviour to achieve their goals and perform better (Hofer, Yu, & Pintrich, 1998; Zimmerman, 1989). Each perspective differs in the strength given to the roles of cognitive, social and environmental influences on the mechanisms of SRL. While the perspective of social-cognitive psychology is favoured in this review, relevant principles will be drawn from the information-processing (Winne, 2001) and Vygotskian (Vygotsky, 1978) perspectives where appropriate.
2.2.1. Overview of the theory of SRL

Zimmerman, a student of Bandura, concentrated his knowledge of social-cognitive psychology into one of the first theories of self-regulated academic learning (Zimmerman, 1989). SRL results from students’ self-generated thoughts and behaviours that are systematically oriented toward the attainment of their learning goals (Schunk, 2001). Rather than passive recipients of information, students are viewed as active agents in their knowledge building and skill acquisition. Thus, self-regulation is a result of the student’s adaptive activity (Zimmerman & Schunk, 2001). Adjustments and changes to activities are necessary due to continual changes in personal, behavioural and environmental factors during the learning process (Zimmerman, 2000). Social-cognitive theorists suggest that human functioning involves reciprocal interactions between environmental variables, behaviours, and cognitive variables. This ‘triadic reciprocality’ is evident when students adaptively change their environment and those changes, in turn, affect cognitive processing and behaviour (Bandura, 1986; Schunk, 2001). In a classroom, for example, educators can identify and remove distractions (environmental factors); an action that may enhance student concentration and effort levels (cognitive processes) and could ultimately contribute to improved academic skills and self-regulatory practices (behavior). As the interaction between the three factors is constantly in flux, self-regulation becomes a cyclical process that must be monitored continually (Zimmerman, 1989). Bandura (1986) also notes that perceived self-efficacy, a person’s beliefs about his or her capability to learn or perform at designated levels, plays a vital role in the triadic interactions.

Social-cognitive psychologists suggest that self-regulation involves the following cyclical phases: forethought, performance and self-reflection (Pintrich, 2000; Schunk & Ertmer, 1999; Zimmerman, 2000). Within each of these phases are specific sub-phases (Figure 1). When
engaging in forethought, individuals analyze the task (e.g., set goals, plan strategies) and enact motivational beliefs (e.g., self-efficacy). During performance, self-monitoring and self-control are both necessary (Schunk, 2001). Finally, during the self-reflection phase, students create self-evaluations of and self-reactions to their performance. Closing the cyclical process, these self-evaluations and reactions influence forethought processes when the student subsequently prepares for a similar learning episode (e.g., similar context or task). Specifically, goal-setting, self-monitoring and self-evaluation will be expanded upon below due to their relevance to the study of clinical skill acquisition.

![SRL diagram](image_url)

Figure 1: Demonstrates how SRL is an umbrella term for several cognitive and metacognitive sub-processes.

2.2.2. Goal-setting

The development of self-regulatory skill involves setting appropriate goals (Pintrich, 2000; Schunk & Ertmer, 1999). Social-cognitive theorists suggest that, to be appropriate, goals must emphasize the student’s situational task context (Zimmerman & Schunk, 2001). Much research has established the benefits of goals that are specific, proximal (i.e., short-term), challenging (i.e., slightly above the student’s performance level), and linked hierarchically
from process to outcome (Locke & Latham, 1990). Students who set general, long term, absolute and non-hierarchical goals typically experience poor performance outcomes and negative affect and motivation (Zimmerman & Schunk, 2001). Without a specific goal, students may be unsure of the next learning step. Long-term goals result in a long waiting period before corrective feedback is obtained. Absolute goals may result in a feeling of slow progress and a consequent loss in motivation. Failure to differentiate performance processes from performance outcomes often causes students to develop poor technique (Zimmerman & Schunk, 2001). Finally, rather than setting easy or overly difficult goals, students should focus on setting challenging yet attainable goals to enhance self-efficacy and promote motivation and interest. Novice students typically self-regulate their learning reactively rather than through high-quality forethought (Zimmerman, 2002). That is, novice students fail to set specific goals and often compare their performance with the performance of others.

Students learning cognitive or motor skills should initially set process goals rather than outcome goals (Zimmerman & Kitsantas, 1997). Process goals focus students’ attention on previously validated learning strategies, whereas outcome goals shift attention to the product alone (Schunk & Swartz, 1993; Zimmerman & Kitsantas, 1996). Novice students may have difficulty relating process goals to their own movements or cognitions in the early stages of learning. However, continued effort with setting process goals can lead to enhanced skill acquisition, self-perceptions of progress and self-efficacy beliefs about future success (Zimmerman & Kitsantas, 2002). Studies of goal-setting strategy have demonstrated a benefit of setting process goals over setting outcome goals for dart-throwing (Zimmerman & Kitsantas, 1996) and academic writing in college students (Zimmerman & Kitsantas, 1999), as well as math (Schunk, 1996) and writing acquisition skills in elementary school children (Schunk & Swartz, 1993).
Instead of asking students to set only process or outcome goals, Zimmerman and Kitsantas (1997; 1999) studied the effect of shifting goals from process to outcome as learning progresses. Students learning dart-throwing skills initially focused on process goals (e.g., throwing form and follow through) and eventually shifted their focus to outcome goals (e.g., attaining the highest numeric score). The shifting goal group scored higher at post-test than a process goal group, an outcome goal group and a ‘no goal’ group. Information-processing theorists note that once students automatize some aspects of a skill’s process this will likely release additional memory resources (Carver & Scheier, 1981). Shifting goals, then, may benefit the student because the new goals allow them to concentrate on more challenging or different aspects of the task (Kanfer & Ackerman, 1989; Winne, 2001).

2.2.2.1. Closing the loop: goal-setting and feedback

Goal-setting and feedback operate in a loop. When feedback is available, a student must first perceive it and then appraise its meaning. Meaning is likely appraised based on the student’s knowledge and their personal goals. Thus, goals are a mediator of feedback; students use goals as a key mechanism to translate feedback into goal-directed action (Locke & Latham, 1990). Likewise, feedback is a mediator of goals because goal-directed action is more reliable when informed by feedback. Feedback can lead a person to maintain a goal, to lower expectations, to alter effort levels, or to try a new strategy. Adaptation as a result of feedback depends on the psychological processes that follow it and one of these processes is goal-setting (Locke & Latham, 1990).

Connecting feedback to SRL may seem confusing because feedback is thought only to arise from a source external to the student. Motor learning theorists have differentiated between this extrinsic, or augmented feedback, and task-intrinsic feedback (Salmoni, Schmidt & Walter, 1984). Task-intrinsic feedback arises from the student’s perceptions during the task.
what they see, hear and feel. Augmented feedback is categorized into two forms – knowledge of results (KR) and knowledge of performance (KP). KR is concerned with the outcome of an action, whereas KP is concerned with the movement pattern that produces an action (Salmoni et al., 1984).

Parallels may be drawn between KR and setting outcome goals, and between KP and setting process goals. In a SRL environment, goal-setting may allow students to self-generate KR and KP. That is, because goals mediate feedback (Locke & Latham, 1990), a student monitoring goal progress may generate information that resembles augmented feedback. An example would be a student learning to pronate and supinate her wrist when suturing. Setting an initial process goal which emphasizes these wrist movements will give the student some ability to analyze performance (Zimmerman & Kitsantas, 2002). As practice continues, the student may notice that when the movement is performed correctly, the simulated skin is not damaged, which produces feedback similar to KR. In the past, the majority of motor learning theorists did not believe that novice students were capable of self-generating such useful feedback. Instead, those theorists suggested that augmented feedback is necessary when the student does not know critical task requirements or when the student is unfamiliar with the link between task goals and required movements. Whether the proposed self-generated, goal-mediated KR or KP is more or less efficient and informative than KR or KP provided by an instructional agent is a question for further inquiry. Overall, the goal-setting literature suggests that students who set goals that emphasize the situational task context will respond to changing task conditions and the receipt of feedback better and more adaptively than students who set poorly formed goals or no goals at all. Students in this dissertation will be asked to set contextually relevant learning goals and the effect such goals have on DSGL processes will be evaluated.
2.2.3. Self-monitoring

After setting a goal, the student’s self-monitoring process is informed by outcomes related to strategic planning (Winne, 2005). According to social-cognitive psychologists, self-monitoring requires students to attend to specific behaviours and cognitive processes deliberately (Schunk, 1983; Schunk, 2001; Zimmerman & Kitsantas, 1996). The self-generated behaviours and cognitive processes used to achieve a goal can be referred to as strategies (Paris, Byrnes, & Paris, 2001). Developmentally, as children we learn what strategies represent (declarative knowledge) and we gain an understanding of how to use strategies (procedural knowledge). And, what must be learned when an adult student encounters a challenging task is when and why certain strategies are effective (i.e., conditional knowledge). Hence, the outcome of a strategic plan will produce conditional knowledge the student can use to self-monitor and assess goal progress (Paris, Byrnes, & Paris, 2001).

2.2.3.1. Self-monitoring according to social-cognitive theory

Self-monitoring is activated during the performance phase of the SRL cycle. Regularity and proximity are two characteristics of self-monitoring (Bandura, 1986). Regularity refers to the continuity of monitoring behaviour. Proximity refers to the temporal relationship that monitoring has with behaviour; during, immediately following, or some time after. Continuous rather than intermittent self-monitoring is necessary to avoid misleading results, while proximal monitoring is more useful than distal monitoring (Schunk, 2001).

Schunk (2001) suggests that self-monitoring is most helpful when it addresses the specific conditions of the learning episode. Hence context plays a vital role. A similar conceptualization of self-monitoring has been offered in HPE where self-monitoring is defined as the “…awareness, in the moment, of whether or not the current situation is going well” (Eva & Regehr, 2008, p. 16). Thus, there is a need to identify the contextual factors that influence
the self-monitoring process. One possible research avenue is to investigate how the regularity and proximity of self-monitoring impact the process of self-monitoring itself as well as the student’s subsequent performance.

Self-monitoring is facilitated when students keep records of their behaviours. Without recording, it is possible for the student to remember behaviours selectively, which may not inform subsequent attempts to self-regulate effectively (Schunk, 2001). Zimmerman and Kitsantas (1996) asked students learning dart-throwing to note aspects of their performance after each trial and found that this form of self-monitoring positively influenced self-efficacy beliefs and skill acquisition. Furthermore, graduate students in a statistics class benefited from self-recording the frequency and intensity of their various learning activities (Lan, 1996). Self-recording amounts to explicit self-monitoring but little research has investigated the spontaneous or implicit self-monitoring processes that are assumed to operate during SRL. However, the consistent findings that self-monitoring groups outperform ‘no monitoring’ groups (Schunk, 1983) suggests that explicit is better than implicit self-monitoring. Nonetheless, in this dissertation students will be provided the opportunity to interact with several elements in the learning environment and this behaviour will be quantified in an effort to identify and appreciate the moments that students self-monitor learning progress implicitly and explicitly.

2.2.3.2. Self-monitoring according to information-processing theory

Self-monitoring is viewed differently with an information-processing lens. Information-processing theorists liken human cognitive mechanisms to the function of computer systems. Winne (2001) suggests that self-monitoring is a process that compares two chunks of information; one chunk represents the standard to which the other is compared. Once initiated, self-monitoring creates new information such as a list of the features of the current chunk that
do and do not match the standard. The new information created by self-monitoring enables searches for chunks that better match the standard’s features. Hence, self-monitoring can lead to shifts in attention when better chunks are discovered and focused upon. Leading students to assemble useful links in long-term memory is an important feature of SRL (Winne, 2001). Indeed, information-processing theorists believe that once students deliberately manage the networks of long-term memory they engage in self-regulation.

Metacognition refers to one’s knowledge concerning one’s own cognitive processes (Flavell, 1976). Whenever a student finds a mismatch between their initial expectations for a task and their current experience they may adjust the context. The products of this self-monitoring can be used to update a number of internal and external aspects of the learning environment (Winne, 2001). First, task conditions may be changed if the monitoring process identifies a need for new resources. Second, cognitive conditions may change, for example, when a student feels a need to increase effort. Third, the student may alter the standards or goals they have associated with task achievement. Fourth, the strategies used in prior cycles of task performance could be altered. A student’s ability to self-monitor and update each of these aspects will be limited by their level of experience, working memory capacity and self-regulation competence (Guadagnoli & Lee, 2004; Winne, 2001). Further limits will be imposed by external task conditions (e.g., resources, time, social factors). Nonetheless, self-monitoring gives student’s the ability to exercise metacognitive control (i.e., self-control) and adaptively update the learning context, which may improve the efficacy of SRL.

Outcomes of self-monitoring characterize the perceived utility of the students’ current strategy (Winne, 2001). If the perceived utility of the current strategy is insufficient, the student will search for and select a new strategy that is deemed more appropriate for the task. Winne (2001) notes that although studies demonstrate that students follow this decision-
making process (Wood, Frank, & Wacker, 1998) there has been little research on decision-making in the context of SRL. However, some evidence suggests that students may be somewhat unreliable in estimating the utility of alternative approaches to a task (Winne, 2001). Moreover, students may not employ effective strategies if they regard those strategies as requiring too much effort (Rabinowitz, Freeman, & Cohen, 1992). Further work is needed to understand what self-guided decisions students make and whether those decisions translate into performance improvements.

In summary, information-processing theorists view self-monitoring processes as feedback loops. A student forms self-evaluative standards based on goals and monitors performance relative to those standards, making adjustments when refinement is deemed necessary. Hence, negative discrepancies between standards and feedback may lead the student to continue efforts until resolution or an acceptable performance is achieved. A feedback loop explained this way is generalizable and is one of the major contributions from information-processing theory to the study of SRL (Zimmerman & Schunk, 2001). One issue with the self-monitoring feedback loop is that it does not account for the variations in students’ responses to negative feedback when learning in unfamiliar settings. When faced with negative feedback, some students choose to develop better strategies, while others accept the conditions and opt for lesser outcomes (Zimmerman & Schunk, 2001). It is likely that self-efficacy beliefs and students’ self-regulatory competence play a stronger role than the self-monitoring feedback loop model gives credit.

2.2.4. Self-evaluation

Following the performance phase, self-regulated students probably self-evaluate by comparing their self-monitored performance levels with their goals. Many factors affect self-evaluations including personal standards, properties of the goal, importance of goal attainment
and the student’s attributions. Attributions are the perceived causes of outcomes and can affect expectations, behaviours and affective reactions (Weiner, 1985). Commonly, students attribute successes and difficulties to their own ability, effort and/or task difficulty. When failure is attributed to personal factors under their control (e.g., insufficient effort), students are more adaptive learners than when failure is attributed to outside factors (e.g., bad equipment) (Zimmerman & Kitsantas, 1999).

This summative view of self-evaluation has been tested in different learning settings. Studies have shown a consistent interaction between goal-setting and self-evaluation, which depends on the evaluation frequency (Schunk, 1996; Schunk & Ertmer, 1999). In situations with frequent opportunities to self-evaluate, students benefit regardless of their goal instruction. However, in conditions with infrequent self-evaluation opportunities, students only benefit when setting process goals (Schunk, 1996). As self-regulatory competence improves, social-cognitive theorists suggest that so too does the content and accuracy of self-evaluations. However, just like the development of self-regulatory competence, self-evaluation accuracy depends on students’ commitment to maintain their interest and effort in the task and in self-monitoring.

### 2.2.5. Development of self-regulatory competence

SRL is used as an umbrella term for a number of processes and each requires the student’s time and effort to cultivate. Many theorists concentrate on the development of each process, and do not address the development of overall self-regulatory competence. Social-cognitive and Vygotskian researchers, on the other hand, have provided rich descriptions of the overall development of self-regulation and these models are outlined next.
2.2.5.1. Social-cognitive perspective

From the social-cognitive perspective, self-regulatory competence develops initially from social influences and subsequently shifts to self influences during four levels of development (Schunk & Zimmerman, 1997; Zimmerman, 2000). Observational learning is the first level, where social influences are strongest and derive from watching others perform the task. Schunk (2001) suggests that the student learns the major features of valid strategies in this phase but requires practice, ideally with some form of feedback. Second, the emulative level is attained when the student is capable of approximating the observed performance (Zimmerman, 2000). In the first two levels, the student internalizes the task or strategy, but internalization relies on exposure to others and thus these two levels are socially dependent (Schunk, 2001).

The third developmental level is called self-control; the hallmark being the student’s ability to use the acquired skill or strategy independently during performance. While the internalization process is nearly complete, the student’s representation is still heavily reliant on the observed general pattern (Schunk & Zimmerman, 1997). The student achieves the fourth level when they become self-regulated. That is, the student becomes able to systematically adapt his skills and strategies to any changes in personal, behavioural and environmental conditions (Schunk, 2001).

Social influences diminish but do not disappear with advancing skill acquisition. Social sources are continually relied upon and therefore self-regulation should not be considered as operating under social independence (Schunk & Zimmerman, 1997). Students should consider themselves as members of a society of students and should be encouraged to use peers, teachers and other sources for feedback or instruction. Schunk and Zimmerman (1997) note that students may not necessarily progress linearly through developmental levels one to four.
Indeed, a student who fails to capitalize on the social environment may fail to acquire the skill because self-teaching methods are not considered reliable in all contexts.

2.2.5.2. A Vygotskian perspective

According to Vygotsky (1978), self-regulation competence develops along a similar yet distinct path to that described in social-cognitive psychology. The major difference between the two developmental paths is that Vygotsky (1978) labels language as the medium by which self-regulation in all domains develops. Indeed, Vygotskian psychology points to the ability to use language as what defines a student’s ability to self-regulate. His studies with elementary school children led to the development of his theory on the use of symbols (especially language) as tools for both social and self-guided activity. Vygotsky (1978) suggests that every function in the child’s development happens twice. First, a student’s language development involves communication with others, which is labeled social or interpersonal. In this stage, the student learns to use language by observing an adult or more capable peer and begins to manipulate language to facilitate interpersonal interaction. Second, as the student becomes a master of social interaction, the role of language changes to self-regulatory or intrapersonal. Once the student masters external speech, this process will inform self-verbalizations that can be used to guide self-regulation (McCaslin & Hickey, 2001). Effective self-verbalizations parallel what other researchers call analytical language, which refers to the use of terms, concepts and frameworks that organize a person’s thinking (Burns & Gentry, 1998).

Bruner (1985) and Vygotsky (1978) note that as students learn, initially language and behaviour are merged which explains why people talk to themselves when performing a difficult task for the first time. Later, as skill improves, language and action become separate and the task can be represented as self-directed speech (Bruner, 1985). Self-directed speech
may be defined as verbalizations addressed to the self for the purpose of self-regulation. Consequently, the student’s task performance improves as does his personal understanding of the task-specific analytical language. More recently, Tharp and Gallimore (1988) have elaborated upon Vygotsky’s stages of SRL development in relation to a different construct, the zone of proximal development, and these stages will be discussed in a later section.

The parallels between social-cognitive and Vygotskian views of self-regulatory development are quite apparent. Self-regulatory competence shifts along the same continuum as our ability to use language, from sources in the social environment to sources inside the individual (i.e., internal representations). While the developmental stages are similar between the two theories, the purposes of self-regulatory development are distinct. For Vygotsky (1978), self-control is the path to socially meaningful activity (McCaslin & Hickey, 2001). That is, the student is always actively seeking out meaning through language in their efforts to internalize, comprehend, and ultimately add their own personal contribution to the collective discourse. Conversely, socially meaningful activity is the oneway path to self-control for social-cognitive theorists (Bandura, 1986). That is, the student pulls what is necessary from the environment so that abilities and knowledge are internalized and used to contribute to personal growth. A second contrast between the two theories is the preferred unit of analysis. Bandura (1986) uses the individual as the unit of analysis because he assessed development by finding what students had internalized. Alternatively, Vygotsky’s (1978) marriage between individual and context suggests that the unit of analysis must go beyond the student. Much research has concentrated on exploiting these gaps between Bandura’s and Vygotsky’s theories (Wertsch, 1979). In this dissertation, these perceived differences will be exploited in a pragmatic fashion to design effective SRL settings.
2.2.6. Synthesis

Persuasive as it may be, SRL theory is not without its limits. Educators should use SRL theory with caution because self-regulatory mechanisms are highly context dependent and therefore a student’s ability to self-regulate is not equal in all domains. Further, self-regulation is not a skill that develops automatically as a person matures nor is it a skill that one acquires passively from the environment (Schunk, 2001). Instead, it is a process that students must be encouraged to engage actively. Also, the mechanisms of self-regulation must be well-structured to be effective. For example, poorly set goals do not provide a relevant standard for effective self-monitoring.

One issue with the social-cognitive perspective is the stated difference between self-monitoring and self-evaluation. Social-cognitive theorists view self-monitoring as reflection-in-practice (happens in the moment of action), whereas self-evaluation is considered reflection-on-practice (happens after performing the action) (Schön, 1983). SRL is much more dynamic than this model implies. A self-regulated student has the luxury to self-monitor and choose to adapt or change the learning setting at odd times, including in the middle of performance. Instead of completing the task, the student can simply stop and select a new strategy. In this example the student is self-monitoring and self-evaluating during the not yet completed performance phase, which contrasts with social cognitivist’s distinct three-phase cycle. While it is useful to design a SRL cycle based on three moments in any learning episode (before, during and after), mini-cycles of self-regulation are probably in operation throughout practice.

With respect to Vygotskian research paradigms, the emphasis on children has left a large gap in the understanding of how novice adults learn independently. There is concern that adults do not routinely become self-regulating and very little is known about the naturalistic development of SRL (Hofer et al., 1998; Pintrich, 2000). In a nurturing environment, novice
students likely develop quickly from social to independent, but evidence of this development in applied settings has been minimal. Modernizing Vygotsky’s paradigm should also involve study of students’ ‘social interactions’ with educational technology, as opposed to a human instructor.

At present, many HPE curricula provide students with few opportunities for SRL. At traditional institutions, clinical educators typically dictate what students do, when and where they do it and how they accomplish it. Conversely, institutions that use PBL curricula do provide explicit opportunities for SRL, however, few PBL research studies have reported exactly how students control their learning in these conditions. Providing students with greater control over practice conditions and monitoring how they work autonomously may provide researchers with a greater understanding of when, why and how students decide to use learning resources. Furthermore, transferring control from the educator to the student will provide useful data about implicit self-monitoring and the independent student’s decision-making processes. Experimental study of broad concepts such as SDL and SRL are evident in the HPE literature, though research that investigates specific self-regulatory mechanisms, such as goal-setting and self-monitoring, is relatively absent. One broad goal of this dissertation is to address this research gap.
2.3. Psychomotor Control and Learning Theory and Self-Regulation

Joe begins planning how to independently practice suturing. Joe sets process goals and decides to focus on wrist pronation and supination. He also sets an outcome goal to have a strong square knot after each attempt.

As he begins to consider how he will self-monitor and self-evaluate his performance, he recognizes that a large portion of clinical practice is psychomotor in nature.

The majority of research on SRL concentrates on how students learn cognitive skills. By contrast, the psychomotor control and learning literature relates closely to learning psychomotor skills in HPE. Psychomotor learning is best defined as “a set of processes associated with practice or experience leading to relatively permanent changes in the capability for movement” (p. 302, Schmidt & Lee, 2005). Two important concepts, skill retention and skill transfer, are highlighted in the psychomotor learning literature whereas both concepts are mostly absent in the SRL literature. Most of the self-learning research in the psychomotor learning literature, however, has been influenced by the design and interpretations of SRL theorists and therefore the terms SRL and self-regulation will continue to be used in the current section of this literature review.

2.3.1. Giving the student control over practice conditions

Evidence is accumulating which suggests that skill acquisition is enhanced when the student is given some control over the practice conditions. In particular, psychomotor learning researchers have tested the value of SRL environments. Wulf and colleagues (Chiviacowsky & Wulf, 2002; Chiviacowsky & Wulf, 2005; Chiviacowsky, Wulf, de Medeiros, Kaefer, & Wally, 2008; Wulf & Toole, 1999; Wulf, Clauss, Shea, & Whitacre, 2001; Wulf et al., 2005;
Wulf, 2007) conducted a number of studies which aimed to understand SRL and the mechanisms of its control. In general, their studies involve comparing a self-regulated group to a yoked control group. Self-regulated participants decide after every practice trial whether they want or do not want to receive feedback or access an instructional tool (e.g., a video). Yoked control participants are matched to a self-regulated participant and are prescribed feedback and instruction based on the actions of their match. Hence, yoked control participants lack control over those variables that SRL participants regulate. Despite both groups following identical practice schedules, self-regulated participants score higher on retention and transfer tests than those experiencing a yoked schedule. A relevant example is Wulf et al.’s (2005) study on the acquisition of a basketball free-throw shot. Self-regulated participants controlled the number of times they viewed a video showing a skilled person perform the shot. During practice, the self-regulated group performed worse than the yoked control group, but on the retention test the self-regulated group reversed this effect and outperformed the yoked control group. Moreover, self-regulated participants did not show a performance decrement across the retention period, while yoked control participants did. Wulf et al. (2005) attribute the superior retention performance to the self-regulated participants’ autonomy in controlling practice conditions.

Other studies of the self-regulated use of physical assistive devices (e.g., ski poles on a ski task) have shown advantages over yoked control conditions for improving the efficiency of task-relevant movement patterns (Hartman, 2007; Wulf & Toole, 1999; Wulf et al., 2001). In those studies, the authors suggested that the self-regulated benefit may be due to participants using different information-processing techniques, such as a trial and error search for the best movement pattern, when they controlled use of the assistive devices (Wulf et al., 2001).
2.3.2. Task difficulty

Wulf et al. (2005) investigated the learning of a complex basketball skill. In most studies of self-regulated psychomotor learning, researchers have used simple tasks such as mouse cursor pointing (Keetch & Lee, 2007), sequential timing (Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002; Lin & Jwo, 2008), or throwing (Chiviacowsky, Wulf, de Medeiros, Kaefer, & Tani, 2008; Janelle, Kim, & Singer, 1995; Janelle, Barba, Frehlich, Tennant, & Cauraugh, 1997). These tasks are classified as simple because they typically require movements with low coordination demands and few degrees of freedom at one or two joints (e.g., finger and wrist). This view of task complexity signals an important dichotomy between the existing psychomotor learning and HPE literature. For example, in psychomotor learning, the one-handed knot tying skill studied by Jowett et al. (2007) would be considered quite complex due to the coordination demands. Conversely, Jowett et al. (2007) regard the knot-tying skill as a basic building block in the student’s progression toward proficiency in more complex tasks and procedures. Whether there is a difference in how students self-regulate their learning across the spectrum of clinical technical and non-technical skills remains to be answered.

2.3.3. Identifying practice variables for self-regulated students to control

For a given task, one student might prefer to control the instruction or feedback schedule, whereas another student may wish to control the use of external resources (Bund & Wiemeyer, 2004). When learning a stroke in table tennis, participants were randomly assigned to either a self-regulated group that controlled the schedule of instruction or a self-regulated group that controlled the variability of practice. Both groups performed well on a retention test and the authors concluded that the effectiveness of SRL does not depend on the practice variable the participant is able to control (Bund & Wiemeyer, 2004). Additional study that compares the
self-regulated control of different practice variables is required to confirm this conclusion, which essentially condenses the benefits of self-regulation down to one explanation: participant autonomy.

In their study of self-regulated feedback schedules, Chiviacowsky and Wulf (2002) found that generally, participants requested feedback following a ‘good trial’. Self-regulated participants’ feedback strategy seemed to be an attempt to confirm that their performance on a given trial was on target, a hypothesis that received support from a subsequent study (Chiviacowsky & Wulf, 2007). These data suggest that during practice participants are able to detect how well they are performing. Findings in the surgical skill acquisition literature are not as clear. Mixed evidence suggests that students can be accurate (Mandel, Goff, & Lentz, 2005; Ward et al., 2003), partially accurate (Jowett et al., 2007), or inaccurate (Sidhu, Vikis, Cheifetz, & Phang, 2006; Ward, Gruppen, & Regehr, 2002) when self-assessing their abilities.

2.3.4. Additional hypotheses for the benefits of self-regulated psychomotor learning

Although many hypotheses have been offered to explain the benefits of self-regulation, Wulf et al. (2005) suggest that participants’ active involvement in the learning process may increase motivation and enhance learning. Further, they suggest that learning may improve due to the consistency of the practice schedule with the participant’s needs. For example, self-regulated participants may extract more, or more relevant, information from an instructional video compared to yoked participants (Wulf et al., 2005). Alternatively, self-regulated participants may use the observed performance to reduce uncertainty about difficult movement patterns or to confirm that their own technique is correct (Wulf, 2007). In the same vein, Chiviacowsky and Wulf (2005) theorize that self-regulated participants may engage in spontaneous error estimation during practice. Error estimation is assumed to benefit learning, because it encourages participants to focus on their intrinsic feedback and promotes
independence from external feedback sources. Each of the hypotheses offered by Wulf and colleagues require greater empirical support. One might expect that each hypothesized information-processing or motivational mechanism will have varying effects that depend on the student, the task and the environment.

2.3.5. Retention and transfer tests

An additional, complex relationship in the psychomotor learning literature should be described. Researchers in psychomotor learning consistently demonstrate a performance-learning paradox: many conditions that enhance performance during practice tend to result in poor skill retention (Guadagnoli & Lee, 2004; Schmidt & Bjork, 1992). A retention or transfer test is included in most studies to measure the persistence of an acquired skill following a break from practice. The break or retention period is used to separate the transient effects of practice from the persistent or permanent changes in behaviour (Schmidt & Lee, 2005).

Specifically, a retention test involves performance of the same task as in practice, whereas a transfer test involves performance of a new variation of the practice task or a completely new task.

The performance-learning paradox is robust in both the psychomotor learning and verbal learning domains (Schmidt & Bjork, 1992). Understandably, many educators find it difficult to resist the salient and convincing nature of the students’ performance capabilities immediately after practice. However, if performance is measured in the long-term (weeks or months; a retention period) educators would see that an appropriate measure of learning is the permanent strength of a response (Schmidt & Bjork, 1992). That is, performance on a retention or transfer test is a better index of learning than immediate post-test performance (Dubrowski, 2005).

Evidence of the performance-learning paradox is prevalent in the self-regulated psychomotor
learning literature, for both simple (Keetch & Lee, 2007) and complex (Wulf et al., 2005) skill acquisition.

Regarding the duration of the retention period, guidelines are surprisingly rare. Schmidt and Bjork (1992) recommend that the period be long enough to ensure the transient effects from the practice intervention have dissipated. Precise estimates of retention periods are not offered in the literature possibly because the retention period is influenced by student and task properties (Russell & Newell, 2007). The typical retention period is 24-hours or longer in the literature, with popular choices being 1-day, 7-days and 28-days. Although the study of optimal retention periods is imprecise, it remains crucial that a retention or transfer test of some kind be used to measure permanent changes in behaviour.

2.3.6. Assessment in psychomotor learning

Compounding the issue of when to measure learning is the question of how to measure learning. Measuring psychomotor learning can be problematic because the participant often learns a set of internal processes that may not manifest as overt changes in the ability to complete a movement (Schmidt & Lee, 2005). Assessment strategies that psychomotor learning researchers use include performance curves, secondary task performance and observation. Charting performance curves allows the researcher to search for trends in the data (Schmidt & Lee, 2005). Performance scores and error scores are commonly represented in these curves. When internal processes are difficult to measure for a primary task, researchers often ask participants to complete a secondary task. Performance on the secondary task is then used to gauge the participant’s remaining information or attentional capacity that is not devoted to primary task performance (Schmidt & Lee, 2005). Rather new to the psychomotor learning field is the idea that performance can be observed and scored using an observer rating
tool (Wulf, 2007). Each assessment strategy is associated with its own issues and therefore the choice of measurement is highly dependent on task and student characteristics.

2.3.7. Synthesis

Wulf and colleagues’ (Wulf, McNevin, Shea, & Wright, 1999) reviews of the psychomotor learning evidence imply that students who are able to control practice conditions engage in different information-processing activities than students who do not have such control. The success associated with SRL has also been linked to an increase in student’s motivation and task interest. Regardless of the underlying mechanisms of SRL, the observed advantages warrant the inclusion of at least some student control in HPE curricula. Allowing the student to select their source of feedback, the timing of feedback or allowing them to control instructional aids will probably have a beneficial effect on learning. So the question in HPE is likely not whether SRL will work but rather how effective SRL is compared to current training strategies and whether SRL effectiveness can be optimized using theoretically informed interventions.

Notice the term DSGL still does not apply to the present discussion because the involvement of an instructional agent in the process has been largely ignored in favour of attending solely to the student’s experiences and preferences. In the following section, the concept of instructional design will be explained and combined with the concept of SRL to produce the conditions for DSGL. Therefore, this represents the transition point in this dissertation from use of the term SRL to the term DSGL when describing a student’s effort to learn independently.
2.4. Instructional Design - Task and Environmental Structure

Joe is excited about the useful SRL tools and tips he has discovered. He believes that his performance is improving and that his own guidance has been a strong influence. However, Joe is beginning to realize that he cannot learn every skill completely on his own. He wants to connect with an educator in some way, who can develop practice exercises or work with Joe to design and implement opportunities for instruction and/or feedback.

What Joe has exposed is an educator’s responsibility to commit to a collaborative learning relationship with students. Joe’s request also produces the conditions for the combination of self- and other-guidance, which requires use of the term DSGL. Indeed, educators can play a number of roles in a student’s DSGL process. The following section provides a detailed account of different theoretical models for the design and structure of learning tasks and environments.

The shift to student-centred instruction has created new needs to investigate the structure and sequence of instruction in simulation-based education. Researchers in the fields of psychomotor learning, instructional design, and educational psychology have intensely studied varying approaches to student-centred instruction. To integrate these approaches optimally, it will likely be most advantageous to coordinate them using principles of instructional design. Berger and Kam (1996) define instructional design as a process whereby an educator analyzes students’ learning needs and goals systematically and develops an instructional delivery system that strives to satisfy those needs. Involved in the instructional design process is a commitment to design, implement and evaluate the instructional materials and activities. Recent educational research is aiming to create a fruitful marriage between instructional design
and self-guidance (van Merriënboer & Sluijsmans, 2009). Indeed, students will likely make productive use of their autonomy in contexts where the educator has contemplated instructional design techniques. Before touching upon the finer details of each theory, an element that all agree is a vital pillar in any learning environment will be reviewed, namely modeling.

2.4.1. Modeling

In a learning context, modeling refers to cognitive, affective and behavioural changes that derive from observing someone (i.e., a model) perform an action or behaviour (Schunk, 2001). Observational learning is evident when students display behaviours that could not be observed before they watched a model (Schunk, 2001). Competent models provide students with information about the appropriate sequencing of overt action and provide hints about covert processes, such as decision-making. An additional function of observational learning is to help students form realistic outcome expectations (Schunk, 2001). Observation allows the student to attend to informational and motivational elements which would be very difficult to do while concurrently performing the skill (Shea, Wright, Wulf, & Whitacre, 2000). Thus, a potential benefit of observational learning is that it offers information-processing opportunities that are not available during physical hands-on performance.

Modeling is the backbone of several learning theories. Evidence suggests that students who watch a model prior to performing a surgical task (i.e., engage in observational learning) perform better than students who do not watch a model (Custers, Regehr, McCulloch, Peniston, & Reznick, 1999). Also, research has shown that there is a synergistic effect of combining observational learning with physical practice (Shea et al., 2000; Wulf et al., 2001). Based on neuroimaging data, Jeannerod (2001) suggests that the human psychomotor control system is part of an imitative neural network that is activated by processes such as mental
imagery and observational learning. Indeed, the hypothesis states that this imitative network allows self-guided learners to assess the feasibility and the meaning of a potential action.

Beyond the neural aspects, social-cognitive theorists believe that the social aspects of observational learning contribute to the development of self-regulatory competence (Bandura, 1986). Similarly, Vygotsky (1978) requires the presence of an adult or more capable peer to model and encourage the SGL process through the use of symbols. Thus, the social source of learning is the model’s behaviour for Bandura, whereas it is the model’s use of symbols for Vygotsky.

Modeling should be used with care because students may identify certain models as too advanced, which could reduce motivation (Schunk, Hanson, & Cox, 1987). A possible reason for reduced motivation when the model is too advanced is that students develop self-evaluative standards when observing a model. Thus, a mastery model with consistently competent performance may leave students feeling incapable, which in turn could reduce motivation. A coping model, that initially experiences errors and gradually improves, may help attenuate the student’s perceived difference and maintain motivation. While students may perceive themselves as more akin to coping models, there is equivocal evidence regarding which form of modeling (mastery vs. coping) is most beneficial in educational psychology (Schunk, 2001; Zimmerman & Kitsantas, 1997) and psychomotor learning (Pollock & Lee, 1992). A study that conformed somewhat to the mastery-coping model dichotomy in surgical education showed that students benefited most when watching a videotaped model that showed a combination of error training and error-less training compared to watching videotaped models that showed error training only and error-less training only (Rogers, Regehr & MacDonald, 2002).
The consistent finding that any modeling is superior to no modeling suggests that educators should integrate observational learning into the design of a DSGL environment. An additional benefit will likely result if observation is combined with hands-on practice. Thus, a recommendation for HPE is to integrate modeling into the curriculum in the forms of a faculty member, fellow student, audio and/or video demonstration. The modality used to demonstrate a skill is certainly important and very little evidence has been generated on this topic. In one study, Reo and Mercer (2004) compared live modeling, videotaped modeling and a handout for teaching a basic exercise program. Live and videotaped modeling were equally and more effective than the handout for teaching this program. The limited evidence on how best to present a model to the student demonstrates the need for further work. In this dissertation, a videotaped demonstration featuring an expert performer will be used as the source of modeling because this is a common and effective technique in medical education research (Jowett et al., 2007; Xeroulis et al., 2007).

2.4.2. Task structuring in psychomotor learning – the challenge point framework

Modeling is just one piece of the puzzle in a comprehensive training regime. Psychomotor learning researchers often study concepts like modeling in an isolated manner and exclude other potentially influential variables. By contrast, the Challenge Point Framework (CPF) aims to integrate several psychomotor learning principles to improve basic and applied studies in the domain. Fundamental to the CPF is the idea that information represents a challenge to the student; whenever there is interpretable information present, there is potential to learn from it (Guadagnoli & Lee, 2004). From this central thesis, the following three principles derive: learning cannot occur in the absence of information; learning will not occur in the presence of too much information; and there is an optimal amount of information for learning, which depends on the students’ skill level and the task difficulty (Guadagnoli & Lee, 2004). The CPF
is very similar to educational psychology constructs, such as Vygotsky’s (1978) Zone of Proximal Development (ZPD), though the CPF is designed specifically to be applied as a theory that addresses issues in psychomotor learning.

Guadagnoli and Lee (2004) associate two components of difficulty with a given task, nominal difficulty and functional difficulty. Nominal difficulty refers to the complexity of a task due to its inherent characteristics such as cognitive and motor demands. Nominal difficulty is the constant amount of task difficulty, regardless of who is performing the task or the conditions under which it is performed (Keetch & Lee, 2007). Functional difficulty is the added difficulty created by factors external to the task. That is, functional difficulty involves an interaction between the nominal difficulty, the skill level of the performer and the environmental conditions in which the task is performed (Guadagnoli & Lee, 2004).

As a student’s skill level improves, his performance expectations will increase. To generate a new challenge for learning requires an increase in potential information, which can only arise from an increase in functional task difficulty (Guadagnoli & Lee, 2004; Gofton & Regehr, 2006). Increasing functional difficulty will result in both a performance decrement and an increase in the potential long-term benefit for learning, up to a point (Guadagnoli & Lee, 2004). At this optimal challenge point, the availability and the interpretability of information are optimal for the student. Therefore, to facilitate learning, functional difficulty must be tailored so that it will maximize the potential for learning without sacrificing performance in practice too greatly. Stated plainly, practice should not be too easy nor too hard otherwise information will not be transferred, uncertainty will not be reduced and permanent learning will not be observed.

The CPF’s most important contribution is the emphasis on the student as a critical factor in determining how to optimize practice conditions. Also useful to educators is the concept of
Identifying the optimal challenge point for each student will promote a balance between performance in practice and the long-term learning benefit.

Although the optimal challenge point is an important theoretical contribution, Guadagnoli and Lee (2004) provide little instruction on how to determine the point for a given student. Further, despite the student-centred view no connections are made between the CPF and DSGL. Learning seems to be viewed as requiring an instructional agent to control the level of functional difficulty for the student. Guadagnoli and Lee (2004) do not consider explicitly the student as a useful resource for designing the practice schedule. Concentrating on how an instructional agent constructs challenges for students also ignores the agent’s additional role, which is to provide support and mentorship (Gofton & Regehr, 2006). Another issue is that the interaction between students and their environment is discussed at a general level, with no regard for how changes to functional task difficulty affect the student’s cognitive, metacognitive, motivational or affective processes. Finally, the CPF provides little guidance on how to manipulate information so that it is easier for students to interpret as learning progresses. Overall, the CPF offers a useful link between task conditions and the student, but it is heavily conceptual and this limits the scope of practical applications.

2.4.3. Elaboration theory and Instructional design

Like the CPF, the elaboration theory focuses on the comprehensive and macro-instructional level of education, with an emphasis on strategies for organizing instruction. The primary aim of elaboration theory is to develop the structure and sequence of content that will optimize student achievement of learning goals (Reigeluth, 1999). A main value of the theory that is particularly relevant to HPE is a commitment to a holistic sequencing approach. This holistic approach involves teaching simpler real-world versions of an entire task, as opposed to
the popular reductionist or part-task training approach. Elaboration theory is applied most often in full course design, with an emphasis on conceptual, theoretical and procedural skills. For present purposes, only those aspects of the theory that apply to procedural skills will be outlined.

Among his proposed methods, Reigeluth (1999) suggests that the simplifying conditions method (SCM) is most applicable for teaching complex cognitive and psychomotor skills. The SCM is a simple-to-complex instruction sequence. Given that any complex task has some conditions under which it is easier to perform than others, an SCM sequence begins with what content experts identify as the simplest real-world version that represents the task as a whole (English & Reigeluth, 1996). Identification of the simple version is called epitomizing. The second stage of the SCM, called elaborating, involves identifying ways the simple version differs from more complex versions of the task – the ‘simplifying conditions’. According to Reigeluth (1999), by adding to the conditions each elaboration will be equally or more authentic than the previous, and also a less common version of the task. Elaboration sequences create an environment where the more complex details of a concept or procedure are easier to understand as learning progresses (Reigeluth, 1999). Informative guidelines on how to design a curriculum using the SCM are available (Reigeluth, 1992; Reigeluth, 2007; Reigeluth, 1999).

Progressing from simple to complex versions of a task is not unlike the CPF. What differentiates the elaboration theory in the context of DSGL is the value placed on allowing the student to make decisions about content and sequencing (Reigeluth, 1992; Reigeluth, 1999). Reigeluth (2007) contends that the student’s decisions should be informed, though he does not expand on the litmus test for detecting an informed student. Moreover, the epitomizing stage of the SCM is almost always described as requiring expert consultations and the time that students become involved in making learning decisions is not mentioned. Finally, elaboration
theory is designed for the macro-instructional conditions of classroom activity, and has been enacted in contexts where student control refers to the preference of the majority of students in a class. Though elaboration theory may not be designed to only please the majority, Reigeluth and colleagues do not discuss how to use the SCM to suit the preferences of individual students.

2.4.4. Structuring for advancement - the zone of proximal development (ZPD) and scaffolding

As mentioned above, the educator often constructs the learning environment to be challenging and informative for the student. The educator’s work should not end here because she plays an equally important supportive role in a student’s learning (Gofton & Regehr, 2006). Educators can provide support via direct contact with the student, or structural supports can be built into the learning environment. Two conceptual frameworks that incorporate the educator’s supportive role are Vygotsky’s (1978) ZPD and scaffolding theory (Wood et al., 1976).

Vygotsky believed that all higher mental functions are developed from a child’s social interactions with more capable others. While studying how socially-mediated activity results in development and learning, Vygotsky introduced the notion of the ZPD. Vygotsky’s ZPD emphasizes collaboration between child and educator and criticizes direct instruction, making the ZPD a concept that contrasts sharply with traditional autocratic and prescriptive approaches to teaching.

Before defining the ZPD, it is important to consider Vygotsky’s (1978) belief that it is necessary to match instruction to the student’s developmental level (c.f. Guadagnoli & Lee, 2004). Most educators are aware of a student’s actual developmental level; the level which is reflected in the student’s already established mental functions and abilities. In addition to the actual level of development, Vygotsky (1978) stressed that educators should consider what the
child is able to complete with the assistance of others versus what they can do alone. This added level of development, defined as the ZPD, refers to “…the phase in development in which the child has only partially mastered a task but can participate in its execution with the assistance and supervision of an adult or more capable peer” (Wertsch & Rogoff, 1984, p. 1). According to Vygotsky (1978) the ZPD:

…is the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with a more capable peer (p. 86).

Thus, the ZPD is viewed as an integral zone where other-guidance has the most potential to enhance development and learning. The adult or more capable other must be able to identify which of the student’s functions require the most attention because the ZPD is most concerned with:

…those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state. These functions could be termed the ‘buds’ or ‘flowers’ of development rather than the ‘fruits’ of development (Vygotsky, 1978, p. 86).

Teaching, then, can be defined as identifying and responding to those moments where the student requires assistance within the ZPD (Tharp & Gallimore, 1988).

2.4.4.1. Stages of the ZPD

As mentioned previously, Vygotsky (1978) defines internalization as the creation of an internal representation from an external activity. Vygotsky’s preliminary thoughts on the process of internalization were elaborated by Tharp and Gallimore into a four-stage model (1988) (See Table 1 below). Stage one will receive the most attention here because it concentrates on the progression from other- to self-guidance. Stage one involves a dynamic interplay between student and teacher, where the student’s responses to teaching inform the educator on how to target assistance. At this stage, the student may have a very limited
understanding of the task or the goal to be achieved (Wertsch, 1979). Through conversation, the more capable other will offer directions by modeling performance, introducing the beginning of a solution or asking leading questions (Tharp & Gallimore, 1988). The term ‘scaffolding’ defines the educator’s actions when he or she controls those task elements that cause the student difficulty, thereby allowing the student to concentrate on task elements within his or her comprehension (Wood et al., 1976). Scaffolding as a metaphor is suggestive of moveable and malleable supports for the student that are faded when redundant (McCaslin & Hickey, 2001). When the educator scaffolds the learning task, they “…make it possible for the child…to internalize external knowledge and convert it into a tool for conscious control” (Bruner, 1985, p. 27). Rather than simplifying the task, scaffolding holds the task difficulty constant while the educator provides graduated assistance that simplifies the student’s role in task performance (Tharp & Gallimore, 1988).

Table 1: Comparison of self-regulatory and zone of proximal development (ZPD) stage models.

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<th>Stage or Level</th>
<th>Social-Cognitive Perspective</th>
<th>Vygotskian Perspective</th>
<th>Tharp &amp; Gallimore (1988) Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Observational</td>
<td>Interpersonal (stage 1)</td>
<td>Socially assisted by others</td>
</tr>
<tr>
<td>2</td>
<td>Emulative</td>
<td></td>
<td>Performance assisted by the self</td>
</tr>
<tr>
<td>3</td>
<td>Self-Controlled</td>
<td>Intrapersonal (stage 2)</td>
<td>Performance becomes automatized</td>
</tr>
<tr>
<td>4</td>
<td>Self-Regulated</td>
<td></td>
<td>Ability de-automatizes; must regress to past stages</td>
</tr>
</tbody>
</table>

Scaffolding can also take place before the learning episode in a process called structuring situations (Rogoff, 1986). The more capable other designs a gradual task set for the student by structuring tasks into sub-tasks and by selecting the appropriate tools and materials to guide the student’s experience (Tharp & Gallimore, 1988). Educators must scaffold learning in a
way that maintains student interest yet progressively challenges the student’s abilities. Once
the initial task is mastered, the educator must ‘raise the ante’ and this leads the student further
into the ZPD and often prevents them from feeling bored. As time passes, there should be a
steady decline or fading of the educator’s assistance, as the student gains greater and greater
task competency (Kneebone, Scott, Darzi, & Horrocks, 2004; Tharp & Gallimore, 1988; Wood
et al., 1976).

An end goal of scaffolding is to produce a student that comprehends the link between
process and product. If task comprehension does not precede task production, then the student
will likely not understand any performance feedback, whether intrinsic or extrinsic (Wood et
al., 1976). The need for students to comprehend the task in scaffolding theory parallels the
need for students to interpret information in the CPF; students must understand information
before they can use it to fine tune their ability.

Captured in the concepts of ZPD and scaffolding is the idea of some form of handover
from educator to student (Bruner, 1996). That is to say, once the student masters the use of a
skill the decisions of how, when or why it should be used are left to his control (Bruner, 1985).
Slowly, external activities and information are transformed from the interpsychological plane
(between people) to the intrapsychological plane (inside the student) (Vygotsky, 1978). A
student who experiences this transformation traverses not only from other- to self-guidance
(Tharp & Gallimore, 1988) but also gains the ability to structure the task for himself, which
has implications for skill transfer (Rogoff, 1986). Stage one is complete when “…the
responsibility for tailoring the assistance, tailoring the transfer, and performing the task itself
has been effectively handed over to the student” (Tharp & Gallimore, 1988, p.32). A student
that grows within the ZPD must successfully incorporate the scaffolds into his repertoire to
mature and achieve competency (Kneebone et al., 2004).
Stages two through four will be covered briefly here as they extend to the development of expertise, which is beyond the scope of this dissertation. In stage two of the ZPD, the student now has the ability to assist their own performance, though performance is not fully developed or automatized (Tharp & Gallimore, 1988). Students at this stage often use self-verbalization and ‘coach’ themselves through performance; a main function of this self-directed speech is self-guidance (Tharp & Gallimore, 1988). The hallmark of stage two is the student’s ability to guide his learning independently.

According to Tharp and Gallimore (1988), stage three manifests when there is no evidence of self-guidance. In their view, the student has internalized and automatized the skill and therefore assistance from the educator and the self is no longer required. From a DSGL perspective, this stage is impossible. While it may be correct that overt evidence of self-guidance (e.g., self-directed speech) is absent, covert processes are always in operation and these manifest as overt changes in behaviour and in the environment. Both research perspectives would agree, however, that an educator’s assistance in Stage three could interfere with the student’s internalization process.

Finally, stage four correctly recognizes that without practice, skills de-automatize and regression through the stages of the ZPD is necessary (Tharp & Gallimore, 1988). Therefore, for every student in every learning environment there will be a mix of other-guidance, self-guidance and automatized processes (Hobsbaum, Peters, & Sylva, 1996). From Bruner’s (1996) perspective, the ZPD begins when the student works with support to encode knowledge (i.e., scaffolding), achieves independence (i.e., handover) and is eventually able to analyze and evaluate learning (i.e., self-monitoring). The student comprehends how to match process to product and, more importantly, is able to detect mismatches between current and goal performance and take proper steps to correct them (Wood et al., 1976). The transition through
these stages is viewed as the basis for the development of metacognitive skills (Bruner, 1996), particularly self-monitoring (Winne, 2001).

2.4.4.2. Applying the ZPD in HPE

Vygotskian researchers have traditionally focused their attention on children in collaboration with adults (Tharp & Gallimore, 1988; Wertsch, 1979) and pay equal attention to the processes of interaction and the products of that interaction. Although Vygotsky’s concepts stemmed primarily from research with children, this should not diminish the explanatory power for any adult student (Tharp & Gallimore, 1988; Dunphy & Dunphy, 2003; Kneebone et al., 2004). Vygotsky’s theories are likely to find application in the context of HPE at both the macro-instructional (e.g., steps needed to graduate medical school) and micro-instructional (e.g., learning to suture) levels.

With the advent of new educational technologies, there is a need to modernize how the ZPD and scaffolding are conceptualized. Indeed, Tharp and Gallimore (1988) noted that new materials and technology could allow students to interact with the task independent of the educator. A contemporary view of Vygotsky’s concept for HPE describes a student’s ZPD as populated with expert educators, experienced peers and electronic learning aids such as computer programs and simulators (Kneebone et al., 2004). Distributing the role of ‘more capable other’ among human and mechanical actors is relevant to the current push for innovative curricula and also may better appeal to today’s students. That said one of the primary features of Vygotsky’s work is the student’s need to interact with a more capable other. The educator has a close relationship with the student and is able to assess and help the student when assistance is needed. Again, a reappraisal of the concept may be needed. Rather than children, HPE involves adult students who have proven they are able to acquire knowledge independently (though at varying levels of efficacy). Some students may also not
be ready to accept assistance and may wish to work alone. Further, the educator may be unwilling to handover control to the student and may limit the student’s progression through the ZPD (Dunphy & Dunphy, 2003). Despite Vygotsky’s (1978) preference for a human educator, students at the higher education level may be capable of directing their own self-guided learning with the use of certain aids, because they have intimate knowledge of their own self- and task-diagnoses.

Additional questions arise from a critical reappraisal of Vygotsky’s (1978) work. First is a question of how much educator intervention is required and when the educator should begin to fade their assistance (Tharp & Gallimore, 1988). Psychomotor learning theorists have shown that frequent feedback can be detrimental to learning, as it may be used as a ‘crutch’, preventing students from developing self-guided competence (Salmoni et al., 1984). Second, Vygotsky’s (1978) definition of the boundaries of the ZPD and how to measure them are rather obscure. Does a situation that provides multiple modalities (e.g., educator, computers, etc.) for learning provide the right context for a student’s ZPD, or is that insufficient? Greater work to understand the ZPD in HPE is necessary.

According to Bruner (1985), future research should be shaped by the idea that social transaction is the fundamental driver of education. Bruner (1985) believes that three questions could improve the understanding of learning by transaction. Which tools can be designed to help students move into the ZPD? What kinds of processes make the student more receptive to the information provided by these tools? What procedures can the more capable other use to scaffold the path for the student? Bruner (1985) relates the elements of these three questions - instruments, processes and procedures to the tangible components of the educational process - curriculum, learning and teaching. In this dissertation, Bruner’s (1985) ideas will be used to frame the general discussion of the results (see Chapter 7).
2.4.5. Synthesis

Educators who use instructional design principles should be as concerned with challenging the student as they are with providing a supportive environment for learning (Gofton & Regehr, 2006). The theoretical frameworks outlined in this section share a similar emphasis that students should actively engage in their own learning process and further that educators should identify and match instruction to each student’s unique needs. Creators of the CPF and ZPD advocate for the selection of tasks that are subjectively moderate in difficulty, because these tasks appear to challenge the student in a way that increases arousal and the students’ potential to acquire new information (Guadagnoli & Lee, 2004; McCaslin & Hickey, 2001). Tasks that are subjectively too easy do not promote the refinement of strategies, while tasks that are perceived as too difficult may lead to avoidance or an overwhelmed student.

In HPE and elsewhere, most instructional designs concentrate on students’ actual level of development. A specific skill is taught in a specific way and once the student ‘gets it’ in that context, educators assume that the student will transfer that skill effectively to other contexts, particularly the clinical setting. Such an approach contains faults: “the actual developmental level characterizes mental development retrospectively, while the ZPD characterizes mental development prospectively” (Vygotsky, 1978, p. 87). Traditional learning environments do not permit prospective views of student development. Instead, instructors plan for prospective development – ‘we’ll get to it next week.’ A question Vygotsky would likely ask is: ‘why not now?’ Curricula that do not have some form of progression built into the ‘context of now’ may lag behind students’ potential development and thus limit the amount of learning that can be achieved. To avoid such a lag, a progressive learning approach to instructional design, which potentially allows the student to consistently practice tasks that are of moderate difficulty, should be tested and implemented. Optimal simulation-based education, from the perspective
of progressive learning theories, involves exposing students to progressively closer approximations of the realities of daily clinical practice (Gofton & Regehr, 2006)

Each theorist reviewed in this chapter would probably note that a major failure of a DSGL approach is the loss of constant connection between educator and student. An interactive computer program or simulator can hardly negotiate mutual expectations with a student and this lack of intersubjectivity would be viewed as dangerous by Vygotsky, Bruner and others. However, a computer will not tire from being asked questions, it will not withhold handing over control to the student, nor will it mistakenly provide too much instruction and/or feedback. This dissertation will seek to determine whether self-guided learners can benefit from using mechanical forms of support such as computer-assisted instruction.
CHAPTER 3: RESEARCH AIMS AND HYPOTHESES

3.1. Problem Statement

This dissertation investigates the effects of DSGL on novice health professions students’ skill acquisition, retention, and transfer in the context of simulation-based education. The series of studies is designed to satisfy four research aims:

1. To examine how DSGL conditions affect the learning process relative to yoked control conditions.
2. To determine if DSGL outcomes can be enhanced by manipulating how students set learning goals.
3. To determine if DSGL outcomes can be enhanced by manipulating the students’ learning environment (e.g., task structure, learning sequence).
4. To observe how students navigate and use resources in a DSGL environment.

To address these four aims, three research studies made use of quantitative methodology. The data collection strategies follow two of Vygotsky’s (1978) recommendations for studying psychological processes: (1) process analysis (e.g., participants’ use of resources) should be combined with outcome analysis (e.g., performance scores); and (2) data analysis should focus on the observable features of a process, as well as its assumed cognitive/metacognitive features. Resource management is a term that refers to the student’s selection and use of available resources during the learning process. A similar term used to describe how students choose and interact with parts of the environment is ecological interfacing (Normann, 1985). By observing students’ resource management and their performance outcomes it may only be possible to make inferences about the operation of cognitive or metacognitive processes; however, all inferences in this dissertation will be based on theoretical principles.
3.2. Overview

Staying true to the definition of DSGL, each study in this dissertation has two degrees of freedom in the design – first, the experimenter directs students to use certain educational tools and/or physical resources and second, some students are able to self-guide their learning and control certain aspect(s) of the practice conditions. Specifically, elements that self-guided students controlled include the practice: content (i.e., which simulator to use, which portion of an instructional video to view), progression (i.e., the timing of transition between different simulators), and/or sequence (i.e., the order in which simulators are accessed). Outlined next are the specific hypotheses about DSGL and how the concept is addressed in each chapter.

The first research chapter (Chapter 4: Process matters) primarily addresses the first and second aims of this dissertation by testing two hypotheses:

**Hypothesis 1.** Students who self-guide their access to instructional materials will show better retention of clinical skills compared to students whose practice is externally controlled (i.e., yoked control group).

**Hypothesis 2.** Students who receive instructions on how to set process goals will show better retention of clinical skills than students who set outcome goals.

In chapter 4, the experimenter directs students to set specific learning goals and self-guided students control their access to an instructional video. This manuscript is the first to describe DSGL in the HPE context. The discussion focuses on the theoretical and practical implications of the main finding, that DSGL seems effective only when students set process goals.

The next research chapter (Chapter 5: Progressive levels of simulation fidelity) takes up the third research aim, to examine how task structure and practice sequence influence DSGL outcomes. The study applies the progressive learning approach outlined in the literature review to the context of simulation-based education. Specifically, the study addresses the hypothesis:
Hypothesis 3. Students using a progressive learning approach (i.e., multiple simulators progressively) will demonstrate better global clinical performance and better skill transfer than students who learn using only high-fidelity or only low-fidelity simulation.

In chapter 5, the experimenter directs students to use particular simulators in a particular sequence, all students self-guide their access to an instructional video and only students using the progressive learning approach self-guide their progression from low- to high-fidelity simulators. The discussion focuses on a new conceptual understanding of progressive learning in simulation-based education.

The third research chapter (Chapter 6: Proficiency-based versus self-guided training) tests whether the finding from the previous chapter, that progressive learning is effective, is related to practice and task structure manipulations, DSGL effects, or a combination of the two. Hence, Chapter 6 is concerned with research aims one and three and seeks to address the following hypotheses:

Hypothesis 4. Students who self-guide their access to instructional materials and their progress through multiple simulators will demonstrate better skill acquisition and transfer compared to students whose practice schedule is externally controlled (i.e., yoked control).

Hypothesis 5. Students who self-guide their learning in an environment that lacks a progressive structure will experience lesser skill acquisition and transfer than students whose practice is structured progressively.

Hypothesis 6. Students who self-guide their learning using the progressive approach will have equivalent skill acquisition and transfer as students that follow the ‘gold standard’, proficiency-based training approach.
In chapter 6 the experimenter directs most students to use simulation resources in a particular sequence. The majority of students self-guide their access to an instructional video, students in one group self-guide their progression from low- to high-fidelity simulators, and students in another group self-guide their use of all resources and thus act as their own directors. Chapter 6 draws on relevant theories from the domains of educational psychology, psychomotor learning, and HPE to explain the observed findings. Of particular note is the surprising way the students acting as their own ‘directors’ decided to structure their practice.

Finally, a common thread throughout chapters 4 through 6 is the observation of how students managed the available resources during practice.

* A specific hypothesis for students' resource management is not provided because this aspect of DSGL has not received significant attention in past research. Essentially, students' resource management is expected to depend on the specific intervention condition.*

Related to the fourth research aim, observing students’ resource management is expected to permit a greater understanding of their decisions and the effectiveness of the strategies they use during practice.

The general discussion chapter (Chapter 7) examines the implications of two theoretically and practically significant issues that arise from the results of this dissertation. First, the cognitive and metacognitive processes that students experience during DSGL are discussed separately and then integrated to provide a modified conceptualization of DSGL. Second, Chapter 7 explores the instructional design principles used in this dissertation and how educators can use such principles to direct students’ SGL. A conclusions chapter (Chapter 8) summarizes the outcomes of this dissertation and a future directions chapter (Chapter 9) outlines recommendations for future research on DSGL and the associated processes.
3.3. Significance

Health care professionals are in a unique circumstance because they are expected to develop SGL skills while working in professions that are mandated to systematically self-govern. Consistently, however, it has been shown that health care professionals have difficulty accurately self-assessing their level of knowledge and skill (Davis et al., 2006). Despite the methodological flaws associated with the self-assessment literature (Eva & Regehr, 2005) the evidence does not raise confidence in a self-governed system that oversees self-guided individuals. Recognizing the need for a paradigm shift from the current training model some have asked “What models of clinical learning have evolved? What evidence do we have for their effectiveness?” (Tanner, 2001, p. 387).

The overall goal of this dissertation is to further test the pedagogical potential of simulation-based education. Simulation centres offer an ideal forum for students to engage in DSGL. However, clinical educators could potentially develop simulation-based training programs that are cost efficient and practical, but ineffective educationally. Therefore, it is critical that researchers conduct studies to develop and test instructional techniques that will help students make effective use of DSGL opportunities (Bell & Kozlowski, 2002). Interactive learning settings that provide structured direction for students should be most sensitive to individual learning differences (Bruner, 1985). This dissertation aims to draw upon theories from a variety of disciplines to build an understanding of DSGL processes, DSGL behaviour and the overall effect of DSGL on clinical skill acquisition, retention, and transfer. The DSGL approach has the potential to address stakeholders’ concerns for cost efficiency while also ensuring that HPE curricula integrate simulation resources effectively. Ultimately, students who learn DSGL processes in training could potentially carry these skills with them to enhance their readiness for clinical practice and as lifelong learners.
CHAPTER 4: PROCESS MATTERS

To date, there is little understanding of whether DSGL can benefit students in simulation-based education. The paper presented in this chapter explores whether self-guided access to instruction and external direction on how to set process goals combine to improve students’ acquisition, retention and transfer of clinical technical skills. The paper was accepted for publication before the completion of Chapters 5 and 6 and thus does not contain greater elaborations on DSGL, though it does introduce the concept.

The paper is published in the journal Medical Education, a journal with a readership of health care professionals, educators and HPE researchers. The discussion is focused on theoretical and practical implications relevant to HPE practice. Issues relating to these results are described further in Chapter 7.
How effective is self-guided learning of clinical technical skills? It’s all about process
Brydges R, Carnahan H, Safir O, Dubrowski A.

In recent years there has been a shift in HPE. Rather than teacher-guided learning, students are now expected to become more capable as well as accountable for their own knowledge production (i.e., a self-directed model). This shift is significant as it shows that educators acknowledge a need for student-centred education models (Dornan, Hadfield, Brown, Boshuizen, & Scherpier, 2005; Greveson & Spencer, 2005). Two factors have had particular influence on this educational shift. First, researchers began advancing the theory that self-direction is a skill that can be used successfully by adult students (Knowles, 1975). Second is the proliferation of simulation centres which stakeholders believe are practical settings where students can self-direct successfully (Waldner & Olson, 2007). However, the theoretical and practical perspectives are both too reliant on the assumption that adults know how to self-direct their learning (Norman, 1999). Regarding the theoretical perspective, our community has struggled to produce a coherent definition of what we mean when we study ‘SDL’ (Ainoda et al., 2005; Dornan et al., 2005). In their review, Ainoda et al. (2005) found that only 5 of 63 articles explicitly defined SDL, while the remainder used the term synonymously with others such as lifelong learning and student-centred education. Regarding the practical perspective, simulation centres have witnessed disproportionate increases in the availability of new educational technologies compared to the growth of educational models which utilize these technologies. Therefore, a new approach to the study of independent learning is needed to supplement: i) theories that do not translate to HPE, ii) the development of advanced educational models, and iii) descriptive accounts of independent learning (e.g., White, 2007).

A theoretical concept that will refine the study of independent learning, which derives from educational psychology (Zimmerman, 1989; Zimmerman & Kitsantas, 1996; Zimmerman &
Kitsantas, 1997) and psychomotor learning (Chiviacowsky & Wulf, 2002; Chiviacowsky & Wulf, 2005; Wulf et al., 2005), is DSGL. A self-guided learner takes responsibility for their knowledge production by becoming behaviourally and metacognitively active. Though this definition resembles the traditional ‘self-directed learner’, we propose that the learning setting employed in the present study fosters DSGL. DSGL is defined as self-guided learning which is informed and structured by external influences (Sargeant, Mann, van der Vleuten, & Metsemakers, 2008). External direction helps shape the educational content and context, which impact the beneficial effects of DSGL (Greveson & Spencer, 2005). Using this framework, we suggest that participants can self-guide their learning of clinical technical skills in the context of simulation-based training.

One issue associated with the self-guided approach is research that shows how poorly students are able to self-assess their current skill level (Eva & Regehr, 2007; Kruger & Dunning, 1999; Regehr & Eva, 2006). However, Eva and Regehr (2008) argue that context strongly influences one’s ability to assess one’s self. Conceptually, this means participants may successfully self-assess based on the specific circumstances they find themselves in rather than on an overall judgment of ability. Within the domain of technical skills acquisition, Jowett et al. (2007) have shown that participants can accurately identify a point during learning where their skills do not improve and there is no need for further practice. Therefore, participants learning fundamental technical skills were able to recognize when they were no longer acquiring new information. Building on this evidence that independent students display accurate contextual awareness, psychomotor learning researchers have demonstrated that participants who self-control their access to instruction/feedback during practice learn more than those whose access is externally controlled (Chiviacowsky & Wulf, 2005). It has been suggested that these participants may experience increased motivation from their active
involvement in the learning process or benefit from the consistency of the practice schedule with their needs (Wulf et al., 2005).

In addition to the study of self-guided practice, we were also interested in determining whether the efficiency of self-guidance could be increased via instructions on how to set goals. Educational psychologists Zimmerman and Kitsantas (1996) define a goal as something an individual accepts and tries to accomplish. When performing procedural skills, participants can set process goals which orient them toward mechanisms of performance or they can set outcome goals which orient them toward products of performance. Although process goals may be difficult for novice students to initially comprehend, participants who assume a process orientation prior to practice better acquire procedural skills and develop adaptable learning strategies (Waldner & Olson, 2007; Zimmerman & Kitsantas, 1999). Indeed, a study of goal-setting when learning to throw darts showed that participants who set process goals acquired the skill better than those who set outcome goals (Zimmerman & Kitsantas, 1997).

Our purpose was to use a quantitative approach to examine the effectiveness of DSGL when novice students practice fundamental technical skills. Our specific purpose was to test whether skill retention improves when novice medical students self-guide their access to an instructional video and how setting goals prior to practice influences long-term skill retention. Tests of skill retention or transfer reflect the durability of the acquired skill, which we define as learning (Schmidt & Lee, 2005). We hypothesized that participants with self-guided access to instruction will learn more than participants whose access to instruction is externally controlled. Also, we hypothesized that participants who set process goals will better learn technical skills than those who set outcome goals.
METHODS

Participants

Participants were 48 medical students (24 male, 24 female; 1st year = 28, 2nd year = 20) from the University of Toronto. A stratified randomization approach was used for group assignment. Experimental groups were balanced for gender, year of training and previous experience with the skill of interest. Participants provided informed consent, which was approved by local ethics boards.

Sample Size Calculation

As our primary measure of interest was the Global Rating Scale (GRS), we used mean GRS scores from previous work (Xeroulis et al., 2007) in a power calculation, which showed that 12 participants per group would adequately power the study at the 0.80 level.

Technical Skill

The skill of interest involved suturing a wound on a synthetic skin bench-top model (Figure 1A) using surgical instruments. The suture ends were then tied using a one-handed surgical knot.

Study Design

Initially, participants were assigned to two groups: a self-guided group (n=24) and a control group (n=24). Participants in the self-guided group freely accessed an instructional video during practice (Jowett et al., 2007; Xeroulis et al., 2007). The exact portions of the video reviewed by participants in the self-guided group were played for their counterparts in the control group, thus the difference between the groups was their autonomy in accessing instruction. Prior to participation, both groups were further divided into a process goal group and an outcome goal group. Groups will be referred to as Self-process, Self-outcome, Control-process and Control-outcome.
Procedure

Participants practiced individually. Initially, participants viewed an eight-minute instructional video of an expert performing the wound closure skill. Participants then received detailed instructions about their assigned goal orientation and were allowed to study the appropriate list of outcome goals or process goals (Table 1). Goal lists were created using previously published guidelines and consultations with practicing surgeons (Zimmerman & Kitsantas, 1996; Zimmerman & Kitsantas, 1997; Zimmerman & Kitsantas, 1999). Once participants verbally acknowledged that they were comfortable with their goals, the list was removed for the remainder of practice.

A total of 15 trials of interrupted suturing were completed. After each trial, participants were asked to record how well they achieved their process or outcome goal. Participants in the process goal group were asked to record goals that were missed or that required improvement (Table 1). Participants in the outcome goal group were asked to record the total time for each trial.

Also during the inter-trial interval, participants in the Self-process and Self-outcome groups were permitted up to 10 minutes of self-guided access to the instructional video. Custom software (Sun Innovations, Toronto, ON) was used to record the exact video segments that self-guided participants viewed; segments viewed multiple times were recorded as separate instances (Dubrowski & Xeroulis, 2005). Evaluating how the self-guided participants used the video was an explicit focus of this investigation. Access to instruction by participants in the two control groups was provided by the experimenter at the same time (e.g., trial 1, 3, 7) and for the same duration as their self-guided counterpart.

In order to assess the learning effects of the four conditions, participants returned one-week after practice to perform a three-trial retention test on the same artificial model and a
three-trial transfer test with the model placed inside an abdominal trainer to simulate wound closure at depth (Figure 1B) (Dubrowski, 2005; Schmidt & Lee, 2005). Participants were explicitly asked to avoid the skill, if possible, during the one-week retention period. No instruction was available during these tests. The entire study across the two days lasted approximately 2.5 hours.

Measures

Hand motion efficiency. The Imperial College Surgical Assessment Device (ICSAD; Imperial College, UK) was used to measure hand motion efficiency (Brydges et al., 2007; Reznick & MacRae, 2006). This device incorporates hand-motion tracking hardware (Patriot, Polhemus, Vermont, USA) and a custom computer software program. We chose this assessment method because it is an objective, reliable and valid tool for assessing the acquisition of open technical skills by novice students (Brydges et al., 2007; Dubrowski, 2005; Reznick & MacRae, 2006; Xeroulis et al., 2007). ‘Hand motion efficiency’ was operationalized as the time on task and the total number of hand movements; both variables measured using the ICSAD. Experts typically require less time and fewer hand movements than novices when completing a technical skill. These two hand motion variables were summed for the first three trials of practice (pre-test), the last three trials of practice (post-test), the three-trial retention test and the three-trial transfer test.

Expert ratings. The first and last practice trials and the first trial of both the retention and transfer tests were videotaped for subsequent analyses by an expert surgeon using two measures from the validated Objective Structured Assessment of Technical Skills exam (Reznick et al., 1997). The two assessment components include: a 7-question, 5-anchored-point GRS (Appendix I), and a 14-item checklist (CL) of skill-specific procedures (Appendix II). Direct evaluation of a student’s performance by an expert rater is considered to be the gold
standard in performance-based assessment of technical skills (Reznick & MacRae, 2006). A subset of ratings from a second expert established a single item intraclass correlation coefficient of 0.73 and 0.70 for the GRS and CL respectively. Both raters were blinded to participants’ identity and group assignment.

**Data Analysis**

To avoid non-orthogonal group comparisons (e.g., self-process vs. control-outcome) separate one-way analyses of variance (ANOVAs) were used to make three planned group comparisons for the pre-test, post-test, retention test and transfer test data. The between-subjects comparisons included: (1) Self-process compared to Control-process, (2) Self-outcome compared to Control-outcome, (3) both groups with process goals compared to both groups with outcome goals. Significance was set to $P < .05$ for all statistical tests.

**RESULTS**

Confirming an adequate randomization process, analysis of pre-test data revealed no significant group differences for any dependent measure.

**Comparison one** examined the effect of self-guided access to instruction by contrasting the performance of the Self-process and Control-process groups. Our analysis showed the two groups did not differ on either the post-test or transfer test (Figure 2). However, participants in the Self-process group performed better on the retention test than participants in the Control-process group (Figure 2). The groups differed according to the time taken ($F_{(1,22)} = 4.33$, $P < .05$), number of movements ($F_{(1,22)} = 4.87$, $P < .05$), global rating scale ($F_{(1,22)} = 6.61$, $P < .05$) and CL ($F_{(1,22)} = 7.07$, $P < .05$).

**Comparison two** examined the effect of self-guided access to instruction by contrasting the performance of the Self-outcome and Control-outcome groups. Our analysis revealed that
the performance of the two groups did not differ on post-test, retention test, or transfer test (Figure 2; \(P>.05\)).

**Comparison three** examined the effects of the two pre-practice goals on the learning process. This was accomplished by contrasting the performance of the two process goal groups with the two outcome goal groups. Our analysis showed no significant difference for any variable on the post-test or retention test (Figure 2). However, analysis of the global rating scale data indicated that the process goal group outperformed the outcome goal group on the transfer test (\(F_{(1,46)} = 4.48, P<.05\)). Analyses of the remaining dependent variables demonstrated no significant group differences on the transfer test (Figure 2, \(P>.05\)).

We also analyzed how frequently the instructional video was viewed during practice. Initially, the video was divided into 10-second time bins (Dubrowski & Xeroulis, 2005). The frequencies with which the two self-guided groups accessed each time bin were analyzed in a two-way ANOVA (2 Groups X 48 Bins). A main effect for group indicated that participants who set outcome goals watched video segments more frequently than those who set process goals (\(F_{(1,22)} = 7.25, P<.05\); Figure 3). A main effect for bin (\(F_{(47,1034)} = 15.01, P<.05\) generally showed that participants viewed time bins during the end of the video more frequently than those at the beginning. The bin by group interaction did not reach a level of statistical significance (\(P>.05\)).

**DISCUSSION**

The study of independent learning, also referred to as SDL or SRL, is not new (Chiviacowsky & Wulf, 2005; Dornan et al., 2005; Miflin, Campbell, & Price, 2000; Zimmerman & Kitsantas, 1996; Zimmerman & Kitsantas, 1997; Zimmerman & Kitsantas, 1999). The current study is unique and contributes to existing literature by introducing the
concept of DSGL. Explicitly, the student often requires direction (i.e., support and interaction) at several stages to enhance the DSGL approach (Dornan et al., 2005; Greveson & Spencer, 2005; Sargeant et al., 2008). Therefore, DSGL in the context of HPE is viewed not as an innate ability but rather as a skill that educator and student collaboratively develop through a process of DSGL (Dornan et al., 2005; Norman, 1999). In the present study, the teacher role was assumed by both the expert in the instructional video and the experimenter who provided the two goals lists.

Our findings demonstrate that a structured setting (i.e., instructional video, goal lists, a simulator and instruments) was sufficient for participants to independently learn how to close a simulated wound. As hypothesized, participants who self-guided their access to instruction and set process goals performed better on retention than those whose access to instruction was externally controlled. Contrary to our hypotheses, this learning benefit was not observed for participants who self-guided their access to instruction and set outcome goals. The hypothesized benefit of process goals over outcome goals was not fully supported.

**Study Implications - DSGL Theory**

Psychomotor learning researchers have shown that participants who control how they receive instruction or feedback during practice benefit more than participants who receive the same information prescriptively (Chiviacowsky & Wulf, 2002; Chiviacowsky & Wulf, 2005; Wulf et al., 2005). Increased autonomy likely allows the participant to tailor knowledge production to his/her specific needs and may also result in increased motivation (Wulf et al., 2005). Regarding our first comparison, the Self-process group performed better on the retention test than the Control-process group. Thus, it appears that participants in the Self-process group effectively used their autonomy in accessing the instructional video. However, this learning benefit did not carry over to the transfer test as expected. Regarding the results of
our second comparison the Self-outcome group was expected to perform better than the Control-outcome group, though this was not observed. Overall this pattern of results indicates a fundamental learning difference between the Self-process and the Self-outcome groups. It appears that the Self-outcome group did not use their autonomy in accessing the instructional video effectively. That is, though the two groups appear to have viewed similar time bins in the instructional video the process goal group’s better skill retention may be due to the participants using the video more effectively to address their own needs or due to their orientation towards process rather than outcome goals.

The results of our third comparison can be situated in Zimmerman’s (1989) model of self-regulation. In that model, participants react to the effectiveness of their learning strategies covertly through changes in self-perceptions or overtly through changes in skilled behaviour (Zimmerman & Kitsantas, 1997). The model predicts that when participants set process goals, they develop a learning orientation that is more beneficial than when they set outcome goals. While not supported by the similar performances between the two process and two outcome goal groups on the retention test, these expectations were fulfilled by group differences on the transfer test. Specifically, the expert raters evaluated the transfer test performance of participants who set process goals more favorably.

**Implications of Self-guided Access to Instruction**

The unexpected way that participants accessed the instructional video provides an alternative explanation for our findings. First, the better skill retention in the Self-process group relative to the Control-process group suggests that the self-process participants tailored the video segments they viewed to their own learning needs. Though both groups watched the same volume of instruction, the autonomy of the self-guided group likely led to the observed learning benefit.
Despite accessing the instructional video at a greater frequency than the Self-process group (Figure 3), the Self-outcome group was unable to demonstrate the same level of skill retention (Figure 2). Self-outcome participants were not only less effective in their learning but their use of the instructional video can be viewed as inefficient. In essence, participants in the Self-outcome group seemed to use the video to gather as much information as possible about the skill rather than to address their own learning needs. Participants in the Control-outcome group watched this same high volume of video. As a result, the Self-outcome and Control-outcome groups likely developed similar information processing abilities (Guadagnoli & Lee, 2004). Such a rationale fits well with the observed similarities in skill acquisition, retention and transfer between the two groups.

When discussing DSGL in the context of technical skills, the data highlight the importance of goal setting. Our findings suggest a possible limitation to the DSGL approach because it matters what the student attends to during practice. Specifically, participants who set process goals used the video more efficiently (vs. the Self-outcome group) and learned more effectively (vs. the Control-process group). It could be suggested, therefore, that self-guided access to instruction and setting of process goals created a student whose skills were stable and transferable. Providing self-guided learners with a process orientation may enhance the efficiency of simulation-based education in the absence of an instructor. A list of process goals can be created for each simulator, which students can access when practicing independently. Traditionally, educators have been good at giving outcome-related feedback, and would likely not find it practical to provide only process goals to their students. Our findings demonstrate, however, that educators should emphasize process-related feedback, especially in the early stages of learning. Indeed, Zimmerman and Kitsantas (1997) showed that students who shift from an initial process orientation to an outcome orientation learn
better than groups that have only process or outcome goals. Research is needed to determine if these findings extend to the learning of clinical technical skills.

**Study Limitations**

As the results of this study are based only on performance of wound closure skill, we cannot assume that the findings generalize to more complex clinical technical skills. Given the notion of specificity of performance, further research is needed to determine if DSGL is effective when students learn other clinical skills and for students at differing levels of competency. A second limitation is our use of a homogeneous population of medical students from only one institution. Finally, it could be perceived that the sample size used in this investigation was small. Though our study was adequately powered, it is possible that the small sample size could affect the generalizability of the results.

In summary, the present study addressed two aspects of DSGL: the control of access to instruction and goal-setting. The findings provide evidence for the benefits of DSGL. Specifically, the combination of self-guided access to instruction with pre-practice setting of process goals was shown to be beneficial and more effective than simply accessing the instructional video more frequently. Our study suggests that the introduction of training paradigms which utilize simulation and independent practice are viable in HPE. Direction from an external resource (e.g., faculty member) which provides a student with a process orientation will further enhance the potency of this approach. Though the advantages of simulation-based training may be limited to early procedural experience, the enhanced early learning curve should allow educators to design more time- and resource-efficient curricula (Reznick & MacRae, 2006). Further, allowing students to initially practice on models rather than patients will help enhance patient comfort and safety.
Table 1: Goal lists for participants in the Outcome Goal and Process Goal conditions.

| **Outcome Goals** | Complete each interrupted suture and knot tie in a timely manner.  
Be sure to equally space the sutures, evert the skin edges, and ensure that every knot is square. |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------|
| **Process Goals** | Needles are loaded on the driver 2/3 along the length and enters tissue perpendicular to the skin  
Concentrate on hand pronation and supination, when passing the needle through the tissue  
Take the same size bite on each side of the wound  
Ensure each throw is down square, either by having the sutures crossed, or by crossing your hands  
Maintain appropriate tension on the tie |
Figure 1: A) The synthetic skin task trainer used during the practice session and the retention test. B) Transfer test scenario – the synthetic skin task trainer was placed inside an abdominal trainer to simulate suturing and knot-tying at depth during an open surgical procedure.
**Figure 2**: Depicted are the means with standard error for A) number of movements, B) time taken, C) global rating scale and D) CL on the post-test, retention test and transfer test. Shown for each test, from left to right are the results for: Comparison 1 between the self-guided group that set process goals (Self-process) and the matched control group (Control-process), Comparison 2 between the self-guided group that set outcome goals (Self-outcome) and the matched control group (Control-outcome), and Comparison 3 between all participants who set outcome goals and those who set process goals. * indicates $p<.05$. 
Figure 3: Depicted is the frequency of access to instruction by the Self-process and Self-outcome groups, charted as a function of time bin from the instructional video (forty-eight 10-second time bins).
CHAPTER 5: PROGRESSIVE LEVELS OF SIMULATION FIDELITY

Building on the finding from chapter 4 - that process goal setting is superior to outcome goal setting - the experimenter directed students to set process goals exclusively in the following two chapters. Also, the simulated task of interest was changed to intravenous (IV) catheterization. One element maintained throughout the next two chapters is that most students self-guided their access to the instructional video.

This shifting focus influenced the direction of this dissertation toward theories of task-structuring and instructional design that include the CPF (Guadagnoli & Lee, 2004), elaboration theory (Reigeluth, 2007), scaffolding (Wood et al., 1976), and the ZPD (Vygotsky, 1978). While these theoretical perspectives acknowledge the individualistic nature of DSGL, they also emphasize environmental and social influences on DSGL. Environmental influences may be studied by providing students with options in the learning setting. Will available resources be used differently? If so, how? Will the differing use of resources impact learning efficacy? To add this layer of complexity, students were directed to use certain simulation resources, but were able to self-guide their rate of progression between multiple simulators. Thus, chapter 5 permits study of how students use both instructional and learning materials.

As the focus of DSGL expanded from individual to individual-environment interactions, so too did the focus on what students learned. Rather than focusing only on isolated technical skills and the associated isolated assessment tools, Chapters 5 and 6 include more general and global assessments of the integrated performance of a range of clinical skills. The paper in the present chapter has been submitted to a general medical education journal, and is intended for an audience of clinical educators and researchers. The implications of organizing simulators using a progressive learning approach are emphasized and it is recommended that clinical training curricula incorporate exposure to multiple simulators to maximize educational benefit.
Coordinating progressive levels of simulation fidelity to maximize educational benefit
Brydges R, Carnahan H, Rose D, Rose L, Dubrowski A
Submitted: Academic Medicine

To facilitate students’ transition to clinical practice accreditation committees have advocated for the integration of simulators into undergraduate and graduate training programs (DaRosa et al., 2008; Reznick & MacRae, 2006). Recent advances in computer science and engineering have resulted in the development of a plethora of simulators that vary across the range of realism, referred to as fidelity. Traditionally, educators have favored high-fidelity simulators based on the assumption that they provide the optimal context to prepare students for clinical duties (Gordon, Wilkerson, Shaffer, & Armstrong, 2001; Issenberg et al., 2005).

The justification for high-fidelity simulation, however, is seldom based on empirical data. Several research studies report similar learning outcomes for low-fidelity and high-fidelity training (Chandra, Savoldelli, Joo, Weiss, & Naik, 2008; Grober et al., 2004; Sidhu et al., 2007). Alessi (1988, 1995, 2000) suggests low-fidelity simulation is best for novice students, initial learning, and performance improvement, whereas high-fidelity simulation is best for advanced students, transfer, and assessment. To guide selection of simulators for educational programs the theoretical principle of progressive learning has been proposed (Dubrowski et al., 2007; Guadagnoli & Lee, 2004; Quinn et al., 1996). Progressive learning involves gradual changes in simulator attributes as the student’s ability improves with training. While Alessi (1988, 1995, 2000) proposed a link between student progress and increases in simulator fidelity, progressive learning may also encompass increases in other simulator characteristics such as information content.

In the present study, we define a simulator’s information content as including its fidelity along with the number of skills being trained, which can range from isolated skills to a set of integrated clinical skills. Most researchers use simulation to train an isolated skill set (e.g.,
technical skill performance) (Brydges et al., 2007; Brydges et al., 2009; Dubrowski et al., 2007; Jowett et al., 2007; Xeroulis et al., 2007), and little evidence exists on the use of simulation to train the integration of multiple skills that prepare students for clinical practice (Kneebone et al., 2006). Using the progressive learning method students may begin with low-fidelity simulators that train an isolated skill and gradually progress to high-fidelity simulators that incorporate the learned skill and introduce other skills in a more global, patient-centred context (Kneebone et al., 2006). Thus, the progressive method may maximize transfer when the student must coordinate all skills in clinical practice. Also, students can be given the opportunity to control their progress and decide when to transition to the next simulator level. Giving students control over practice conditions reflects growing evidence that DSGL enhances clinical skill acquisition (Brydges et al., 2009; Jowett et al., 2007).

We tested the efficacy and feasibility of progressive learning of IV catheterization on low-, mid-, and high-fidelity simulators compared to use of either low- or high-fidelity simulators in isolation. Skill transfer was tested using a scenario from the IPPI, an innovative simulation-based training and assessment approach that emphasizes integrated use of skills in patient-clinician interactions (Kneebone et al., 2006; Kneebone et al., 2007; LeBlanc et al., 2009; Moulton et al., 2009). We hypothesized that students in the progressive group would demonstrate better global clinical performance (e.g., technical, communication) and better skill transfer than students who learned entirely on a low- or high-fidelity simulator.

**METHODS**

**Study Population**

Participants were recruited from all medical undergraduate years at the University of Toronto. Participants with previous experience inserting more than 10 peripheral IV catheters
were excluded. Sample size was calculated using the global rating scale (GRS) score as this is considered the gold standard in performance-based assessment (Reznick & MacRae, 2006). Based on previous work (Xeroulis et al., 2007), we required 12 participants per group to adequately power the study at $\beta = 0.80$, $P = .05$. We used a random number generator to assign forty-five participants equally to one of three interventions: progressive, low-fidelity and high-fidelity. The University of Toronto research ethics board approved the study protocol. All participants provided written consent.

Study Apparatus

We categorized three simulators as either low, mid or high using Alessi’s (1988, 1995, 2000) definition of simulator fidelity. Our low-fidelity simulator was the Virtual IV (Laerdal Medical), a computer-based system that provides haptic feedback and rudimentary patient communication cues. While this simulator is advanced technologically it does not offer students opportunity for physical contact in many aspects of the procedure (e.g., instruments or veins), thus limiting the simulator’s responsiveness and resulting in low fidelity. The mid-fidelity simulator was an inanimate plastic arm (Nasco Health Care, Model LF01121U), the most commonly used simulator for training IV catheterization (Engum, Jeffries, & Fisher, 2003). Although patient communication cues were not present, physical interaction with instruments and veins containing simulated blood enhanced the fidelity relative to the Virtual IV. The high-fidelity simulator was a SimMan (Laerdal Medical, Model 211-00050) used in a highly contextualized environment resembling a hospital ward. SimMan was placed in a hospital bed, its veins contained ‘blood’ and it responded to the student’s actions. Responses were communicated by a research assistant trained to react to participants’ actions based on an IPPI script (Appendix III, Kneebone et al., 2006; Kneebone et al., 2007; LeBlanc et al., 2009; Moulton et al., 2009) using a microphone in a remote location. Relative to the inanimate arm,
SimMan had higher fidelity because the ‘patient’ responded to the student’s actions. For the transfer test, students performed IV catheterization on an IPPI-type simulation that combined a Standardized Patient (SP) with a different inanimate plastic arm (Nasco Health Care, Model LF01126U) and a second patient case from the IPPI protocol (Appendix IV, Kneebone et al., 2006; Kneebone et al., 2007; LeBlanc et al., 2009; Moulton et al., 2009). Use of a SP in the context of a mock hospital room represented the highest level of fidelity in the study.

**Study Design and Procedure**

We used a randomized, three-arm, intervention study design (progressive, high-fidelity, and low-fidelity). Initially all participants watched an eight-minute instructional video of an expert performing IV catheterization. In the video, an expert nurse performed IV catheterization on a real patient. Interlaced between video of the preparatory (e.g., maintaining sterility) and technical aspects of the procedure were powerpoint slides that discuss how to build patient rapport, and tips on patient communication and patient safety. Participants were then assigned to their study groups and provided with a list of seven process goals (Table 1). Process goals are designed to direct the student’s attention to the mechanisms of their performance and have been shown to benefit learning (Zimmerman & Kitsantas, 1996). The goals list was created using published guidelines (Zimmerman & Kitsantas, 1997) and in consultation with experts in IV catheterization. Participants could refer to the goals list at any time during practice.

Participants in the progressive group switched from low- to mid- to high-fidelity simulators in a self-guided manner. After switching, participants could not return to a previous simulator. Participants were informed that “…the final trial you perform on each simulator will be videotaped for subsequent analyses.” Participants in the high-fidelity and low-fidelity groups practiced on their respective simulators until they chose to end practice. All participants
were told “if you feel that you have learned the task proficiently, you do not need to stay the full 2 hours.” We provided no further definition of the term proficiently.

The maximum practice time was 2-hours. Access to the instructional video was available to all participants at any time during practice. We used custom software to record individual participant’s total video viewing time. One week after practice all participants returned to complete a transfer test on the standardized patient IPPI simulation.

**Follow-up and Outcome Measures**

We videotaped each participant’s transfer test performance. Two IV catheterization experts watched the videos and evaluated participant performance using two scoring systems. Both scoring systems are analytic, meaning performance is separated into measurable components that are scored first and then summed to generate an overall score (Hodges & McIlroy, 2003). First, global clinical performance was separated into isolated skill sets such as professionalism, situational awareness, communication, technical skill, and patient safety. The experts’ evaluated participants’ global clinical performance using the IPPI rating tool (Appendix V), a series of 7-point rating scales (Kneebone et al., 2006). Second, technical and communication skills were separated into measurable components and evaluated as follows: technical skills were evaluated using the validated Global Rating Scale (Appendix VI, GRS) and Checklist (Appendix VII, CL) (Faulkner, Regehr, Martin, & Reznick, 1996; Reznick & MacRae, 2006), and communication skills were assessed using a previously validated 5-item global scale of communication and interpersonal skills (Appendix VIII, Hodges et al., 1996; Hodges & McIlroy, 2003; Moulton et al., 2009). Ratings from the two experts were used to establish a single item intraclass correlation coefficient of 0.55, 0.55, 0.61 and 0.71 for the IPPI rating, GRS, CL, and communication scale, respectively. Both raters were blinded to participants’ identity and group assignment.
We assessed how participants’ documented the procedure to determine if the three experimental groups differed in the ability to multitask and accumulate relevant information about the simulated patient and the procedure. After the transfer test each participant completed a progress note using their own terminology to document the procedure. Documentation was scored on a previously reported 5-point scale (Engum et al., 2003) that included notation of location, date placed, catheter size, patient tolerance, and the participants’ signature.

To evaluate participants’ resource management, defined as the use of available resources during practice, we assessed the total time the groups engaged in hands-on practice with each simulator and the total time the groups viewed the instructional video during practice. Additionally, participants’ perceptions of the educational value of each simulator were evaluated using a 5-item Likert scale. Scale anchors were: not useful (1), somewhat useful (3), and very useful (5).

**Statistical Analysis**

A multivariate analysis of variance (MANOVA) using the Wilks-Lambda criteria tested for group differences in performance and resource management data. Following a significant MANOVA, separate univariate ANOVAs tested for group differences on each dependent measure. Post-hoc analysis was performed using the Student-Newman-Keuls procedure.

A multivariate repeated-measure ANOVA assessed the progressive group’s resource management. The within-group factor of simulator fidelity (low, mid, high) tested for differences in total practice time, total video time, and participants’ ratings of each simulator.

Two independent samples t-tests compared the progressive group’s ratings of the low- and high-fidelity simulators with the respective ratings from the low-fidelity group and the high-fidelity group. Statistical significance was assessed at $P<.05$ throughout, and all analyses were
conducted using SPSS version 15.0 (SPSS Inc, Chicago, Ill). Finally, we converted means and standard deviations to standardized mean differences (Hedges g effect sizes).

**RESULTS**

The multivariate test of differences between groups was statistically significant ($F_{14,72} = 5.96; P<.001$). Follow-up univariate comparisons are outlined below and in Figure 1.

**Performance Data**

IPPI ratings for the transfer test differed among groups ($F_{2,42} = 12.29; P<.001$). Progressive participants had better global clinical performance than high-fidelity participants (effect size = 0.78; 95% CI, 0.03-1.52) who performed better than low-fidelity participants (effect size = 0.72; 95% CI, -0.01-1.46; Figure 1A). The progressive group provided better documentation of the procedure ($F_{2,42} = 9.11; P<.001$; Figure 1A) than the low- (effect size = 0.98; 95% CI, 0.22-1.73) and high-fidelity groups (effect size = 1.40; 95% CI, 0.61-2.20).

According to the GRS ($F_{2,42} = 7.68; P<.001$) and communication scale ($F_{2,42} = 5.76; P<.01$) the progressive group (GRS effect size = 1.20; 95% CI, 0.42-1.97; communication effect size = 1.07; 95% CI, 0.30-1.83) and high-fidelity group (GRS effect size = 1.29; 95% CI, 0.51-2.08; communication effect size = 0.85; 95% CI, 0.11-1.60) performed better than the low-fidelity group (Figure 1B). Only the progressive group scored higher than the low-fidelity group according to the CL ($F_{2,42} = 4.32; P<.05$; Figure 1B; effect size = 0.96; 95% CI, 0.21-1.72).

**Resource Management Data**

Between groups, we found that the progressive group practiced longer ($F_{2,42} = 10.11; P<.001$) than the other two groups and that the low-fidelity group practiced longer than the high-fidelity group (Figure 2). Participants in the high-fidelity group watched a greater amount
of the instructional video ($F_{2,42} = 3.53; P<.05$) than those in the progressive and low-fidelity groups (Figure 2). Finally, progressive participants rated the low-fidelity simulator lower than the low-fidelity group ($t_{28} = 3.12, P<.01$) and rated the high-fidelity simulator the same as the high-fidelity group ($t_{28} = 1.38, P=.18$).

Within the progressive fidelity group, participants practiced longer ($F_{2,28} = 8.80; P<.001$; Figure 2) and watched more video ($F_{2,28} = 13.40; P<.001$; Figure 2) on the low-fidelity simulator. These time measures did not differ when participants practiced on the mid- and high-fidelity simulators. Participants rated the mid- and high-fidelity simulators as more educationally valuable than the low-fidelity simulator ($F_{2,28} = 25.64; P<.001$; Figure 3).

**COMMENT**

Informed by the psychomotor learning (Dubrowski et al., 2007; Guadagnoli & Lee, 2004) and psychology (Alessi, 1995; Vygotsky, 1978; Wood et al., 1976) literature we hypothesized that the progressive group would benefit more than groups practicing exclusively on either low- or high-fidelity simulators. Our findings support this hypothesis as the progressive group scored higher than the other groups on global clinical performance and also documented the procedure in greater detail (Figure 1A). Evaluations of isolated skills showed no difference between the progressive and high-fidelity groups on technical (GRS) and communication skills, though both scored better than the low-fidelity group. Finally, the progressive group outperformed the low-fidelity group according to a second measure of technical skill (checklist), whereas the high-fidelity group did not differ from either group.

While results from the progressive versus high-fidelity group comparison are mixed (i.e., the progressive group scored higher on global but the same on isolated skill assessments), we favour the global assessment approach. Students’ performance according to the global
assessment has greater implications for their interactions with patients in real clinical settings as this assessment combines a broad set of inter-related clinical skills (Kneebone et al., 2006). Further, the isolated skill assessment data followed the same trend as the IPPI rating data (Figure 1B) and the lack of significant differences could be due to a measurement sensitivity issue.

The finding that the progressive group demonstrated the best global clinical performance score on the transfer test can be explained using three theoretical perspectives: scaffolding theory (Alessi, 1988; Vygotsky, 1978; Wood et al., 1976), SRL theory (Zimmerman & Kitsantas, 1996; Zimmerman & Kitsantas, 1997), and psychomotor learning theory (Shea & Wulf, 2005). In accordance with scaffolding theory, the progressive group received scaffolded (i.e., structured) information content in a way that facilitates skill transfer to a realistic patient encounter. Initial practice on the low-fidelity simulator emphasized the procedural steps of IV catheterization (e.g., choice of instruments) without the need for careful motor performance or communication with the patient. The mid-fidelity simulator allowed participants to achieve greater familiarity with technical skills and sensory feedback arising from performance (e.g., flash back on successful catheterization). Practice with actual instruments and physical contact with a real arm built upon experience from the low-fidelity simulator yet did not require patient communication. Finally, the high-fidelity simulator enabled knowledge consolidation from the first two simulators, knowledge application in a new setting, and the development of communication and professionalism skills.

From a SRL perspective the benefits of progressive learning arise from participants’ frequent opportunities to self-monitor progress; increased self-monitoring opportunities leads to better learning (Schunk, 1996). Self-monitoring has been identified as an important mechanism of DSGL (Zimmerman & Kitsantas, 1996; Zimmerman & Kitsantas, 1997).
hypothesize that progressive participants switched between simulators based on the combined effect of their motivation and their self-monitored levels of ability. By self-monitoring when to progress between simulators the progressive group likely benefited from engaging in more explicit learning decisions than the low- and high-fidelity groups.

Researchers employing psychomotor learning theory have found skill transfer is enhanced during variable practice compared to practice limited to the same learning context (Shea & Wulf, 2005). The progressive learning method clearly offers students such variety. Further, the gap between novice students’ background knowledge and the information content of a high-fidelity simulator may impede learning by overwhelming the students’ information processing abilities (Guadagnoli & Lee, 2004) and possibly reducing motivation (Schunk, 2001). Our findings add to a growing body of evidence suggesting medical students can effectively self-guide and learn fundamental clinical skills (Brydges et al., 2009; Jowett et al., 2007). However, stronger conclusions cannot be drawn because further research is needed to determine if DSGL is as effective as instructor-guided learning.

The resource management data show the progressive group spent the most time engaging in hands on practice; this was expected as this group was required to practice on three separate simulators, as opposed to a single simulator. By contrast the high-fidelity group had the lowest total practice time yet achieved high scores on all performance measures. This indicates high-fidelity practice might be more efficient than progressive practice. Closer inspection of the data, however, suggests a different interpretation. Figure 2 shows that although the progressive group engaged in the most hands on practice, 70% was on the low- and mid-fidelity simulators. The progressive group’s average combined time practicing and watching the video was 16.5 minutes on the high-fidelity simulator compared to 51 minutes for the high-fidelity group. Thus, progressive participants had close to 70% less time on the resource-intensive
high-fidelity simulator. Instruction using the high-fidelity simulator requires knowledge of SimMan technology and an educator to provide instruction and the patient’s ‘voice’.

We also assessed the within-group resource management data for the progressive group. Though progressive participants rated the educational value of the mid- and high-fidelity simulators higher than the low-fidelity simulator, they spent more time practicing and watching the video when working with the latter (Figure 2). Interpreted within scaffolding theory, low-fidelity simulators are useful but must be implemented properly to develop a broadly skilled clinician. Our finding that the low-fidelity group achieved the lowest performance scores combined with the progressive groups’ low rating of the low-fidelity simulator demonstrate that further work is needed to determine the best use of low-fidelity simulation.

There are limitations to this study. The single item intraclass correlation (ICC) values tended to be in the low to acceptable range for most dependent measures. The ICC values are, however, close to those generally reported in previous work (Hodges et al., 1996; LeBlanc et al., 2009). Next, some may suggest the progressive group’s improved transfer test performance could be attributed to this group’s opportunity to practice on a similar inanimate arm simulator not available to the other groups. Experience with the inanimate arm simulator may have enabled the progressive group to focus on other aspects of performance for the transfer test. We acknowledge the low-fidelity participants were distinctly disadvantaged, as they did not perform a realistic IV catheterization during practice. However, similarities of the mid- and high-fidelity simulators functionality means the progressive group likely did not have this advantage over the high-fidelity group. Also the mid-fidelity simulators for the practice and transfer tests were not the same model. Lack of generalizability beyond the learning of IV catheterization is another study limitation. Also, differences in available resources across
institutions will limit application of our study findings because progressive learning, while cost effective, is simulator-resource intensive. Finally, while DSGL appears to be effective, this educational approach is not without boundaries and further work is needed to determine what supports (i.e., peers, tutors, faculty) are needed when individual learning falters.

CONCLUSION

In summary, our data suggest that simulation modalities should be integrated into curricula using evidence-based theoretical principles. Educational research intensity must match the rate at which simulation modalities are introduced into the medical field. Innovative approaches, such as the progressive learning model presented here, may reduce costs and educator time demands for simulation-based activities. Our results suggest that the question is not which level of simulator fidelity is best, but rather how we should incorporate the range of simulator fidelities into a progressive training regime. Further research is needed to understand how the progressive learning model applies to other simulator characteristics such as task difficulty.
Table 1: List of seven process goals provided to participants during practice.

<table>
<thead>
<tr>
<th>Process Goals</th>
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<tbody>
<tr>
<td>Place the tourniquet 10-12 cm above the insertion site,</td>
<td></td>
</tr>
<tr>
<td>Clean the insertion site – use the in-to-out circular technique,</td>
<td></td>
</tr>
<tr>
<td>Make sure the bevel of the needle is up and inserted into the vessel at 10-30</td>
<td></td>
</tr>
<tr>
<td>degree angle,</td>
<td></td>
</tr>
<tr>
<td>Hold the skin taut while inserting using thumb,</td>
<td></td>
</tr>
<tr>
<td>Hold the stylet stable and advance the catheter into the vein over the stylet</td>
<td></td>
</tr>
<tr>
<td>seat it in the vessel,</td>
<td></td>
</tr>
<tr>
<td>Stabilize the catheter and release the tourniquet,</td>
<td></td>
</tr>
<tr>
<td>Flush the lock with normal saline to check catheter patency.</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1: Displays the results of univariate ANOVAs for (A) IPPI rating and documentation scores and (B) global rating scale (GRS), checklist and communication scale. Error bars represent the 95% confidence interval (CI). Asterisks indicate comparisons significant at $P < .05$. 
Figure 2: Displays ANOVA results for the resource management variables. Error bars represent the 95% confidence interval (CI). Stacked columns demonstrate the total time the progressive group spent practicing and watching video while working exclusively with the three simulators.
Figure 3: Displays the participant educational value ratings for each simulator. Error bars represent standard deviations. No deviation is present for the high-fidelity group’s rating of the high-fidelity simulator as all participants rated 5/5. Asterisks indicate comparisons significant at $P<.05$. 
CHAPTER 6: PROFICIENCY-BASED VERSUS DIRECTED SELF-GUIDED TRAINING

Though the results from Chapter 5 support the progressive learning approach, the conclusions were equivocal. Two possible interpretations of the observed learning benefit include: the participants in the progressive group did a good job self-guiding when to progress between simulators, or the participants benefited from the combination of self-guidance and other psychomotor learning variables such as variability of practice and/or context specificity. Consequently, two additional intervention groups were included in the present chapter: an unstructured, open-ended group to determine the influence of the progressive structure, and an experimenter-control group to test the effect of DSGL. Finally, a proficiency-based training group was included as the gold standard of individually prescribed training. Thus, the manuscript compared different training groups in which students are fully directed with respect to their use of and advancement between simulators (e.g., proficiency-based and experimenter-control), with a group that conforms to DSGL (progressive) and a group that is almost exclusively self-guided (open-ended). In addition, the manuscript seeks to answer the general question: How do self-guided learners navigate environments and do they do so more efficiently in certain conditions?

This manuscript has been submitted to a nursing education journal, and is targeted to an audience of nursing educators and nursing education researchers. Nursing research and educational practice that associate learning theory and simulation-based education are both in their infancy (Kaakinen & Arwood, 2009). This manuscript introduces the nursing education community to specific theories from the psychomotor learning, educational psychology and medical education literature in an effort to stimulate educational research that considers the theoretical and practical applications of simulation.
Comparison of proficiency-based and self-guided training approaches for learning intravenous catheterization using simulation: Evaluation with baccalaureate nursing students
Brydges R, Carnahan H, Rose D, Dubrowski A
Submitted: *Journal of Advanced Nursing*

Encouraged by nursing shortages and the need to increase enrollment, educators, researchers and administrators are revamping current training practices. Simulation is an increasingly popular educational technology that can be used to teach various nursing skills including assessment, psychomotor skills, decision-making and communication. Simulation is not a new tool in nursing; educators have used role-playing and mannequins to simulate patients for some time (Overstreet, 2008). Relatively recent in nursing is the arrival of advanced computer-based simulations that expand the educational potential of simulation. Benefits of most simulators include students’ ability to learn in a self-paced manner, to learn from errors without harming patients and to learn how to perform in different clinical contexts (Beyea et al., 2007; Jeffries, 2005). Training in a simulated setting allows the student to repetitively and safely practice the words, actions and reactions they will experience in the clinical setting. New training tools require new ways of teaching, and simulation is no different (Alinier, Hunt, Gordon, & Harwood, 2006). Further, the link between simulation and learning theory in nursing research is currently quite weak (Kaakinen & Arwood, 2009). Thus, additional inquiry is needed to understand how best to teach with simulation and how best to enhance students conceptual learning using the technology.

Simulation is now a favoured training mode for technical skills (Brydges et al., 2007; Brydges et al., 2008; Brydges et al., 2009; Dubrowski et al., 2007; Love, McAdams, Patton, Rankin, & Roberts, 1989). Researchers in nursing (Alinier et al., 2006; Jeffries, Woolf, & Linde, 2003; Lasater, 2007) and medicine (Kneebone et al., 2006) are just beginning to use simulation for global clinical training that emphasizes technical skills and non-technical skills.
such as communication. One method that may be used to structure global clinical training is to organize simulators based on fidelity and information content. Simulator fidelity can be defined as the student’s perceived sense of realism and how realistically the simulator allows and responds to the student’s actions (Alessi, 1988). A simulator’s information content includes the fidelity as well as the number of clinical skills (i.e., isolated or multiple) integrated into the simulation experience.

Organized simulation-based training represents an ideal forum for the study of students’ independent learning. Researchers have recently developed an independent learning method called proficiency-based training, which requires achievement of a criterion score before students may progress to the next learning level (Brydges et al., 2008; Ritter & Scott, 2007; Stefanidis, Acker, & Heniford, 2008). Researchers have effectively implemented this system for the training of laparoscopic surgical skills (Stefanidis, Acker, Swiderski, Heniford, & Greene, 2008). Though the student learns independently in proficiency-based training, an educator is needed to select and set the proficiency criteria. A paradigm that gives the student greater control over their experiences may lead to an equal educational benefit.

Greater student control in simulation-based training is one component of the progressive learning approach (Alessi, 1988; Reigeluth, 1992). Progressive learning involves step-wise increases in simulator characteristics (e.g., information content) from simple to complex that are matched to the student’s skill level. Allowing opportunity for progression as the student’s skill level improves is a principle derived from psychology (Reigeluth, 1992; Vygotsky, 1978; Wood et al., 1976), nursing (Waldner & Olson, 2007), and psychomotor learning (Dubrowski et al., 2007; Guadagnoli & Lee, 2004). However, little research has tested the progressive learning approach and there is little understanding of when students should advance from one skill level to the next.
In a previous study (Brydges et al., 2009) we developed a concept called DSGL which is based on evidence suggesting that learning does not occur in isolation (Vygotsky, 1978; Zimmerman, 1989) and that students make good educational decisions (Chiviacowsky & Wulf, 2002). DSGL is defined as a process in which an educator collaboratively designs the setting in which students self-guide their learning (Brydges et al., 2009). DSGL occurs when students have control of an element of practice and therefore are metacognitively, behaviourally and motivationally active in their learning (Zimmerman, 1989). An initial study of DSGL showed a beneficial learning effect for wound closure skills (Brydges et al., 2009). However, the generalizability of DSGL must be extended to other tasks and other health professions.

An issue with DSGL is the well-documented evidence that health care professionals are ineffective self-assessors (Eva & Regehr, 2005; Eva & Regehr, 2008; Kruger & Dunning, 1999). Most studies define self-assessment as a summative evaluation; a conceptualization that may not properly address the role of self-assessment in a health care professional’s daily practice (Eva and Regehr, 2008). Rather than as a summative tool, self-assessment might be better defined as awareness, in the moment, of whether or not the current situation is going well. A process that includes such contextual awareness is defined as self-monitoring (Eva & Regehr, 2008; Schunk, 2001). Indeed, researchers identify self-monitoring as the most important process that drives context specific SGL (Winne, 2001). Supporting the utility of self-monitoring, Jowett et al. (2007) showed that medical students can self-monitor the correct amount of practice needed to efficiently learn a knot-tying skill.

In the present study, we created an environment for students to progressively learn and advance from low- to mid- to high-fidelity simulators of IV catheterization. We compared four training interventions: proficiency-based, progressive, an open-ended intervention where
students were totally independent and an experimenter-control intervention. Though proficiency-based training is the current gold standard, we hypothesized that the progressive learning approach would offer an equivalent educational benefit. Based on principles of DSGL, we hypothesized that the lack of practice structure for the open-ended group would lead to lower achievement than the proficiency-based and progressive groups. Psychomotor learning literature has shown that students who self-guide their practice learn more than students whose practice schedule is externally controlled (Brydges et al., 2009; Chiviacowsky & Wulf, 2002; Keetch & Lee, 2007). Therefore, we hypothesized that the progressive group would outperform the experimenter-control group.

In addition to the study of learning outcomes, we directly observed DSGL behaviour. Past research has not explicitly specified how students interact with the features of a learning setting (Evensen, Salisbury-Glennon, & Glenn, 2001). Moreover, descriptions of DSGL behaviour have often been overlooked, though there are exceptions (Evensen et al., 2001; Slotnick, 1999; Slotnick, 2000). In the present study, we observed how nursing students managed the available resources to get a greater understanding of their decisions and the effectiveness of the strategies they use during practice.

METHODS

Study Design

In this study we used a randomized, four-arm experimental design to compare the effectiveness of proficiency-based, progressive, open-ended, and experimenter-control training interventions for IV catheterization skills.

Participants

We used advertisements to recruit three experienced registered nurses from a local clinic. These nurses provided performance data, which we used to determine the proficiency criterion.
for each simulator. To test our training interventions, we recruited a stratified random sample of 60 fourth year baccalaureate nursing students. Experimental groups were counter-balanced based on participant sex (two males assigned to the progressive and experimenter-control groups and one male assigned to the proficiency-based and open-ended groups). Recruitment involved an oral presentation at a nursing orientation day and subsequent email messages. Participants were excluded if they had previously completed more than 10 IV starts (mean participant experience = 0.32 IV starts).

**Power Calculation**

We completed a power calculation using global rating scale (GRS) scores from previous work (Brydges et al., 2009), because the GRS is regarded as the gold standard in performance-based assessment (Reznick & MacRae, 2006). Our calculation showed that twelve participants per group would adequately power the study at the 0.80 level. We assigned fifteen participants to each of the four experimental groups.

**Data Collection**

**Study Apparatus**

We arranged three IV catheterization simulators from low- to mid- to high-fidelity using Alessi’s (1988) definitions of fidelity. The low-fidelity simulator was the Virtual IV (Laerdal Medical), a computer-based system that provides haptic feedback and simple patient communication cues. While this simulator uses advanced technology, the lack of physical contact with many aspects of the procedure (e.g., instruments, veins) limits the simulator’s responsiveness and results in low fidelity. An inanimate plastic arm (Nasco Health Care, Model LF01121U) represented the mid-fidelity simulator, which is the most common method of simulated instruction for IV catheterization (Engum et al., 2003). While patient
communication cues were not present, physical interaction with instruments and veins that contained simulated blood enhanced the fidelity of this simulator relative to the Virtual IV. The high-fidelity simulator was a SimMan (Laerdal Medical, Model 211-00050) used in a simulated hospital ward. SimMan was placed in a hospital bed, its veins contained ‘blood’ and a research assistant responded to participants’ actions based on an IPPI script (Appendix III, Kneebone et al., 2006; LeBlanc et al., 2009) using a microphone in a remote location. The one-week delayed transfer test combined a Standardized Patient (SP) scenario with a different inanimate plastic arm (Nasco Health Care, Model LF01126U) and used a second script from the IPPI protocol (Appendix IV).

Procedure

Initially, participants watched an eight-minute instructional video of an expert performing IV catheterization. Participants were then provided instructions regarding their assigned group and a list of seven process goals (Table 1). Process goals direct the participant’s attention to the mechanisms of their technical skill performance, which has been shown to benefit learning (Brydges et al., 2009; Zimmerman & Kitsantas, 1996). We created the process goals list using published guidelines and consultations with experts in IV catheterization. Participants could refer to the goals list at any time during practice.

To define proficiency criteria for the low-, mid- and high-fidelity simulators, we measured the average time each registered nurse needed to perform an IV start on each simulator. In total, the three registered nurses performed three IV starts on each simulator. We calculated a mean performance time for each nurse and set each simulator’s proficiency criterion according to an overall average of the three nurse’s times (Table 2). Participants in the proficiency-based group advanced to the next simulator after being informed that they achieved each proficiency
criterion or after 40 minutes of practice. This latter manipulation gave the proficiency-based group the opportunity to spend approximately the same time on the three simulators.

We told participants in the progressive and open-ended groups that: “...the final trial you perform on each simulator will be videotaped for subsequent analyses” and “if you feel that you have learned the task proficiently, you do not need to stay the full 2 hours.” We provided no further definition of ‘proficiently’. Participants in the progressive group advanced from low- to mid- to high-fidelity simulators on their own accord. We matched each participant in the progressive group to a participant in the experimenter-control group (Brydges et al., 2009; Chiviacowsky & Wulf, 2002; Chiviacowsky & Wulf, 2005). Experimenter-control participants advanced between simulators after completing the same number of trials as their match in the progressive group. Participants in the open-ended group self-guided their practice schedule and moved freely between the three simulators (i.e., they could move back and forth). Participants’ final trial on each simulator was considered a post-test. To ensure we did not miss the ‘proficient trial’ on each simulator for the proficiency-based group, we videotaped performance on every trial. For the open-ended group, we informed participants that once they elected to have the ‘final trial’ videotaped they could not return to that particular simulator.

All participants could access the instructional video at any time, except for experimenter-control participants who watched the same video segments viewed by their match in the progressive group. Therefore, the progressive and experimenter-control groups differed both in their autonomy when choosing the practice schedule and when accessing the instructional video (Brydges et al., 2009). We used custom software to record the exact portions of video that each participant viewed (Dubrowski & Xeroulis, 2005). One week after practice participants returned to complete the transfer test.
Follow-up and outcome measures

Dependent measures for the low-fidelity post-test included a performance score, and performance time. We videotaped the mid-fidelity post-test, the high-fidelity post-test, and the transfer test. Two IV catheterization experts watched the videos and evaluated participant performance using two scoring systems. Both scoring systems are analytic, meaning performance is separated into measurable components that are scored first and then summed to generate an overall score (Hodges & McIlroy, 2003). First, we separated global clinical performance into isolated skill sets such as professionalism, situational awareness, communication, technical skill, and patient safety. The experts evaluated participants’ global clinical performance on the high-fidelity post-test and transfer test using the IPPI rating tool (Appendix V), a series of 7-point rating scales (Kneebone et al., 2007). Second, we separated technical and communication skills into sub-components. The experts evaluated technical skills using the validated 5-item global rating scale (GRS; Appendix VI) and a procedural checklist (Appendix VII, Martin et al., 1997; Reznick et al., 1997) and communication skills using a validated 5-item scale of communication and interpersonal skills (Appendix VIII, Hodges et al., 1996; Hodges & McIlroy, 2003; Moulton et al., 2009).

Ratings from the two experts were used to establish a single item intraclass correlation coefficient of 0.67, 0.62, 0.63, and 0.45 for the IPPI rating, GRS, checklist, and communication scale, respectively. Both raters were blinded to participants’ identity and group assignment.

To evaluate participants’ resource management, we assessed the four experimental groups’ total number of trials and total practice time on each simulator, and the total time spent watching the video. Participants also rated the educational value of each simulator using a 5-
item Likert scale. Scale anchors were: not useful (1), somewhat useful (3), and very useful (5). Finally, we recorded the sequence that open-ended participants followed during practice.

**Ethical Considerations**

The Human Ethics Research Ethics Board at the local university approved our research design. Participants received a participant code and signed a consent form prior to the practice session. Data were considered confidential because only the investigators knew the identity of the participants; participants were aware of this confidentiality. Participants who successfully completed the study received a certificate of attendance.

**Statistical Analysis**

A MANOVA using the Wilks-Lambda criteria tested for group differences on the low-, mid- and high-fidelity simulator post-tests. Analysis of post-test data permitted the assessment of participant’s performance levels at the points of transition during practice. Post-tests, however, are not sensitive to long-term learning effects (Dubrowski, 2005; Guadagnoli & Lee, 2004; Schmidt & Bjork, 1992).

A second MANOVA tested for group differences in the transfer test performance data and the three resource management variables (i.e., total trials, total practice time, total video time). For both post-test and transfer-test data, we followed up on a significant MANOVA with separate univariate ANOVAs for each dependent measure.

A repeated-measures ANOVA tested for group differences in participants’ resource management, which we defined as the total practice time, total trials, total video time, and participants’ ratings of each simulator. ANOVA factors included fidelity (low, mid, high) and group. We selected Tukey’s HSD as the post-hoc test and assessed statistical significance at $P<.05$. All analyses used SPSS version 15.0 (SPSS Inc, Chicago, Ill).
RESULTS

Participants, on average, ended the practice session short of the time limit (mean duration = 91.42 ± 15.45 mins, no group differences). Using the MANOVA, we detected group differences on the low-fidelity post-test ($F=4.11$, d.f.=6, $P<.001$), mid-fidelity post-test ($F=9.39$, d.f.=6, $P<.001$), high-fidelity post-test ($F=3.20$, d.f.=6, $P<.01$) and transfer test ($F=2.11$, d.f.=6, $P<.01$). As a follow-up to the MANOVA, we conducted the univariate comparisons outlined below.

Post-test data

On the low-fidelity post-test, groups differed according to the performance score ($F=3.24$, d.f.=3, $P<.05$) and performance time ($F=7.92$, d.f.=3, $P<.001$). Comparisons showed that the proficiency-based group scored higher than the open-ended group and that the progressive and experimenter-control groups did not differ from any other group (Figure 1A). The open-ended group’s average performance time was greater than all other groups on this post-test, reflecting less efficient performance.

On the mid-fidelity post-test, groups differed according to the global rating scale (GRS; $F=7.21$, d.f.=3, $P<.001$) and checklist (CL; $F=18.12$, d.f.=3, $P<.001$). Post-hoc comparisons showed that the proficiency-based group scored higher than the progressive and experimenter-control groups according to GRS and higher than all groups according to CL (Figure 1B-C).

Keeping with the above pattern of results, the groups differed in their performance on the high-fidelity post-test according to the global rating scale ($F=5.43$, d.f.=3, $P<.01$), CL ($F=4.90$, d.f.=3, $P<.01$) and IPPI rating ($F=6.94$, d.f.=3, $P<.001$). Specifically, the proficiency-based group scored higher than the progressive (GRS and IPPI), experimenter-control (GRS, CL, IPPI) and open-ended (GRS, CL) groups and those three groups did not differ according to any measure (Figure 1B-D).
Transfer test

Finally, the transfer test aimed to assess how well the students retained and could transfer the skills learned during practice. On the transfer test, the groups differed once again according to the CL ($F=3.43$, d.f.=3, $P<.05$), communication scale ($F=3.72$, d.f.=3, $P<.05$) and IPPI ratings ($F=4.77$, d.f.=3, $P<.01$). By contrast, the groups did not differ according to the GRS ($F=1.55$, d.f.=3, $P=.21$). Post-hoc comparisons showed that the experimenter-control group had a lower IPPI rating than the other three groups, which did not differ on this measure (Figure 1D). On the communication and checklist scales, the progressive group scored higher than the experimenter-control group, while the proficiency-based and open-ended groups did not differ from any group on these measures (Figure C-D).

Resource management during practice

An analysis of participants’ resource management data showed no differences in the total practice time ($F=0.74$, d.f.=3, $P=.54$) or the total video time ($F=1.57$, d.f.=3, $P=.21$) (Figure 2). Conversely, the groups did differ in the total trials completed ($F=4.19$, d.f.=3, $P<.01$) and follow-up comparisons showed that the proficiency-based group performed more trials during practice than the other groups (Figure 2A, B).

When assessing how the participants made use of and rated the three simulators, differences were evident according to the total practice time ($F=3.69$, d.f.=2, $P<.05$), total trials ($F=10.99$, d.f.=2, $P<.001$), total video time ($F=6.24$, d.f.=2, $P<.001$), and participants’ ratings ($F=99.07$, d.f.=2, $P<.001$). Our analyses also showed a group by fidelity interaction for total practice time ($F=4.45$, d.f.=6, $P<.001$) and total trials ($F=5.12$, d.f.=6, $P<.001$). Post-hoc analysis of the interactions showed that the open-ended group practiced for less time and completed fewer trials on the low-fidelity simulator compared to the other groups (Figure 2A-B).
Post-hoc comparisons for the various main effects showed that when practicing on the high-fidelity simulator, the participants watched the instructional video less than on either the low- or mid-fidelity simulators. Participants rated the low-fidelity simulator lower than the mid- and high-fidelity simulators, which they rated similarly (Figure 2C). Finally, the proficiency-based group rated the educational value of the simulators higher than all other groups (Figure 2C).

**Open-ended participants’ practice schedules**

We recorded each open-ended participant’s practice schedule and found that the majority (11 of 15) independently chose a schedule that was either identical (n=5) to the progressive group’s practice schedule, or deviated by one trial (n=6). An example of a one trial deviation is the schedule: low-low-mid-high-mid-high-high-high. All participants who did not choose the progressive practice schedule (n=4) used the low-fidelity simulator just once, began with the mid-fidelity simulator and continued to use it for the majority of practice.

**DISCUSSION**

**Study limitations**

This study had a number of limitations. We cannot generalize our findings beyond learning of IV catheterization to more complex clinical skills. In terms of study replication, we had access to many simulator resources that are likely not available at all institutions. Widespread demonstration of our findings, then, may be limited. Next, we recruited the ‘proficient’ registered nurses from a convenience sample population. These nurses may not have accurately represented the proficient population for IV catheterization. Further, we selected performance time as the proficiency criterion for practical purposes; however, time may not be the best predictor of proficient performance. Proficiency criteria that incorporate
other measures such as deductions for errors have been favoured in past studies of proficiency-based training and warrant further study (Scott et al., 2007). Also, having proficiency-based participants advance to the next simulator after 40 minutes rather than after achieving the proficiency criterion is a limitation as it could be concluded that those participants did not engage in true proficiency-based training. Finally, the observed single item intraclass correlation (ICC) values were in the low to acceptable range for most dependent measures. While the low values are a concern, they are close to those generally reported in previous work (Hodges et al., 1996; LeBlanc et al., 2009).

Discussion of results

Consistently, the proficiency-based group scored higher than the other groups on each simulator’s post-test. Drawing conclusions based on these data, however, would be premature. Indeed, the post-test group differences were not maintained following the one-week rest period (Figure 1). According to the transfer test data, the proficiency-based, progressive and open-ended groups scored similarly on all dependent measures. These findings confirm our first hypothesis because the progressive group achieved similar skill transfer compared to the proficiency-based group. At the same time, however, the data surprisingly refute our second hypothesis as the open-ended group scored similarly to the progressive group. Supporting our third hypothesis, the progressive group scored higher than the experimenter-control group on the CL, communication scale and IPPI rating (though not on the GRS).

A beneficial effect of proficiency-based training is not new (Ritter & Scott, 2007; Stefanidis et al., 2005). Based on psychomotor learning and SRL theory, we propose three explanations for the similar performance between the proficiency-based and progressive groups. First, our initial hypothesis did not recognize that proficiency-based training is experimenter-controlled practice. That is, participants had to achieve a pre-defined criterion
score before advancing. Findings in psychomotor learning (Chiviacowsky & Wulf, 2002; Chiviacowsky & Wulf, 2005) and medical education (Brydges et al., 2009) suggest that self-guided practice leads to better skill retention and transfer than externally controlled practice conditions and that students seem to know their own learning asymptotes (Jowett et al., 2007). The progressive group’s autonomy when controlling the practice session may have resulted in this group’s learning benefit.

Second, progressive group participants displayed contextual awareness whenever they chose to advance to the next simulator. That is, we suggest that participants self-monitored their performance before deciding to advance (Eva & Regehr, 2008; Jowett et al., 2007; Winne, 2001). By contrast, the experimenter monitored and directed the proficiency-based group’s progression. Schunk (1996) suggests that more frequent self-monitoring of progress results in better learning, a benefit that would be experienced by the progressive group.

Third, participants can set goals related to performance processes or goals related to performance outcomes. While process goals are usually better for learning than outcome goals (Brydges et al., 2009; Zimmerman & Kitsantas, 1996), combining process and outcome goals can lead to better performance than setting one or the other (Zimmerman & Kitsantas, 1997; Zimmerman & Kitsantas, 1999). Whereas all of our groups set process goals during practice, only the proficiency-based group had an implicit outcome goal – to achieve the proficiency criterion. We did not, however, define achievement of each criterion as a learning goal; thus participants may not have regarded the criterion as an outcome goal. Also, the additive effect of process and outcome goals requires initially setting process goals followed by outcome goals (Zimmerman & Kitsantas, 1996), which did not happen in the present study. And finally, because our choice of time as the proficiency criterion is problematic, it could be that the proficiency-based participants focused on the ‘wrong’ outcome by trying to improve their
time. The most accurate explanation notwithstanding, the equivalent global clinical
performance displayed by the proficiency-based and progressive groups suggests that nursing
students chose when to progress between simulators ‘at the right time’.

The progressive learning approach is derived from theories such as optimal learning
points (Dubrowski et al., 2007; Guadagnoli & Lee, 2004) and the ZPD (Vygotsky, 1978) from
psychomotor learning and educational psychology, respectively. A tenet of both theories is
that the student should be provided with external assistance or scaffolding (Wood et al., 1976)
to help them structure the learning setting. The structure provided in the present study - an
instructional video, a process goal list and gradual increases in simulator fidelity and
information content - appeared to enhance learning. Inconsistent with our expectations, the
open-ended group achieved similar performance levels as the progressive group. Surprisingly,
11 of 15 participants in the open-ended group chose a progressive practice schedule. The open-
ended participants’ clear preference for the progressive schedule may explain the absence of a
group difference. Apparently, the majority of open-ended participants directed their own self-
guidance (Brydges et al., 2009). An open-ended, self-guided group like the one studied here is
often referred to but rarely observed in education research. That is, researchers often suggest
that a learning tool can be used for ‘SDL’ yet fail to report observational data of how students
use the tool. Thus, direct observation of how the open-ended group navigated the simulation
resources in the present study provides new insights to simulation research.

Our comparison between the progressive and experimenter-control groups supported our
final hypothesis. Only the progressive group performed better on the transfer test than the
experimenter-control group according to measures of technical skill (CL, but not GRS),
communication skill and global clinical performance (IPPI rating). Both groups followed the
same practice schedule and viewed the same amount of instructional video; consequently the
progressive group’s superior performance can be attributed to their autonomy in controlling these resources. Further work is needed to understand why the open-ended group’s autonomy during practice did not result in consistently superior performance (i.e., only scored higher on IPPI rating) relative to the experimenter-control group.

**Management of resources**

Studies of independent learning in HPE rarely report how students manage the resources available to them. We believe that this information is a useful adjunct to performance-based measures for understanding the mechanisms of DSGL. In the present study, we found that the proficiency-based group completed more trials during practice than the other groups. More trials were likely needed to achieve the proficiency criteria and may have resulted in the proficiency-based group’s higher post-test scores. Achieving a high score is often associated with increases in student satisfaction. This connection, or the participants’ knowledge that they performed proficiently, may explain why the proficiency-based group rated the educational value of all simulators higher than the other groups.

The open-ended group chose to practice for the fewest trials and least amount of time on the low-fidelity simulator. This lack of use may help to explain the open-ended group’s low post-test scores on that simulator. In addition, these findings have educational implications. Participants given the choice to guide their practice elected to spend little time on the low-fidelity simulator. Beyond the low-fidelity post-test, this decision did not lead to a negative effect on the open-ended group’s learning. These observations may call into question the educational utility of this particular VR simulator. Participants in all groups rated the VR simulator the lowest in educational value. This evidence is supported by simulation researchers, who suggest that viewing a simulation on a computer screen and interacting through keyboard and mouse clicks is very low in both actual and perceived fidelity (Alessi,
Future research is needed to resolve when and if virtual reality simulators are educationally valuable, which requires departure from the notion that high technology is necessarily related to improved learning outcomes.

CONCLUSIONS

Our data have implications for nursing educators and students alike. We believe nurse educators will benefit from rethinking DSGL as a collaborative activity between student and educator. The educator can structure the learning setting to promote DSGL, which seems appropriate given the progressive groups impressive learning gains. Alternatively, the educator can structure the environment and define a proficiency criterion, which may provide a more concrete assurance of eventual proficient student performance in the clinic. Different still, we found that student intuition can be effective – open-ended group students independently chose the theoretically best approach to learning and benefited from doing so.

Our data support using principles from psychomotor learning and educational psychology to design simulation-based training approaches. DSGL, however, is not without its drawbacks. Anecdotal evidence from this study suggests that not all students enjoy the autonomy that comes with DSGL. Thus, a compromise should be reached between providing students with this autonomy and the ‘hands on’ guidance to which most are accustomed.

Progressive learning is resource intensive so it may not be the best approach for all institutions. Despite this concern, educators likely have more than one resource to teach any one skill. Creative analysis and thoughtful integration of those resources into the curricula will benefit students tremendously. A progressive approach is one concept that can guide this process. Moreover, DSGL is less resource intensive in terms of faculty time than approaches like proficiency-based training (e.g., time needed for monitoring and standard setting).
Nevertheless, if educators prefer the proficiency-based approach, we recommend further study of the population that should be used to define proficiency criteria and how the criteria are defined (i.e., time vs. time plus error scores).

Undergraduate nursing students often struggle with the transition from classroom learning to ‘real-life’ patient settings (Medley & Horne, 2005). It is important for nursing educators to provide a safe and non-threatening environment in order to facilitate experiential learning that can be applied to patient settings (Medley & Horne, 2005). Simulation modalities are available in nursing laboratories, but are often under-utilized. For simulation to be advantageous for nursing students, reliable and valid research is needed. Equally, to move simulation-based educational research forward, educators must demand evidence of simulator effectiveness and scholars must use theoretical and pedagogical principles in simulator and curriculum development (Kaakinen & Arwood, 2009).
Table 1: Process goals provided to all participants

<table>
<thead>
<tr>
<th>ProcessGoals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place the tourniquet 10-12 cm above the insertion site,</td>
</tr>
<tr>
<td>Clean the insertion site – use the in-to-out circular technique,</td>
</tr>
<tr>
<td>Make sure the bevel of the needle is up and inserted into the vessel at 10-30 degree angle,</td>
</tr>
<tr>
<td>Hold the skin taut while inserting using thumb,</td>
</tr>
<tr>
<td>Hold the stylet stable and advance the catheter into the vein over the stylet to seat it in the vessel,</td>
</tr>
<tr>
<td>Stabilize the catheter and release the tourniquet,</td>
</tr>
<tr>
<td>Flush the lock with normal saline to check catheter patency.</td>
</tr>
</tbody>
</table>
Table 2: Nursing data used to define proficiency criteria

<table>
<thead>
<tr>
<th>Trial</th>
<th>Nurse 1 Time (min)</th>
<th>Nurse 2 Time (min)</th>
<th>Nurse 3 Time (min)</th>
<th>Nurse 1 Time (min)</th>
<th>Nurse 2 Time (min)</th>
<th>Nurse 3 Time (min)</th>
<th>Nurse 1 Time (min)</th>
<th>Nurse 2 Time (min)</th>
<th>Nurse 3 Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.77</td>
<td>3.11</td>
<td>4.16</td>
<td>4.77</td>
<td>3.11</td>
<td>4.16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.26</td>
<td>0.25</td>
<td>0.28</td>
<td>0.26</td>
<td>0.25</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Group mean | 4.77 | 3.11 | 4.16

Group SD | 1.03 | 0.68 | 0.31
Figure 1: Displays data for all groups on the low-fidelity post-test (A). Global rating scale (B), and checklist (C) are plotted as a function of mid-fidelity post-test, high-fidelity post-test and transfer test. IPPI ratings (D) are plotted for the high-fidelity post-test and the transfer test. Communication ratings (D) are plotted for the transfer test. Error bars represent standard deviations from the mean. Asterisks indicate significant post-hoc comparisons at the $P<.05$ level. LF, MF and HF refer to low-, mid- and high-fidelity simulators.
Figure 2: Displays the resource management and participants’ simulator rating data for the four groups. Shown are plots for: total practice time, which is separated into the time spent on each simulator (A), total trials and total video time, plotted to show the number of trials and video time on each simulator (B), and participants’ ratings of the educational value of each simulator (C). Error bars represent standard deviations from the mean. Asterisks indicate significant post-hoc comparisons at the $P<.05$ level, while n.s. represents non-significant findings.
CHAPTER 7: GENERAL DISCUSSION

The purpose of this dissertation was to investigate the effects of DSGL on skill acquisition, retention, and transfer of novice health professions students in the context of simulation-based education. Taken together, the three manuscripts presented offer a view of how health professions students engage in DSGL. Most notably, this dissertation is one of the first to systematically and experimentally investigate DSGL of clinical technical and non-technical skills. Simulation, an emerging educational technology, was used primarily because it is an ideal tool for DSGL, and also because many self-learning theories have not been updated to include students’ use of educational technologies. This dissertation explored how the combination of external direction and student self-guidance influences: students’ cognitive and metacognitive processes, student interactions with the learning environment and available resources, and how students learn in different DSGL contexts.

The key findings from each manuscript and how they address the specific hypotheses of this dissertation have been included in the relevant chapters. In this final chapter, Bruner’s (1985) recommendations for the study of learning, teaching and curriculum will be used to frame the discussion of DSGL. Student experiences during <i>self-directed learning</i> can be linked to Bruner’s (1985) focus on learning processes. Specifically, the findings in this dissertation will be related to literature on learning processes such as self-directed speech, goal-setting, and metacognition. How the experimenter <i>directed</i> students to set goals and use certain resources can be linked to Bruner’s (1985) focus on teaching and curriculum. Hence, this chapter also discusses evidence generated regarding how an instructional agent can design the learning environment to benefit students’ DSGL.

It is important to note that because Chapters 4 through 6 are written for publication, not all of the data could be reported in those manuscripts due to word limit constraints. Hence, this
general discussion is viewed as a forum in which a more elaborated interpretation of the study results can take place. Data that are new to the reader will be discussed as will some of the author’s inferences that have been generated while writing and reflecting upon the contents of this dissertation. Some may view inferences as plain conjecture; however, the intention is to weave the inferences with study findings in an effort to generate an initial theory on DSGL that will be expanded in a future research program.

7.1. What learning processes make students more receptive to DSGL?

Joe is feeling confident. Joe recognizes the value of simulation-based education and its potential for his DSGL. He will continue to set effective learning goals, and to self-monitor and self-control his behaviour during his attempts to achieve those goals. He plans on being more vocal in the future so that he can provide some input to the instructional design process and he will try to gain more control over his practice conditions.

He is still trying, however, to understand which processes are activated when he self-guides his learning.

Traditional definitions of SRL mention the terms monitor, control, cognition, motivation, and behaviour. While motivation is clearly discussed in up to 50% of SRL definitions (Dinsmore, et al., 2008), the present study concentrated on metacognitive, cognitive and behavioural elements. What follows is an examination of the critical link that can be made between self-directed speech, goal-setting, metacognitive activity and learning outcomes.

7.1.1. Self-directed speech and self-verbalization

Students in this dissertation were novices and therefore did not possess the vocabulary that is associated with the practiced tasks. Vygotsky (1978) suggests that an instructional agent is
needed to mediate the student’s development from external to self-directed speech. In this
dissertation, students accessed an instructional video and therefore they ‘socialized with
technology’ in their efforts to develop the language associated with each task.

During practice, particularly in the studies detailed in Chapter 6 and Chapter 7, students
asked if SimMan “had to talk the whole time?”, with at least two people muttering “I wish you
would just shut up.” SimMan’s questions and responses may have been interfering with the
students’ efforts to use self-directed speech. Moreover, on the standardized patient transfer
test, many students overtly self-verbalized and when queried by the patient, replied “I’m just
talking to myself”. Taking the perspective of Vygotskian researchers, it appears that many
students achieved Stage II of the ZPD - the ability to assist their own performance. A hallmark
of Stage II is self-verbalizations and other forms of self-guidance during performance (Tharp
& Gallimore, 1988).

Vygotskian theorists view goal-directed action as the outcome that arises when self-
verbalization mediates behaviour (McCaslin & Hickey, 2001). Students who lack the ability to
self-verbalize will be confused and their performance on a goal-directed action will suffer.
Hence, when a student learns a new skill not only is the skill being internalized, but so too is
the language to make the skill fluent and understandable. In this dissertation, students’
socialization with technology and their access to goal lists likely aided in their development of
self-directed speech.

7.1.2. Goal-setting and goal orientation

Goal-setting is an essential planning process that can motivate and focus competent self-
guided students (Locke & Latham, 1990; Schunk, 1990). In Chapter 4, self-guided students
who set process goals outperformed yoked control students, whereas self-guided students who
set outcome goals did not. That study is one of the first to add clinical skills to the growing list
of abilities that self-guided students learn better when setting process goals rather than outcome goals (Zimmerman & Kitsantas, 1996; Zimmerman & Kitsantas, 1997).

In goal theory, another dichotomy besides process-outcome goals is the distinction between mastery and performance goals. A mastery goal orientation is evident when the student focuses on acquiring new knowledge and skills, enhancing self-competence and seeking understanding (Paris et al., 2001). By contrast, a performance goal orientation is observed when students emphasize social comparison, the bettering of normative standards or when goals are set to merely complete a task. Most students received process goal lists in this dissertation and it was assumed that they would implicitly set mastery goals. The proficiency-based group in Chapter 6, on the other hand, attempted to achieve a proficiency criterion on each simulator. The implicit performance orientation this likely created in this group could explain their superior post-test performance and subsequent drop in transfer test performance relative to the progressive and open-ended groups. Without directly assessing each student’s goal orientation this interpretation cannot be confirmed, yet it opens up an avenue for further inquiry.

The distinction between mastery and performance goal orientations’ is not trivial. Recent research shows that students with a mastery goal orientation have higher metacognitive activity and better performance scores compared to students with a performance goal orientation (Schmidt & Ford, 2003). In fact, students with a performance goal orientation who received a metacognitive intervention actually experienced a decrease in metacognitive activity. Though a distinction between mastery and performance goal orientations’ was not outlined in this dissertation, the studied population likely experienced some level of interaction between their goal orientation, metacognitive activity and performance. Indeed, research suggests that goal lists may operate by making the student aware of normally covert internal
processes and making explicit the behaviours which the student can use to accomplish the goals (Hobsbaum et al., 1996).

7.1.3. Metacognition – self-monitoring and self-control

Flavell (1979) defined metacognition as “thinking about your thinking.” Two primary functions of metacognition are self-monitoring and self-control. Self-monitoring requires students to deliberately and selectively attend to specific behaviours and cognitive processes (Schunk, 1983; Schunk, 2001; Zimmerman & Kitsantas, 1996), and to compare current performance to their own goal performance (Winne, 2001). Self-control includes decisions regarding how to allocate one’s resources and how to sequence performance (Schmidt & Ford, 2003).

Self-monitoring and self-control are critical processes that students must develop to ensure SGL competence. For complex tasks, information-processing theorists suggest that self-guided learners use the IF-THEN-ELSE procedure: “IF conditions are met, THEN enact a particular tactic, ELSE use a different tactic” (Winne, 2001, p. 175). A student using the IF-THEN-ELSE procedure when learning multi-stage tasks will generate feedback as each step is completed (Butler & Winne, 1995). If the student comprehends the feedback, he will be updated about task conditions and can use the feedback to mediate further goal-setting and strategy selection. Therefore, feedback from self-monitoring interacts with the process of self-control. Based on self-monitoring, for instance, a student may decide to use self-control and seek out an external feedback source or switch to a new task. Dinsmore et al. (2008) draw a link between metacognitive processes and DSGL, noting that the concepts are nested within one another. Students monitor their thoughts and actions in an effort to gain some control over them and ultimately to guide how they learn. Consequently, intention to act (to be self-guided) and self-awareness (metacognition) become intertwined.
Up to now, this section has focused on DSGL and made assumptions and hypotheses about metacognition. Assumptions are sometimes necessary when analyzing psychological phenomena because some processes can be observed and explained in explicit terms, whereas others can only be conceived implicitly (Vygotsky, 1978). Students displayed self-monitoring and self-control in both explicit and implicit forms in this dissertation. In Chapter 4, students self-monitored their performance explicitly by recording their goal progress. Self-control was explicit in Chapters 4, 5 and 6 when students altered their behaviour by accessing the instructional video and/or progressing between simulators. By observing student behaviour, it was assumed that implicit interactions between self-monitoring and self-control were evident when students made ‘in-the-moment’ assessments of performance and subsequently decided to use the instructional video, process goal list, and to progress to the next simulator.

Many of the group comparisons in this dissertation involved an indirect evaluation of each group’s capacity to self-monitor and self-control. The results from Chapter 4 indicate that students in the process goal group self-monitored their performance effectively, self-controlled their use of the video efficiently, and ultimately displayed better skill retention than the yoked control group (cf. Wulf et al., 2005). Similarly, students in the progressive group in Chapter 6 self-controlled their use of the video and their advancement between the simulators. On the transfer test the progressive group outperformed the experimenter-control group. In both Chapters 4 and 6, the self-guided groups’ superiority was not evident during practice and did not surface until the retention or transfer test, illustrating the importance of including these longitudinal measures of learning (Dubrowski, 2005; Schmidt & Bjork, 1992). Overall, the self-guided groups’ superior performance in both chapters may be attributed to their autonomy in controlling the practice resources (Chiviacowsky & Wulf, 2002; 2005; 2007). Potentially, self-guided students use their autonomy to engage in information-processing activities that are
limited for yoked control students, such as trial-and-error or experimentation with different techniques (Wulf et al., 2001).

Recall that the term ecological interfacing describes how students choose the parts of the environment with which they interact (Normann, 1985). Past observations of students learning independently have shown that some will intentionally avoid new, unfamiliar experiences while others will be drawn to novel situations (Burns & Gentry, 1998). The following interpretations assume that student behaviours in DSGL conditions are overt manifestations of the covert outcomes of self-monitoring and self-control processes. In Chapter 5, students in the progressive group self-guided their learning progression. Progressive group students probably advanced between simulators based on the combined effect of their motivation and their self-monitored level of ability. The effectiveness of the progressive group students’ behaviour was confirmed in Chapter 6 when the group demonstrated better skill transfer than the experimenter-control group and similar performance relative to the proficiency-based group. These findings suggest that self-guided students in the progressive group transitioned between simulators in a way that was tailored to their needs and which led to enhanced skill transfer. Moreover, by self-monitoring when to progress between simulators the progressive group likely benefited from engaging in more explicit learning decisions than the low- and high-fidelity groups in Chapter 5 and the experimenter-control and proficiency-based groups in Chapter 6 (Schunk, 1996). This interpretation fits with motor learning evidence showing that students use feedback sources to confirm that their performance is accurate (Chiviacowsky & Wulf, 2007). Engaging in this process of error estimation and subsequent confirmation is a form of self-monitoring that may allow students to analyze more critically their intrinsic feedback during performance in DSGL conditions (Chiviacowsky & Wulf, 2005).
Chapter 6 included an open-ended group to understand how students operate in an environment that is almost completely self-guided. Observation of the open-ended group’s resource management provides new insights to the field because HPE researchers rarely consider evaluating and keeping a record of the DSGL process and instead have focused on learning outcomes. Notable exceptions are researchers who study PBL and emphasize the theoretical links between learning and process. Despite this rhetoric, Hak and Maguire (2000) note that process-oriented research on the PBL cycle is lacking. Indeed, only a small number of rigorous studies address the processes and strategies that self-guided students use in a PBL curriculum (Dolmans & Schmidt, 1994; Evensen et al., 2001; Van den Hurk, Wolfhagen, Dolmans, & Van der Vleuten, 1999; Yew & Schmidt, 2009). By contrast, extensive work in applied psychology has consistently shown that self-guided learners make poor instructional use of resources (see for example: Bell & Kozlowski, 2002; Kozlowski & Bell, 2006) or use resources in profoundly different ways in the same environment (Schmidt & Ford, 2003). The findings in this dissertation do not conform to those in applied psychology because the majority of open-ended students were capable of independently selecting the theoretically best learning sequence (i.e., progressive). Most importantly, the students’ self-guided decisions did not lead to the predicted degradations in performance on the transfer test. Apparently, the majority of open-ended students directed their own SGL.

A logical question here is why the open-ended group performed so well. Williams (1993) completed a large review of the learner-controlled instruction literature and reported that prior knowledge, prior ability and student motivation are mediating factors in how students respond to learner-controlled conditions. In the applied psychology literature, the participants are typically psychology students who have heterogeneous levels of knowledge and ability and are probably motivated most by the potential to earn extra course credit. In stark contrast, the
nursing students in Chapter 6 may have lacked in prior ability, but likely possessed relatively high levels of prior knowledge and motivation. Fourth year nursing students have surely been exposed to human anatomy, the tools of nursing, along with mock and real patient interactions. Another assumption is that these future nurses were highly motivated to learn IV catheterization (a relevant skill for their profession), more so than a psychology student is to learn to track blips on a radar screen (Bell & Kozlowski, 2002). Therefore, the open-ended group may have performed well due to the nursing students’ high levels of prior knowledge and motivation. Whether these personal characteristics truly relate to the findings presented in this dissertation is a question for future empirical study.

Self-monitoring and its influence on subsequent decision-making is clearly an important element of any DSGL experience. The present series of studies is partially restricted by the fact that self-monitoring could only be inferred by observing the explicit decisions students made. Greater study of the actual experiences students have during these moments and the factors involved in their decision-making is warranted. Nonetheless, the present study provides an initial understanding of how students self-assess performance in the moment (Eva & Regehr, 2008). Further, observing students’ use of resources, or their ecological interfacing (Normann, 1985), provides information on how students overcome challenges learning a task and, in the process, “hone and internalize the analytical language common to that ability” (Burns & Gentry, 1998, p. 139).

While the previous sections outline the positive findings on self-monitoring and self-control in this dissertation, there were indications that students did not efficiently self-monitor some aspects of their performance. A concrete example is provided from observations during the data collection phases for the studies reported in Chapters 5 and 6. In both chapters, students would advance the IV catheter into the simulated vein and continue advancing until
the IV catheter punctured the other side of the vessel; yet in the majority of cases, students were not aware of the error. In those same studies, the students also lacked contextual awareness. Though this point was not mentioned in the research chapters above, the SP transfer test required the SP to portray a blind patient. Students did not notice the patient’s blindness in 60% and 62% of cases in Chapter 5 and 6, respectively. Clearly there is a need to improve student’s self-monitoring and contextual awareness and future studies can address these aspects of performance.

7.1.4. A modernized view of DSGL

The observations and inferences about students’ cognitive and metacognitive processes that stem from this dissertation create a fresh blend between the perspectives of Vygotsky and social-cognitive theorists like Bandura and Zimmerman. When a student assumes a process goal orientation and attends to valid learning strategies, he not only observes and emulates those strategies but he also begins to develop a language for the task. Providing the self-guided student with some form of modeling or instruction (e.g., a video) will promote the transfer of analytical language from the environment to the student. Educators must consider the student’s current level of skill and knowledge to ensure that goals lists and models provide information that he can comprehend and interpret. The student’s initial difficulties matching learning goals with specific identifiable behaviours are inevitable, but should be resolved with continued practice.

Developed analytical language and self-verbalizations equips the student with the vocabulary he can use to perceive and critique his own intrinsic feedback. If the student’s self-monitoring processes detect a need to adapt a strategy, then this means he has noticed that an aspect of his cognition, behaviour or environment requires change. Self-monitoring, then, allows him to diagnose his own performance and provide his own augmented feedback,
possibly in the form of KR or KP. After detecting and interpreting this feedback, if the student alters his actions or cognitions, then he starts to self-control his learning. Now the student is using analytical language to regulate the learning environment and his own cognitive mechanisms. Thus, the student perceives that the current learning situation is not going well and is using self-monitoring to inform subsequent adaptation and self-control. A student may use these procedures to immediately self-monitor his performance in the moment or he may do so summatively following a practice session. This novel DSGL perspective suggests that self-guidance is composed of many mini-cycles of processes that accumulate to form larger cycles as the student develops and learns. DSGL is also viewed as falling on a continuum with complete self-guidance and complete other-guidance as the poles (Figure 1). Notice Figure 1 is similar to the figure provided in the introduction of this dissertation with the addition of the experimental groups outlined in the three research chapters.

Some aspects of this view of DSGL are speculative and certainly require further investigation. Overall, this perspective is a new interpretation of DSGL that modernizes previous theories by studying learning in adult students as opposed to children and by considering students’ ‘social interactions’ with educational technology, as opposed to a human instructor. Based on the data in this dissertation, it is evident that the DSGL process can be both effective and ineffective, depending on the student, practice conditions, and several other factors. Competence in DSGL will likely improve as the student gains experience enacting strategies, generating feedback and iteratively engaging in self-monitoring and self-control.
Figure 1: Depiction of the self-guided-other-guided learning continuum. Marked along the continuum are SRL, PBL as one application of SDL, the ideal for the new model of DSGL, and the nine experimental groups included in the present dissertation.
7.2. The educator’s role in instructional design

Joe recognizes that students must be aware of their cognitive and metacognitive processes when self-guiding their learning. Equally, Joe is hopeful that his future clinical educators will read the education literature so that they create challenging and supportive learning environments with features like modeling, scaffolding and tasks that consider Joe’s potential development. Further, he hopes educators will create retention and transfer tests to assess his learning longitudinally. He recognizes the value of forming a collaborative relationship with an educator and of seeking direction in his efforts to self-guide his learning. He thinks that the progressive learning approach appears to be a suitable and generalizable training strategy. He also sees potential in using integrated and global training strategies, such as the IPPI, in simulation-based education. In sum, Joe believes that his new knowledge of DSGL will enhance the educational benefits of his future micro-instructional and possibly macro-instructional training opportunities.

Skeptics of DSGL may suggest that it is best to always have an expert clinical educator present to inform and direct student learning. Other-guided learning certainly has its merits. However, giving students some control over their learning may serve as the initial step for teaching broad self-guided competence (Corbalan, Kester, & Merriënboer, 2006). If the field of HPE is serious about molding lifelong learners from novice students, then improving how clinical educators create and support DSGL is paramount.
7.2.1. Positioning ‘directed’ in the concept of DSGL

Chapter 4 introduced the concept of DSGL. Rather than viewing SGL as a solitary activity, DSGL requires the educator to build supports or scaffolds into the learning setting that the student can use when required. Educators who design a DSGL curriculum must use scaffolds that the student will understand, be able to use, and that will enhance the student’s learning (Bell & Kozlowski, 2002; Guadagnoli & Lee, 2004; Wood et al., 1976).

Environmental structures and/or learning tools designed for use as scaffolds for students in this dissertation include: goal lists, task performance modeled on an instructional video, progressive practice schedules, and proficiency criteria that students must achieve. Process goal lists appear to have aided students to self-guide more effectively than outcome goal lists in Chapter 4, practice structure and practice variability likely contributed to the superiority of the progressive group over the high-fidelity and low-fidelity groups in Chapter 5, and the ability to self-guide how they used elements in the learning environment led to better retention and transfer for students in the self-guided groups relative to experimenter (yoked) control groups in Chapter 4 and Chapter 6. Collectively, the results suggest that DSGL is a training strategy that has great potential for health professions students learning fundamental clinical skills using simulation modalities.

Whereas educators cannot become directly involved in each individual student’s learning process due to practical limitations, the comparison between self-guided and other-guided learning would still be of important theoretical interest. Taking this into consideration, a logical next step in the present research program is to study the relative educational benefits of self-guidance, co-guidance amongst students and other-guidance in the presence of a more knowledgeable educator (cf. Rogers, Regehr, Gelula, Yeh, Howdieshell, & Webb, 2000).
7.2.2. Progressive learning approach – theoretical implications

Narrowing the focus to the structure of practice conditions, the progressive learning approach was tested in both Chapters 5 and 6. The success of the progressive learning approach in those chapters is attributed to the training strategy keeping students in the ZPD (Vygotsky, 1978). Scholars who study the ZPD (Bruner, 1985; Wertsch, 1979) and the CPF (Guadagnoli & Lee, 2004) advocate for the use of tasks that the student will perceive as moderate in difficulty. Tasks perceived as moderately difficult challenge the student in a way that increases arousal and his potential to acquire new information and that does not leave him bored or overwhelmed. Importantly, what the student perceives as ‘moderately difficult’ will change as practice continues so several tasks should be made available to ensure the student remains in his ZPD and is appropriately challenged.

In this dissertation, students who learned progressively had the opportunity to decide, for themselves, when to advance between simulators and this likely kept them within their own self-diagnosed ZPD. Hence, when an educator creates a progressive learning opportunity for students, one could say that a form of scaffolding is set in place. That is, scaffolding may not only apply to contexts where task difficulty is maintained whilst the educator increases support to allow the student to complete the task (Wood et al., 1976). In addition, the concept of scaffolding could be broadened to encompass contexts where the educator places an overarching structural framework in the learning setting that facilitates students’ efforts to build new skills and knowledge (cf. Azevedo, Cromley, Winters, Moos, & Greene, 2005).

By this new definition, the progressive groups’ training regime was scaffolded (Wood et al., 1976) with progression built into the ‘context of now’ (Vygotsky, 1978), which likely promoted students’ potential development and enhanced their learning. The progressive group’s consistently high level of performance in Chapter 5 and 6 supports these
interpretations. Thus, it appears that a DSGL environment with multiple simulation modalities provides a good context for a health professions student to maintain their ZPD. Gofton and Regehr (2006) summarize the ideal HPE training environment elegantly:

> It is challenging enough, but not too challenging. It is stressful enough, but not too stressful. It is supportive enough, but not too supportive. And it is a different mix of these balances for each individual and for each skill an individual is trying to master (p. 105).

Therefore, SGL combined with a progressive learning structure creates a DGSL environment that students can adapt and that can be individualized and frequently restructured. Achieving Gofton and Regehr’s (2006) ideal blending of challenge, stress and support should be a goal of future HPE research.

Clearly, achieving such an ideal blend for each individual represents a massive challenge to researchers and educators alike. The findings presented in this dissertation indicate that the student can be a good partner in the process of keeping the instructional context within his personally unique ZPD. Of course, the question remains about whether students need a collaborative partner when judging their preparedness to advance through the requisite levels of the ZPD. More advanced educational technologies, intra- and inter-professional peers, and expert mentors each represent potential collaborators to help a student traverse the complex path through the stages of the ZPD and, more generally, DSGL.

7.2.3. Practical implications

Instructional design that considers students’ cognitive and metacognitive processes and which uses a progressive learning approach has practical implications. Clinical educators may use the principles outlined in this discussion to effectively integrate existing simulation resources into their curricular design. Educators can consult clinical experts to derive process goals lists and to produce instructional materials, they can assess the fidelity and information content of simulators and sequence them appropriately and they can concentrate on how
students use those resources. Adherence to these recommendations will allow fine-tuning of the efficiency of simulation-based education and will encourage an iterative view of instructional design: design-implement-observe student performance-note necessary adjustments-repeat.

7.3. Assessment of DSGL

To ensure successful self-guided learners, educators may wish to design not only the training regime but also assessment tools that the student can use independently and that evaluate DSGL effectiveness (Brydges, Carnahan & Dubrowski, 2009). Although the students in Chapters 4 through 6 did not have access to such tools, it would be of theoretical interest to understand how assessment tools designed for the self-guided learner would affect DSGL processes. Assessment tools should clearly reflect DSGL processes – researchers should first explicitly define a concept and then develop a tool to assess the concept rather than the reverse sequence (Schunk, 2008). Following development, the tool should undergo proper tests of validity and reliability before it is further implemented. The development of assessment tools that the student can use independently and therefore avoid the need for expert raters or computers has the potential to improve the cost- and time-efficiency of simulation-based education.

An additional assessment method used in this dissertation was the IPPI rating. The IPPI rating assesses students’ global clinical performance and has great implications for their interactions with patients in real clinical settings. The present study demonstrated that the IPPI rating has high concurrent validity (Table 1) and reasonable reliability. The sensitivity of the IPPI rating to the superior overall performance of groups in this study adds to the body of positive work associated with the IPPI educational approach (Kneebone et al., 2006; Kneebone et al., 2007; LeBlanc et al., 2009; Moulton et al., 2009; Nestel et al., 2003). Further, an
innovative and novel use of the IPPI method was tested in this dissertation. That is, this is the first study to report use of an IPPI scenario as a longitudinal test of skill transfer in the HPE literature. Researchers may wish to continue using IPPI as a transfer test strategy because the use of SPs enhances the simulations’ fidelity, information content and clinical relevance relative to other forms of simulation.

Table 1: IPPI Rating correlated with other dependent measures as assessed on the transfer tests in chapter 5 and chapter 6.

<table>
<thead>
<tr>
<th></th>
<th>IPPI with GRS</th>
<th>IPPI with CL</th>
<th>IPPI with Communication Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 5</td>
<td>0.821**</td>
<td>0.606*</td>
<td>0.869**</td>
</tr>
<tr>
<td>Chapter 6</td>
<td>0.700**</td>
<td>0.678**</td>
<td>0.816**</td>
</tr>
</tbody>
</table>

** Pearson correlation is significant at the 0.01 level; * correlation significant at the 0.05 level.

7.4. Study Limitations

Specific limitations for each research paper are included in the relevant chapters. The following section will discuss limitations of the dissertation's quantitative approach as well as general limitations of the study of DSGL.

In Chapters 5 and 6, the single item intraclass correlation (ICC) values tended to be in the low to acceptable range for most dependent measures. The evaluation approach in this dissertation involved one rater evaluating all performance data and a second rater that evaluated a subset of those data. The same two expert raters provided ratings in both chapters. However, the single item ICC was based on one rater’s scoring in chapter 5 and on the other rater’s scoring in chapter 6. The ICC values are close to those generally reported in previous work (Hodges et al., 1996; LeBlanc et al., 2009) and are comparable between studies, suggesting some consistency between the two raters. The data do suggest a need for further
exploration of the reliability of the employed evaluation approach versus an approach where both raters evaluate all performance data.

Another methodological concern involved the use of the GRS and CL as assessment tools. Though the GRS and CL are regarded as gold standards in the assessment of technical performance, they may not be the best measures for studying integrated or global clinical skill performance. The ‘technical bias’ in the GRS and CL may explain why the two measures were not sensitive to the group differences detected using the IPPI rating in chapters 5 and 6. A similar concern may arise when considering that GRS scores were used for all power and sample size calculations. Despite this potential issue, the findings reported in chapter 5 and 6 of this dissertation likely did not suffer from a lack of statistical power. A post-hoc power calculation of Chapter 6 data, for example, indicates that 350-1000 participants per group would be needed to detect transfer test performance differences between the progressive, proficiency-based and open-ended groups. Conversely, a limitation of chapter 4 is that the study was not sufficiently powered to demonstrate a goal setting (process or outcome) by autonomy (self-guided or yoked) interaction. A larger sample size in future studies should rectify this limitation.

From a theoretical perspective, the initial hypotheses in Chapter 6 did not recognize that proficiency-based training is a form of experimenter-controlled practice. Though this did not negatively affect the study, this oversight emphasizes the need for researchers conducting comparative studies to critically appraise all training methods using the theoretical lens they have selected. Close scrutiny of this dissertation also reveals a disconnect in how the goal-setting intervention was implemented in each chapter. In Chapter 4, students were only able to review the process and outcome goals lists at the beginning of practice. The goals lists were removed to prevent students from using the goals list as a crutch when self-recording
information about their performance. Conversely, in Chapters 5 and 6, the students were able to access the process goals list throughout practice. In those chapters, students were given full access to the goals list to replicate the real-world conditions of simulation-based education. This methodological change prevents a complete comparison of the effects of goal-setting between the different chapters in this dissertation. Future work to address this issue should compare a group that receives a goals list only at the beginning of practice versus a group that accesses the goals list throughout practice.

Finally, there are limitations to the study of DSGL. First and foremost, self-guided practice was not compared to other-guided practice. Thus, this study does not demonstrate the comparative efficacy of self- versus other-guidance. Along the same line, feedback has been identified as a critical necessity in simulation-based education (Issenberg et al., 2005) and the students could only provide their own feedback in this dissertation. Additional work is needed to determine how best to integrate external feedback into the DSGL curriculum.

Another limitation may result because the students in this dissertation came from nursing and medical training programs. Hence, combining the results from these two different samples could be problematic due to their differing knowledge base and training expectations. Furthermore, the generalizability of the findings in this dissertation is limited. DSGL as it is conceived in this dissertation applies only to skill acquisition, retention and transfer on the specific suturing and IV catheterization simulators. Consequently, there is a need to extend the concepts of DSGL and the progressive learning approach to other skill sets (e.g., cognitive skills, diagnosis, patient physical examination), other populations (e.g., residents, other health care professionals) and other forms of learning (e.g., computer-based instruction). Overall, DSGL is only one of the many educational approaches that have a place in the HPE curricula – this study aimed to evaluate the marriage between DSGL and simulation-based education.
CHAPTER 8: CONCLUSIONS

This dissertation makes theoretical advances in how DSGL is conceptualized in HPE. Many HPE researchers believe that if a technology provides students the opportunity for independent study, then successful learning will follow. This laissez-faire approach does little to advance the theory of DSGL and makes too many assumptions about students’ abilities to self-guide. Rather than leaving students to their own devices, the present study conceptualizes DSGL as an activity that is collaborative between student and educator. In this collaborative role, the educator must provide scaffolds in the learning environment, and consider the student’s current and potential development as well as the interactions between the student’s behavioural, cognitive and environmental factors. Finally, DSGL is conceived as dimensional, rather than having boundaries. Kaplan (2008) suggests that a dimensional view allows concepts to gradually transform into each other. Concepts that may be represented as dimensions include: individual-environment, other-guided-self-guided, and surface strategies-deep strategies (Kaplan, 2008). An additional dimension from this dissertation is implicit self-monitoring-explicit self-monitoring. Overall, this dissertation has produced the novel concept of DSGL and evaluated its application in the micro-instructional context of simulation-based education.

In addition to forming a basis for DSGL, this dissertation has queried several specific DSGL processes. This series of studies extends the findings from the kinesiology literature (Chiviacowsky & Wulf, 2002; 2005; 2007) and supports the hypothesis that self-guided groups benefit over yoked control groups due to the self-guided students’ autonomy in selecting the practice schedule and tailoring practice to their own learning needs. A theoretical examination of instructional design elements that can stimulate students’ DSGL showed that, in the early stages of clinical skill acquisition, a process goal orientation is more efficient than an outcome
goal orientation. Further, a practice schedule that students can self-guide and which exposes them to progressively higher levels of simulator fidelity and information content led to improved skill transfer in a realistic SP encounter. The data also underscore the need for longitudinal assessments of performance in the form of retention and/or transfer tests. Finally, this dissertation stresses the idea of observing students’ ecological interfacing, or the specific ways that they manage the available resources during practice. Future studies that focus on this process of learning will contribute more to our understanding of learning outcomes than focusing on outcomes alone.

In HPE, students will always need to be exposed to a variety of learning environments before they begin clinical practice. DSGL is one pedagogical approach that can help a student evolve into a lifelong learner. However, the present study exposes the current state of research on self-learning in HPE as ambivalent and consequently lacking direction and impact. The concept of DSGL should be studied iteratively with the intent to integrate the discovered principles into the research and training activities of educators who use simulation and other educational technologies.
CHAPTER 9: FUTURE DIRECTIONS

Future research efforts should continue to delve into the mechanisms that connect self-verbalization, goal-setting, metacognition, and self-guidance.

9.1. Self-verbalization

One inference in the preceding discussion section is that students learn clinical skills by developing their goal-directed action and task language; the latter can be represented in self-verbalizations. Future studies should examine the content of students’ self-verbalizations. These studies could determine whether self-directed speech approximates analytical language and whether aspects like the content and frequency of self-directed speech change as learning progresses. Furthermore, recording self-verbalizations will allow study of how the content contributes to goal-directed action. A second stream of studies should aim to determine if the development of self-verbalization parallels the development of goal-directed action, or if one matures more rapidly than the other. Another area of investigation is the role of learning tools like goals lists and instructional material in the development of self-verbalization. For example, research could compare an instructional video’s influence on self-verbalizations versus lectures, handouts or podcasts.

9.2. Goal-setting

To probe deeper into the findings on goal-setting, one step would be to investigate the effect of goal shifting. Researchers have found a beneficial effect of allowing students to initially set process goals and eventually shift to set outcome goals during practice (Zimmerman & Kitsantas, 1997; Zimmerman & Kitsantas, 1999). Evidence suggests that the shifting goal group performs better than process only, outcome only and no-goal groups. Comparisons of clinical skill acquisition between these four groups would advance our
understanding of the impact of goal-setting. If the shifting goal group proves to be successful, a follow up study could determine how best to coordinate the shift from process to outcome goals. For instance, students may shift in a self-guided manner, or they could switch after achieving a proficiency criterion.

An additional study should probe the relationship between metacognitive activity and either a mastery or performance goal orientation. In the present study, it was assumed that students would have a mastery goal orientation. However, future studies should determine what type of goal orientation students have when in a DSGL environment. Once determined, it would be important to examine whether each student’s goal orientation influences their metacognitive activity and/or learning processes and outcomes.

### 9.3. Self-monitoring

Additional studies should investigate implicit or spontaneous self-monitoring processes. One instance where this can be studied is when students make self-guided decisions. Determining why students switch to a new resource, make use of a learning tool or access instruction will inform future DSGL interventions. Factors that may influence these decisions and other self-monitoring processes include task characteristics, cognitions (e.g., I need more effort), and changes in performance standards, strategies or environmental characteristics.

Research methods for the study of self-monitoring may include self-report, questionnaires, think-alouds, generic question stems and/or self-modeling (i.e., the student reviews their own videotaped performance) (Schmidt & Ford, 2003; Schunk & Hanson, 1989). Other researchers have also measured self-monitoring using variables such as the frequency of off-task thoughts, cognitive focus and practice focus (Kozlowski & Bell, 2006).

To promote self-monitoring, students may need to be prompted with questions or asked to reflect-in-action (Schön, 1983). An example of a question stem to help students recognize that
they inserted the needle through the simulated vein with the IV needle could be: “If blood flashes into the catheter, but the catheter is not ______, then the vein has been ______”. The correct answers would be ‘patent’ and ‘punctured’. These and higher-order questions could prompt students to apply, analyze and create knowledge in the moment and may enhance their self-monitoring abilities.

Another branch of study could focus on the information that is collected via self-monitoring. One query would be whether the information produced by self-monitoring resembles feedback in the form of knowledge of results (KR), knowledge of performance (KP), both, or neither. Finally, effects of the regularity of self-monitoring could be studied by comparing students who are prompted to frequently self-monitor ‘in the moment’ versus students who self-monitor in a summative manner.

9.4. Instructional design and task structure

The success of the progressive learning approach raises the question of whether other task characteristics could be structured in a similar manner. Applied psychologists have advocated for training regimes that gradually increase task difficulty from simple to complex (Bell & Kozlowski, 2002; Corbalan et al., 2006). However, one study in surgical education showed no benefit of a progressively difficult training regime over training in a high difficulty practice condition (Dubrowski et al., 2007). Nonetheless, future studies should concentrate on simulator characteristics that are conducive to a progressive learning approach. Furthermore, the progressive learning approach in this dissertation should be applied and studied to the DSGL of other clinical skills using different simulations. Finally, a study should probe a progressive learning approach that conforms to the SCM of the elaboration theory (Reigeluth, 1992). That is, content experts should be asked to define the simplest real-world version of a skill (the epitome) as well as the more complex elaborations of that skill. Structuring student
progression based on the SCM may be more effective than the present conceptualization of progressive learning which relies on theory rather than expert opinion.

While the structure of the learning environment is important, how that structure is delivered to the student will contribute to performance and learning outcomes. Much research in the psychomotor learning (Schmidt & Lee, 2005) and the surgical literature (Moulton et al., 2006) shows that distributed practice (e.g., 4 lessons over 4 weeks) is more beneficial than massed practice (e.g., 4 lessons in 1 day). Determining if this principle applies to the progressive learning approach would be valuable. A potential study could compare the massed progressive learning approach used in this dissertation with an approach during which students practice a skill on the three different simulators on three different days.

9.5. DSGL in general

In the present study, students practiced in the micro-instructional context of ‘formal training’ in the simulation centre. A future research program should focus on expanding the concept of DSGL to the macro-instructional conditions of daily practice in HPE. Research at the macro-instructional level will certainly have its challenges; however, it would be valuable to investigate whether the DSGL processes engaged in the micro-instructional context of simulation-based education will differ from those processes required to navigate the macro-instructional contexts in medical or nursing school.

An additional study involves examining whether and to what extent DSGL skills are context dependent. Such a study would help determine if some DSGL processes transfer between contexts while others may not. Finally, viewing learning as a continuum from self-guidance to other-guidance, it would be valuable to study the influence of certain groups of ‘others’. Understanding how students learn with peers, in interprofessional settings and during faculty-guided learning would help define the borders of the self-guidance-other-guidance
continuum (Hadwin et al., 2005; Kaplan, 2008). Finally, while research that identifies potential differences in how students *acquire* skills in other-guided versus self-guided settings is important, of equal and possibly greater import is research that identifies potential differences in how students *forget* learned skills after practicing in other-guided versus self-guided contexts (Hays, 2009).

In this dissertation, DSGL was not used as collaboratively as its definition intends. The current generation of students expects greater involvement in the design of educational environments, processes and curricula. Future studies should evaluate what role self-guided learners should play in instructional design and should concentrate on the wealth of knowledge the student can contribute to the educator.

Advances in technology and the ability to access extensive educational literature will allow broader and deeper investigations of DSGL and its associated mechanisms. Technology will allow researchers to document students’ subtle actions with minimal intrusion and qualitative approaches such as ethnography will allow researchers to probe students’ thoughts and justifications for both explicit and implicit behaviour. Indeed, “it may be that neither quantitative nor qualitative approaches alone will suffice to illuminate the nature of monitoring and regulation, but that some combination is required” (Dinsmore et al., 2008, 406).

Finally, this dissertation has followed the tradition in HPE by studying why and how students learn rather than concentrating on why people *do not* learn using different training strategies. Studies that aim to determine why certain students have difficulty in specific learning environments, like a DSGL setting, deserve further inquiry in HPE.
## Global Rating Scale of Operative Performance

Please circle the number corresponding to the candidate's performance in each category.

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

<table>
<thead>
<tr>
<th>Time and Motion</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many unnecessary moves</td>
<td>Efficient time/motion but some unnecessary moves</td>
<td>Economy of movement and maximum efficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instrument Handling</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeatedly makes tentative or awkward moves with instruments</td>
<td>Competent use of instruments but occasionally appeared stiff or awkward</td>
<td>Fluid moves with instruments and no awkwardness</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Suture Handling</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awkward and unsure with repeated entanglement, poor knot tying and inability to maintain tension</td>
<td>Careful and slow with majority of knots placed correctly with appropriate tension</td>
<td>Excellent suture control with correct placement of knots and correct tension</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow of Operation and Forward Planning</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequently stopped operating and seemed unsure of next move</td>
<td>Demonstrated ability for forward planning with reasonable progression of operative procedure</td>
<td>Obviously planned course of operation with efficiency from one move to the next</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge of Specific Procedure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient knowledge. Looked unsure and hesitant at most operative steps</td>
<td>Knew all important aspects of the operation</td>
<td>Demonstrated familiarity with all aspects of operation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>FINAL PRODUCT</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final product unacceptable quality</td>
<td>Final product of average quality</td>
<td>Final product of superior quality</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TASK-SPECIFIC CHECKLIST FOR SUTURE OF SKIN LACERATION

<table>
<thead>
<tr>
<th></th>
<th>Not done or incorrect</th>
<th>Done correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUTURING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hold needle driver properly (thumb and long/ring finger with index as stabilizer)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Loads needle properly (at tip of jaws, ½ to 2/3 from point)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Loads needle with forceps (not fingers)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Needle enters perpendicular to skin</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Equal bites on either side</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Wound edges everted</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Passes needle through tissue without sawing, following curve of needle</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No gap between wound edges</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No dog ears</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>The sutures are appropriate distance apart</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>KNOT TYING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protects needle when tying</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>First knot placed square</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Second throw different from first, using middle finger to place square knot</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Appropriate tension maintained while tying</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Appropriate tension on wound edges (does not tighten knot excessively)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Sutures are cut properly</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>MAXIMUM POSSIBLE SCORE</strong></td>
<td>[16]</td>
<td></td>
</tr>
</tbody>
</table>

**STUDENT’S TOTAL SCORE**

---

Appendix II: Checklist used in Chapter 4

**ASSESSED FILE NAME:** _________________
Appendix III: IPPI Script for High-Fidelity IV Catheterization Simulator

**Venous Catheter Insertion**

**Instructions for candidate**

Mr. Lawrence Tegle was referred to the hospital by his GP. He has had diarrhea and vomiting for 2 days. He is in the Emergency Department and requires IV catheter insertion for fluid replacement.

Your tasks are to:

1. Manage and communicate with the patient
2. Insert a peripheral venous catheter into his right arm
3. Record details of the procedure in the patient chart
Instructions for SimMan Simulated Patient

Name               Mr. Lawrence Tegle or Mrs. Laurie Tegle

Age                75 years old

Summary
You were referred to the hospital by your general practitioner (GP). You have been unwell for 2 days and have diarrhea and vomiting. You are experiencing general aches and pains. Give the student time to explain, reassure and advise you before prompting him/her with questions unless the student asks you what you want to know.

Behaviour, affect, mannerisms
• You are pale, dehydrated and tired
• You are reasonably comfortable although quiet and withdrawn
• You don’t like being in hospital and don’t want to cause any trouble
• You are coherent and co-operative
• You are very sensitive to the actions of the student – you make facial expressions that show pain – you are not needle phobic, you just don’t like the idea, you would also prefer to watch rather than turn away
• You have had an IV catheter inserted before and it was ok – the last time you were in hospital for hernia repair – many years ago – you don’t remember much about it
• You are concerned about the incontinence with the diarrhea and also very embarrassed

Questions and prompts
• If the candidate offers to tell you what is happening, then accept this offer and prompt them if you think they are doing something and they are not telling you.
• You do not think this is serious but you are slightly worried – You do ask “what do you think it is?”

History of present illness
• You have had diarrhea and vomiting for two days
• You have felt hungry, but are unable to keep anything down
• You have not noticed any other changes in your bowel habits leading up to this illness
**Sample Script**

Beyond these particular instances, the student should always be maintaining an ongoing conversation with you in order to provide distraction and to establish your comfort. If they make an effort, return the favor by responding.

- The student should introduce themselves and ask how you feel.
  - Say hello, Respond with a weak voice, mention things like “My mouth is dry” and “I’m really thirsty” or “I haven’t been able to pee”
- Next the student should let you know why they are in your room and what they are going to do. If they do not provide this information, prompt them until they do. “Why are you here?” “What are you doing?”
  - After explaining the procedure, they should ask “Is now a good time?” or “Do I have your consent?”
- Next they will begin preparing the supplies they need to complete the IV start. During this time, there may be an awkward silence. Ask them what they are doing if they do not explain or maintain a conversation.
- The next step is for them to identify an accessible insertion site. If they touch you before requesting permission, call attention to this. The student should always let you know when they are going to touch you prior to doing so.
- They will then put on gloves and apply the tourniquet. Again, you should be told why they are doing this. Ask why if they do not explain.
- After applying the tourniquet, they will palpate the vein to check that it is ready to be punctured.
  - They may also tap the vein during this time.
  - They should ask you if you have any allergies. Say no to latex. Say yes to iodine. The student will then clean the insertion site using alcohol. Ensure you are told about each of these steps.
- Next is the insertion. Say that you would prefer to watch rather than turn away. You should always be told about the needle stick prior to the catheter entering your arm. If not, complain.
- Any time you are touched, remember to ask what is happening if the student is not forthcoming with this information.
- When the student begins disposing of their equipment, they should also be making sure that you are comfortable; they should clear the room of any equipment they brought in and should ask you “Do you need anything else?” Respond “No, thank you.”
- Finally, they will terminate the conversation/give closure to the scenario. If they do not explain that they are not returning say “Wait, are you coming back? What happens now?”
- Once they have said goodbye that marks the end of the scenario.
Appendix IV: IPPI Script for Standardized Patient IV Catheterization Simulator

Venous cannulation & infusion

Instructions for candidate

Ms. Ellen Hilton was referred to hospital by her GP. She has had diarrhoea and vomiting for 3 days.

Your tasks are to:

1. Insert a peripheral venous catheter
2. Document the procedure in the patient chart
Venous cannulation & infusion

*Instructions for organisers*

**People**
- Male or female simulated patient

**Room**
- Consultation room
- 1 chair
- Table
- Procedure trolley

**Equipment and consumables**

- **Candidate**
  - Tray
  - Cannula (green)
  - Alcohol-based hand scrub/hand wash
    - Alcowipe or street wipe
  - Extension set – N/A
  - Needleless injection cap – N/A
  - Hypoallergenic tape-IV tape
  - Prescribed fluid/s - N/A
  - Drip stand – N/A
- **Tourniquet**
  - Patient chart for prescribed fluid/flow rate with correctly filled out form (laminated) so this version can be copied on to patient’s fluid balance chart
  - Sharps bin X 2
  - Disposable gloves – S M L
  - Bin and extra bags
  - Scissors

**Simulated patient**

- Barrier sheet
- Fake blood
- White cane
- Wrist band
- Cannulation arm
- Dark glasses
- Clipboard, forms & pen

**Patient gowns X 2**
- Pillow
Venous cannulation & infusion

Instructions for simulated patients

Name  Mr. Alan or Ms. Ellen Hilton

Age   35-50 years old

Summary
You were referred to hospital by your general practitioner (GP). You have been unwell for 3 days and have had diarrhoea and vomiting. A clinician is coming to insert a drip in your arm in order to establish an IV infusion to rehydrate you. Your skin is quite dry. You have congenital blindness. You wear dark glasses and have a white cane. Give the doctor time to explain, reassure and advise you before prompting him/her with questions unless the doctor asks you what you want to know. You have a false arm “attached” to your body.

Behaviour, affect, mannerisms
• Nervous, tired
• Speak fairly slowly but so that you can be understood
• Maintain vigilance and wariness – perhaps with one ear in the direction of the candidate in order to pick up cues – this is exaggerated because your are blind – The student should notice that you are blind
• Feel uncomfortable with silence unless the candidate let’s you know what the silence is for (e.g. “I am just preparing the equipment.”)

Questions and prompts
• Do not tell the candidate that you are blind – we would hope that they should notice and adjust their communication style accordingly
• If the candidate offers to tell you what is happening, then accept this offer and prompt them if you think they are doing something and they are not telling you
• You think you must have picked up a bug somewhere
• You do not think this is serious but you are slightly worried – You do ask, “What do you think it is?”
• You do not like being in the hospital
• You are expecting to be in hospital for a couple of days and that will be it

History of present illness
• You have had diarrhoea and vomiting for three days
• You have felt hungry and thirsty but every time you have eaten something it has come straight back up or out your back passage
• You have not noticed any other changes in your bowel habits leading up to this illness
• Your diarrhoea is very watery, yellow/brown color, fatty, smelly and it does not have visible blood (Your mother looked)
• You anticipate the vomit and usually manage to reach the toilet bowl – it is watery and your food is barely digested
Past medical history
- No previous medical problems

Social history
Your social history is uncomplicated since the aim is to keep the candidate focused on the exercise.
- You are single although you have a partner who is a musician
- You live with your parents
- You are a piano tuner – many years experience – work part-time at the Royal College of Music
- You smoke 10 cigarettes per day
- You have helpful relationships with friends and family
- You drink 2-3 units of alcohol a week (1/2 bottle of wine)

Family history
- No known family history

Considerations in playing this role
- You have congenital blindness
- You use a cane
- It is difficult to keep the fake arm in place and it can be uncomfortable so move about between scenarios
- You wear a hospital gown
- You have a sheet over you
- Wear old and dark coloured clothes because the blood is sometimes messy
Appendix V: IPPI Rating Tool (DOPS) used in Chapters 5 and 6

Assessor:                                         Candidate:

<table>
<thead>
<tr>
<th></th>
<th>Below expectations for starting clinical duty</th>
<th>Borderline for starting clinical duty</th>
<th>Meets expectations for starting clinical duty</th>
<th>Above expectations for starting clinical duty</th>
<th>Unable to comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction/establish rapport</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>2</td>
<td>Explanation of intervention including patient’s consent to proceed</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>3</td>
<td>Assessment of patient’s needs before procedure</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>4</td>
<td>Preparation for procedure</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>5</td>
<td>Technical performance of procedure</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>6</td>
<td>Maintenance of asepsis</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>7</td>
<td>Awareness of patient’s needs during procedure</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>8</td>
<td>Closure of the procedure including explanation of follow-up care</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>9</td>
<td>Clinical safety</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>10</td>
<td>Professionalism</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>11</td>
<td>Overall ability to perform the procedure (including technical and professional skills)</td>
<td></td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
</tbody>
</table>

B. How would you rate the candidate’s performance (circle one)

Incompetent             Borderline             Competent
Appendix VI: Global Rating Scale used in Chapters 5 and 6

Expert evaluator ________________   Participant # ______________

Global Rating Scale - For Mid-Fidelity, High-fidelity and Standardized Patient Scenarios

Please circle the number corresponding to the participant’s performance in each category:

<table>
<thead>
<tr>
<th>Category</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respect for Tissue</td>
<td>Frequently used unnecessary force on tissue or caused damage by inappropriate use of instruments</td>
<td>Careful handling of tissue but occasionally caused inadvertent damage.</td>
<td>Consistently handled tissues appropriately with minimal damage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time and Motion</td>
<td>Many Unnecessary moves</td>
<td>Efficient time/motion but some unnecessary moves</td>
<td>Clear economy of movement and maximum efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrument Handling</td>
<td>Repeatedly makes tentative or awkward moves with instruments through inappropriate use.</td>
<td>Competent use of instruments but occasionally appeared stiff or awkward.</td>
<td>Fluid movements with instruments and no stiffness or awkwardness.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow of Procedure</td>
<td>Frequently stopped operating and seemed unsure of next move.</td>
<td>Demonstrated some forward planning with reasonable progression of procedure.</td>
<td>Obviously planned course of operation with effortless flow from one move to the next.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVERALL PERFORMANCE

1 Very poor
2 Competent
3 Clearly superior
### Appendix VII: Checklist used in Chapters 5 and 6

#### Task Specific Checklist for IV catheter insertion

<table>
<thead>
<tr>
<th></th>
<th>Item</th>
<th>Done Correctly</th>
<th>Done Incorrectly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Retrieve needed equipment / Bring to the room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Introduce self, Identify patient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Obtain patient’s consent for procedure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Position bed to appropriate level for insertion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Prepare supplies for insertion (e.g., open packages, etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Identify accessible insertion site – tap vein, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Apply disposable gloves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Place the tourniquet 10-12 cm above the insertion site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Palpate the vessel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Clean the insertion site - use in-to-out circular technique</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Inform the patient of needle stick</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Make sure the bevel of the needle is up and inserted into the vessel at 30-degree angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Hold the skin taut while inserting using thumb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Confirm the vein has been entered by blood return</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Hold the stylet stable and advance the catheter into the vein over the stylet to seat it in the vessel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Occlude the vein above the insertion site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Stabilize the catheter and release the tourniquet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Properly dispose of the needle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Connect the catheter to the flushed saline lock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Flush the lock with normal saline to check catheter patency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Apply the sterile dressing properly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Label the dressing with the date, time, catheter gauge and length and initials.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Dispose of gloves and supplies, and wash hands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Document the procedure in patient’s record properly</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix VIII: Communication Rating Scale used in Chapters 5 and 6

<table>
<thead>
<tr>
<th>Student</th>
<th>Case #</th>
<th>Time</th>
<th>Examiner</th>
</tr>
</thead>
</table>

**OVERALL ASSESSMENT OF THE KNOWLEDGE AND SKILLS DEMONSTRATED IN THE INTERVIEW**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Responds inappropriately and ineffectively to the task indicating a lack of knowledge and/or undeveloped interpersonal and interviewing skills.</td>
</tr>
<tr>
<td>2</td>
<td>Responds effectively to some components of the task indicating an adequate knowledge base and some development of interpersonal and interviewing skills</td>
</tr>
<tr>
<td>3</td>
<td>Responds precisely and perceptively to the task, consistently integrating all components.</td>
</tr>
</tbody>
</table>

**GLOBAL RATING SCALES for SimMan**

*Circle the rating which best reflects your judgement of the student's performance in the following categories:*

**RESPONSE TO PATIENT'S FEELINGS AND NEEDS (EMPATHY)**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Does not respond to obvious patient cues and/or responds inappropriately</td>
</tr>
<tr>
<td>2</td>
<td>Responds to patient's needs and cues, but not always effectively.</td>
</tr>
<tr>
<td>3</td>
<td>Responds consistently in a perceptive and genuine manner to the patient's needs and cues.</td>
</tr>
</tbody>
</table>

**DEGREE OF COHERENCE IN THE INTERVIEW**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No recognizable plan to the interaction, the plan does not demonstrate cohesion, or the patient must determine direction of the interview</td>
</tr>
<tr>
<td>2</td>
<td>Organizational approach is formulaic and minimally flexible and/or control of the interview is inconsistent</td>
</tr>
<tr>
<td>3</td>
<td>Superior organization, demonstrating command of cohesive devices, flexibility, and consistent control of the interview</td>
</tr>
</tbody>
</table>

**VERBAL EXPRESSION**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Communicates in manner that interferes with and/or prevents understanding by patient</td>
</tr>
<tr>
<td>2</td>
<td>Exhibits sufficient control of expression to be understood by an active listener (patient)</td>
</tr>
<tr>
<td>3</td>
<td>Exhibits command of expression (fluency, grammar, vocabulary, tone, volume and modulation of voice, rate of speech, pronunciation)</td>
</tr>
</tbody>
</table>

**NON-VERBAL EXPRESSION**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fails to engage, frustrates and/or antagonizes the patient</td>
</tr>
<tr>
<td>2</td>
<td>Exhibits enough control of non-verbal expression to engage a patient willing to overlook deficiencies such as passivity, self-consciousness, or inappropriate aggressiveness</td>
</tr>
<tr>
<td>3</td>
<td>Exhibits finesse and command of non-verbal expression (eye contact, gesture, posture, use of silence, etc.)</td>
</tr>
</tbody>
</table>

**Key Points**

| Yes | No | Comments: |


Hodges, B., Regehr, G., McNaughton, N., Tiberius, R., & Hanson, M. (1999). OSCE checklists do not capture increasing levels of expertise.


*Educational Psychologist, 25*(1), 71-86.


