Examining the Role of Self-Regulated Learning in the Context of Enhancing Critical Analysis in a Computer-Supported Collaborative Medical Journal Club Activity

Yuan-Jin Hong

Department of Educational and Counselling Psychology

McGill University, Montreal, Quebec, Canada

September 2012

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctor of Philosophy

Acknowledgements

First, I would like to sincerely thank my supervisor, Dr. Susanne Lajoie, for her tremendous patience, support, and guidance. Without her, this thesis would never have come to be. I would also like to thank Dr. Krista Muis and Dr. Jeffrey Wiseman for their great insights and valuable feedback. The support of my family members was also of immeasurable help in the completion of the thesis. I would like to express my appreciation to my friends Bruce and Madeleine for their willingness to act as sounding boards and to offer suggestions in a number of areas. I am also grateful to my labmates, particularly to Eric for his contributions during the data collection and analysis processes. The encouragement and moral support provided by Shannahn and "the group" through both smooth and challenging times was a source of strength throughout. Last but certainly not least, the research presented in this dissertation would have been impossible to carry out without the participation of the medical students who freely chose to be involved in this study.

Abstract

This research examines how self-regulated learning facilitates critical analysis development among undergraduate medical students in a journal club, and how computer-supported collaborative learning influences their self-regulated learning. Fourteen of the 29 second-year medical students who initially consented to participate in the study actually completed the training. A mixed method design was employed as both quantitative and qualitative data were collected. Quantitative data included pre- and post-tests on self-regulated learning and critical analysis, and qualitative data consisted of audio and video tapings of pair discussions and participants' reading processes. Quantitative analysis indicated that none of the results was significant, due primarily to the small sample size. Despite the lack of significance, participants' self-regulated learning was nonetheless a strong predictor of their critical analysis performance. Analysis of learners' reading processes showed that highlighting was used more than any other tool across both groups. Analysis of verbal interactions indicated that students in the experimental group frequently demonstrated self-monitoring, commonly engaged in co-regulation, often exhibited summarizing and explaining strategies, and regularly engaged in responsive and informative activities while attempting to understand journal articles. Findings suggest that medical students require more scaffolding in the development of self-regulated learning and critical analysis skills. Moreover, using a heterogeneous grouping based on prior knowledge and employing specifically designed software are beneficial in helping students regulate crucial aspects of their learning while critiquing journal articles.

Résumé

Cette étude examine comment l’apprentissage auto-régulé facilite l’analyse critique parmi les étudiants et étudiantes du premier cycle en médecine dans un club de lecture, et comment l’apprentissage collaboratif supporté par ordinateur affecte l’autorégulation de l’apprentissage. Tous les efforts ont été faits pour recruter autant de participants que possible pour l’étude. Même si plusieurs étudiants et étudiantes ont exprimé un intérêt au début, leurs horaires exigeants étaient tels que seulement 14 personnes pouvaient compléter la formation. L’étude a suivi un devis expérimental mixte puisque des données qualitatives et quantitatives sont collectées. Les données quantitatives incluent les résultats pré- et post-tests portant sur l’autorégulation de l’apprentissage et l’analyse critique, et les données qualitatives consistent en des enregistrements audio et vidéo des discussions et des processus de lecture. Les analyses quantitatives indiquent que les résultats ne sont pas significatifs, due à la taille de l’échantillon. Malgré cela, les résultats supportent la relation entre l’apprentissage auto-régulé qui prédit la performance à la tâche d’analyse critique. L’analyse des processus de lecture des étudiants et étudiantes a démontré que le surlignage a été utilisé le plus souvent chez les deux groupes. L’analyse des interactions verbales a indiqué que les étudiants et étudiantes dans le groupe expérimental ont fréquemment démontré la régulation, la co-régulation, des stratégies incluant des sommaires et explications, et ont régulièrement participé à des activités réactives et informatives lors de la compréhension des articles de journaux. Les résultats suggèrent que les étudiants et étudiantes en médecine requièrent plus d’échafaudage en le développement de l’apprentissage auto-régulé et des habiletés d’analyse critique. En plus, l’emploi d’un groupe hétérogène basé sur leurs connaissances précédentes et l’application d’un logiciel spécialisé seraient bénéfiques pour permettre aux étudiants et étudiantes de réguler certains aspects cruciaux de leur apprentissage lors de la critique des articles de journaux.

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

As part of their medical education, undergraduate medical students are frequently told to "read around their patients" in order to build their clinical knowledge in response to their clinical experiences. At the same time, students are rarely taught explicitly how to "read around patients" in a clinical setting. "Reading around patients" is a patient-centered, self-directed process carried out by the physician that begins with seeing a patient, reflecting upon the patient's health care problems, and considering the pertinent answerable clinical questions (Sackett & Parkes, 1998). The physician proceeds to retrieve the best scientific evidence from studies in order to address those questions. It is up to the physician to interpret and critically appraise such evidence, then integrate the results of that appraisal with the patient's unique biology and expectations. The physician must also explain the risks and benefits of different courses of action to the patient and then carry out a self-evaluation of performance (Sackett & Parkes, 1998). As the curriculum now stands, however, students may be given courses in how to systematically use the medical literature to answer clinical questions, but may have difficulty applying these skills since they have not been taught how to efficiently use them in day-to-day practice (Forester, Cole, Thomas, & McWhorter, 2007; Guyatt & Busse, 2006; Guyatt, Cook, & Haynes, 2004; Parkes, Hyde, Deeks, & Milne, 2001). It is important, therefore, to familiarize undergraduate medical students with "reading around their patients," early in their medical careers to equip them to learn more effectively from clinical experience and provide better patient care in the long term.

One context in which such training could occur is the journal club (Edwards, White, Gray, & Fischbacher, 2001; Moharari et al., 2009; Seymour, Kinn, & Sutherland, 2003). The journal club, defined as a group of individuals who meet regularly to critically discuss the clinical applicability of current articles found in medical journals, is an authentic, time-honoured activity that has become an internationally recognized teaching tool in many medical education fields since the first formal club was introduced by William Osler in 1875 at McGill University in Montreal (Akhund & Kadir, 2006; Ebbert, Montori, & Schultz, 2001; Phitayakorn, Gelula, & Malangoni, 2007). At the outset, these clubs helped students stay current with medical literature. Later, the clubs were designed to improve acquisition of knowledge in the fields of clinical epidemiology, biostatistics, and research design; more recently, they have played an important role in teaching critical appraisal skills (Akhund & Kadir, 2006; Green, 1999; Kellum, Rieker, Power, & Powner, 2000; Letterie & Morgenstern, 2000; Linzer, Brown, Frazier, DeLong, & Siegel, 1988; Markert, 1989; Sidorov, 1995). Given the rise of web-based tools, traditional journal clubs utilize on-line discussion forums routinely (Kuppersmith, Stewart, Ohlms, & Coker, 1997; MacRae, et al., 2004).

Journal clubs are a regular part of medical education and they purport to foster critical thinking, aid in the dissemination of information, promote research, and impact clinical practice. However, there is not a great deal of research about how efficient journal clubs are in changing attendees' critical appraisal skills (Ebbert et al., 2001). Although numerous articles discuss how journal clubs can be used to evaluate medical literature, only a few have examined what medical students, residents, and physicians are actually doing in journal clubs (Moberg-Wolff & Kosasih, 1995).

One aspect of medical journal clubs which has heretofore been neglected in the research is how participants self-regulate their learning in order to meet the objectives of these clubs. Self-regulated learning refers to “the process by which learners personally activate and sustain cognition, affects, and behaviours that are systematically oriented toward the attainment of learning goals” (Schunk & Zimmerman, 2008, p. vii). Self-regulation is a key element of medical education, particularly in a journal club context, as medical students are expected to be aware of what they know and do not know as they treat patients, as well as how and where to seek help when necessary (Brydges & Butler, 2012). Moreover, this ability to self-regulate is invaluable preparation for the continual life-long learning skills needed to be accurate medical practitioners (Brydges & Butler, 2012). Given the clear importance of self-regulated learning in medicine, it is surprising that no research has investigated how students’ self-regulated learning skills influence their development of critical analysis in journal clubs.

Another aspect of medical journal clubs that has not been explored in the literature is how learning performance, specifically critical analysis, can be improved by collaboration. Collaboration is, in fact, a key component of medical journal clubs, given that these clubs involve individuals coming together to discuss medical journal articles, evaluate the reliability and validity of evidence, reach collective understandings, and discuss the applicability of these insights to their practices in order to improve patient care (Plastow & Boyes, 2006). Surprisingly, there has been no research on how students work together and engage in small group discussions in order to improve their critical analysis skills. Likewise, no studies have investigated the impact that collaboration may have on learners' self-regulated learning.

A final aspect of medical journal clubs that has not yet been investigated by researchers is the role of technology in these clubs. Since in our digital age medical journal articles are most easily accessed via the Internet, it is imperative that medical students have the ability to search for and find information online in order to provide quality patient care. It follows that once such information has been found, students must be able to critically analyze these articles in order to evaluate their usefulness and practicality. Virtually no studies have examined the impact of the use of technology on students' self-regulatory processes and critical analysis skills in medical journal clubs.

In conclusion, medical journal clubs aim to promote in-depth, lifelong learning that helps learners increase their knowledge base by familiarizing them with strategies to search and interpret information relevant to patient care. However, there is very little empirical evidence as to the effectiveness of journal clubs in teaching medical students these aforementioned skills. This research study will explore the medical journal club setting to see how such clubs can help prepare future physicians to become better health care providers. More specifically, a consideration of the constructs cited above, namely self-regulated learning, critical analysis, collaborative learning, will be examined in the context of a medical journal club supported by technology.

Purpose and Research Questions

The purpose of this research study is twofold: first, to examine the role of self-regulated learning in terms of how it facilitates the development of critical analysis (or "critical appraisal") among undergraduate medical students in a medical journal club activity; and second, to investigate the influences of a collaborative, technology-rich learning environment (TRE) on individuals' self-regulated learning processes. A TRE, as broadly defined by Lajoie and Azevedo (2006), is a learning environment that is designed for an instructional purpose and uses technology to support the learner in achieving the goals of instruction. In order to reach the stated objectives of this study, a pedagogical intervention involving computer-supported collaborative learning was created to represent a learning context derived from the current theoretical understanding of learning (Koschmann, 1996; Koschmann, Hall, & Miyake, 2002).

The proposed research attempts to answer the following questions:

1. Is self-regulated learning related to medical students' critical analysis performance?
2. Does participation in computer-supported collaborative learning influence self-regulatory processes? If so, how?
3. Does participation in computer-supported collaborative learning influence the use of annotation tools?
4. Does computer-supported collaborative learning influence individuals' self-regulated learning in terms of the development of critical analysis? If so, how?
5. What is the nature of group dynamics as students engage in self-regulated learning in a computer-supported collaborative learning environment?

Chapter 2

Literature Review

Understanding students' ability to deliberately plan, monitor, and regulate cognitive, motivational/emotional, and behavioural processes in their learning endeavours has been a focal issue of discussion among educational researchers, educators, and policy-makers in recent decades (Artino & Stephens, 2006; Boekaerts & Corno, 2005, Paris & Paris, 2001; Schunk & Zimmerman, 1998). Scholars argue that the capacity to self-regulate is the central issue in learning, decision making, problem solving, and resource management in education (Boekaerts & Corno, 2005). Self-regulated learning is particularly important in medical education as medical students are expected to understand their own learning needs, to identify what they do not know when providing care to patients, and to obtain assistance when encountering challenging professional situations (Brydges & Butler, 2012). The importance of self-regulated learning in medical education is such that recent curricula have been designed to foster the development of self-regulation among students in various learning contexts (Brydges & Butler, 2012).

One such context in medical education that provides opportunities for students to develop self-regulated learning skills is the journal club. In journal clubs, students learn to critically analyze research articles in terms of their validity, reliability, and applicability to patient care (Akhund & Kadir, 2006; Phitayakorn et al., 2007). Journal clubs also provide an environment in which individuals can collaborate as they learn (Plastow & Boyes, 2006). Collaboration is fast becoming an integral aspect of medicine, as sharing ideas and expertise is increasingly prevalent among physicians across disciplines and across continents. Technology facilitates this collaboration, making it easier for students to interact with each other as they engage in problem solving and reach shared understandings.

Having established the importance of the key constructs at the heart of this work, namely critical analysis, self-regulated learning, and computer-supported collaborative learning, the researcher will now examine the literature on each of these constructs. First, the significance of critical analysis in medicine and research into the teaching of critical analysis skills are presented. Next, the theory of self-regulated learning, applied in the present research to examine the development of critical analysis among medical students, is reviewed. Third, the theory of computer-supported collaborative learning, used in this study to design a learning context that may foster critical analysis and self-regulated learning, is presented. Finally, the researcher's hypotheses vis-à-vis the relationships among critical analysis, self-regulated learning, and computer-supported collaborative learning are provided.

Critical Analysis

Introduction to critical analysis. Critical analysis (or critical appraisal), as it pertains to medical education, is defined as the ability to dissect medical literature, assess and interpret the evidence, analyze the strengths and weaknesses of studies, relate the results to one's work, and adjust one's professional approach accordingly (Krueger, 2006; Last, 2001). It describes thinking that is self-directed, self-disciplined, self-monitored, self-corrective, and fair-minded (Paul & Elder, 2008). Critical analysis is also a purposeful and self-regulatory judgment that includes an explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is founded (Facione, 1990). Critical analysis is task specific in the sense that it involves applying analytical skills to medical research in order to read around patients. Scriven and Paul (1987) speak more broadly to how these skills are general cognitive skills and aptitudes. According to these scholars, critical analysis is made up of two elements: (1) a set of (cognitive) skills to process and generate information and beliefs, and (2) the habit, the affective dispositions, and the aptitude to carry out those skills to guide behaviour.

When individuals are able to engage in critical analysis, they are able to think or read critically, and are more willing to take the time to reflect on the concepts found in readings (Halpern, 1998; Paul & Elder, 2009; Schumm & Post, 1996; Seymour et al., 2003). According to Paul and Elder (2009), individuals who engage in critical analysis are able to think logically, and also assess and work out problems while reading and searching for answers rather than simply memorize a set of facts. Moreover, these individuals are ready to express their opinions on a topic, explore alternative views, and have open minds to new ideas that might not concur with their previous manner of thinking. Furthermore, critical thinkers or readers are able to base their judgments on ideas and evidence, identify mistakes in thought and persuasion as well as identify good arguments, and are willing to take a critical position on issues. These individuals typically ask deep, thought-provoking questions to evaluate ideas, and are aware of their personal thoughts and ideas about a topic; they are prepared to re-evaluate these perspectives when new or contradictory evidence enters into the equation and is evaluated. Finally, critical thinkers or readers are capable of recognizing arguments and issues, as well as seeing relationships between topics and bringing in knowledge from other disciplines in order to augment their reading and learning experiences.

The importance of critical analysis in medicine. Many of the advances in health care are disseminated through vast and growing numbers of reports of scientific studies published in academic journals and presented at conferences. The most prominent school of thought in health care at the current time, evidence-based medicine (EBM), suggests that health care professionals should incorporate the results of the best available research evidence with the desires and unique contexts of each patient when making patient care decisions (Khan & Gee, 1999; Mulhall, 1997; Sackett, Rosenberg, Muir Gray, Haynes, & Richardson, 1996; Seymour et al., 2003). Medical trainees must learn specific skills in fashioning an answerable clinical question, locating literature relevant to the question, evaluating the validity, reliability and applicability of answers found in the literature, and integrating it with the desires and contexts of each individual patient (Khan & Gee, 1999; Rosenberg & Donald, 1995).

Because critical analysis skills, which involve the comprehension of scientific and statistical methods together with an inquiring and skeptical approach, are so essential in the medical field, formal training in this area is an advantage to workers in the area of health care (Parkes et al., 2001). It may aid them in the interpretation of studies, as it informs them of possible biases and facilitates the understanding of numerical results; it also helps them to decide whether scientific and medical articles are pertinent and relevant, and how these articles should impact patient care (Parkes et al., 2001). By shedding greater light on those research designs with improved internal validity, critical analysis may similarly assist health care workers in coping with the ever-worsening issue of information overload. This applies not only to health care professionals, but to anyone who is in a position to make decisions regarding health care; this may include health authority managers, users of the health care system, and the media who make public information related to health care matters (Parkes et al., 2001) and patients. For all parties involved, these skills are particularly important as present-day health care professionals encounter more seriously ill patients, more advanced technology, and challenging ethical issues.

It is of the utmost importance to determine if health care professionals' critical analysis skills become more sophisticated as part of their training and ongoing self-directed learning. Phrased differently, do these health care providers receive adequate training to analyze critically?

The teaching of critical analysis skills in medicine. The need to develop critical analysis skills has been taken seriously in medical training in recent decades in postgraduate and continuing education via courses, workshops and journal clubs (Coomarasamy, Taylor, & Khan, 2003). There has also been a drastic change in the teaching of critical analysis in undergraduate medical school curricula (Parkes et al., 2001). It is necessary to understand just how effective this teaching is, what impacts the efficacy of teaching, and whether acquiring critical analysis skills has an influence on the comportment of health care workers or patient outcomes, bringing together research and practice (Parkes et al., 2001).

A variety of approaches have been developed to assist medical professionals in the development of critical analysis skills (Taylor, Reeves, Ewings, &Taylor,

2004). A number of critical appraisal checklists have been published, and the teaching of critical analysis skills has been introduced into undergraduate and post-graduate education. The teaching of critical analysis has become a topic of much scholarly interest, and numerous systematic reviews have explored the methods and effectiveness of critical analysis skills training (e.g., Alguire, 1998; Coomarasamy et al., 2003; Green, 1999; Greenhalgh, 2001; Norman & Shannon, 1998; Parkes et al., 2001; Taylor et al., 2000). These reviews state that the duration of the teaching interventions ranged from 3 to 16 hours or longer, and that participants included both medical undergraduates and residents. The learning environments in which the interventions took place were diverse, including journal clubs, workshops, courses, lectures, discussions, seminar series, and practical sessions, and among the measures used in the interventions were written tests, self-report questionnaires, self-assessments, multiple choice questionnaires, open-ended questions, and patient write-ups. The topics included appraisal skills, reading behaviour, knowledge of epidemiology and biostatistics, and attitudes toward medical literature. These reviews reported that the teaching of critical analysis skills had positive effects concerning knowledge gain in methodological and statistical issues related to clinical research, and showed possible improvements in critical appraisal skills, attitudes toward the use of medical literature in clinical decision making, and reading habits.

The effectiveness of the teaching of critical analysis is, however, a matter of debate among scholars. For example, after reviewing ten studies on the impact of teaching critical analysis skills to medical students or residents between 1966 and 1997, Taylor et al. (2000) concluded that the teaching of critical analysis skills to clinicians is beneficial as regards knowledge of methodological/statistical issues in clinical research and attitudes towards medical literature. Coomarasamy et al. (2003), on the other hand, reached different conclusions. In their review of 17 studies looking at the effectiveness of evidence-based medicine and critical analysis teaching at the postgraduate level, the reviewers determined that a significant improvement does indeed occur in the area of knowledge, but not in the realms of attitude, skills or behaviour, when critical analysis skills are taught. Norman and Shannon (1998) had similarly mixed findings. In reviewing ten studies examining the impact of teaching critical analysis skills to medical students and residents, they concluded that increases in knowledge of clinical epidemiology topics steadily improved among medical undergraduates in relation to the teaching of critical analysis, while only small changes in knowledge occurred among residents.

It is essential to note that most scholars agree these findings need to be interpreted cautiously as many of the studies being reviewed had poor internal validity and their methodological quality was poor (Taylor et al., 2000). Furthermore, only a handful of studies of the teaching of critical analysis employ randomized controlled trials (e.g., Krueger, 2006; Linzer et al., 1988; Taylor et al., 2004). Moreover, the majority of the research in this area has failed to blind outcome assessment (Taylor et al., 2004). Coomarasamy et al. (2003) warn that in order to draw reliable conclusions from studies on the teaching of critical analysis, it is necessary to have trials that are well designed and concentrate on curriculum content and delivery as well as the way in which outcomes are assessed.

In summary, the reviews on the effectiveness of critical analysis skills training (Coomarasamy et al., 2003; Norman & Shannon, 1998; Parkes et al., 2001; Taylor et al., 2000) reveal a variety of educational interventions that varied in terms of type and duration. Nevertheless, these reviews invariably found that training in critical analysis skills leads to minor improvements in participants' knowledge of methodological and statistical matters in clinical research and improves their attitudes toward using medical literature in clinical decision making. These findings must nonetheless be interpreted carefully given the poor internal validity of the studies and somewhat questionable methodology and design employed by researchers. Moreover, much of this research used instruments that had not been validated at the time that knowledge and skills were measured (Fritsche et al., 2002).

It is hoped that the present research will yield more reliable, conclusive findings than has previous research, and will thereby contribute to scholarship in the area. The first matter under consideration is the methodology used in the present study. Given that several researchers have pointed out the limitations of employing a single research approach and have outlined the advantages of combining quantitative and qualitative methodologies (e.g., Bradley, Oterholt, Nordheim, & Bjorndal, 2005; Hatala & Guyatt, 2002; Stacey & Spencer, 2000; Wolff, 2001), the decision was made to use a mixed methods design. The mixed methods approach will yield quantitative data on measuring the effects of interventions on participants' learning performance as well as qualitative data describing participants' learning processes under different conditions.

Second, a randomized controlled trial with pre- and post-tests was applied to compare the development of critical analysis skills as well as self-regulated learning between the experimental and control groups. Finally, in order to assure the validity and reliability of the measures of learning outcomes, the researcher adapted respected, commonly used questionnaires with high degrees of reliability to suit the purposes of the present study (see Chapter 3 for details).

Self-Regulated Learning

Introduction to self-regulated learning. The definitions of self-regulated learning have become more and more encompassing over the last few decades (Paris & Paris, 2001). Self-regulated learners were described in the early literature as aware on a metacognitive level, planful, and strategic (Brown, 1987; Butler, 1998a; Flavell, 1976). Following this, during the 1980's and 1990's, the view of self-regulated learning came to include interactions between students' knowledge (e.g., metacognitive, domain specific, epistemological), cognition (e.g., application of a cognitive strategy), metacognitive skill (e.g., planning, monitoring), and motivation (e.g., self-efficacy beliefs, attributions) (Alexander & Judy, 1988; Borkowski & Muthukrishna, 1992; Butler, 1998a; Butler & Winne, 1995; Schommer, 1990; Schunk, 1994). The manner in which self-regulated learning is a function of the knowledge and skill that students construct over time has been emphasized (Paris & Byrnes, 1989).

Evolving definitions of self-regulated learning, at the same time, examine how enactment of self-regulated perspectives on learning is dependent on individuals acting in social contexts (e.g., Paris & Paris, 2001; Patrick & Middleton, 2002; Zimmerman, 1995). In this approach, an emphasis is placed on the fact that self-regulated learning is a product of not only individual knowledge and skill, but also "involves a social aspect that includes interactions with peers and teachers" (Patrick & Middleton, 2002) who shape learners' task engagement through "co-regulating" learning (Meyer & Turner, 2002). Self-regulated learning, therefore, is now believed to take place when learners are motivated to reflectively and strategically participate in learning activities within environments that facilitate the development of self-regulation (Butler, 2002).

Review of self-regulated learning models. As several definitions of self-regulated learning emerged, various models were introduced (e.g., Boekaerts, 1997; Boekaerts & Niemivirta, 2000; Butler & Winne, 1995; Corno, 2001; Corno & Mandinach, 1983; McCaslin & Hickey, 2001; Pintrich, 2000b; Winne & Hadwin, 1998; Zimmerman, 1989, 2000a) to explain how different components of self-regulated learning are related to each other. Each model emphasizes different individual and contextual characteristics in relation to students' self-regulatory skills (Butler & Winne, 1995; Pintrich & De Groot, 1990; Schunk, 1994; Winne, 1995; Zimmerman, 2000a). Clearly, then, researchers in the field do not share a single theoretical model of self-regulated learning, nor do they agree on the set of factors that might influence it.

The main focus of this section will be an examination of the three models of self-regulated learning that are most frequently cited in scholarly literature in the field of education: Pintrich's conceptual framework, Winne and Hadwin's model, and Zimmerman's model. Following this will be a critical evaluation and comparison of the models.

Pintrich's conceptual framework of self-regulated learning. Pintrich (2000b) defined self-regulated learning as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment" (Pintrich, 2000b, p. 453). As shown in Table 2.1, Pintrich developed a conceptual framework for classifying the different phases and areas for regulation (Pintrich, 2000b; Pintrich & De Groot, 1990; Pintrich, Wolters, & Baxter, 2000). The four phases that make up the rows of Pintrich's table are processes that many models of regulation and self-regulation share (e.g., Zimmerman, 1998a, 1998b, 2000a), and reflect goal-setting, monitoring, control and regulation, as well as reflective processes.

Table 2.1

Pintrich's Conceptual Framework of Self-Regulated Learning

Phases	Areas for regulation			
	Cognition	Motivation/Affect	Behaviour	Context
Phase 1				
Forethought, planning, and activation	♦Target goal setting ♦Prior content knowledge activation ♦Metacognitive knowledge activation	♦Goal orientation adoption ♦Efficacy judgments ♦Perceptions of task difficulty ♦Task value activation ♦Interest activation	♦Time and effort planning ♦Planning for self-observations of behaviour	♦Perceptions of task ♦Perceptions of context
Phase 2				
Monitoring	♦Metacognitive awareness and monitoring of cognition	♦Awareness and monitoring of motivation and affect	♦Awareness and monitoring of effort, time use, need for help ♦Self-observation of behaviour	♦Monitoring changing task and context conditions
Phase 3				
Control	♦Selection and adaptation of cognitive strategies for learning, thinking	♦Selection and adaptation of strategies for managing, motivation, and affect	♦Increase/decrease effort ♦Persist, give up ♦Help-seeking behaviour	♦Change or renegotiate task ♦Change or leave context
Phase 4				
Reaction and reflection	♦Cognitive judgments ♦Attributions	♦Affective reactions ♦Attributions	♦Choice behaviour	♦Evaluation of task ♦Evaluation of context

Phase 1 involves planning and goal setting as well as activation of perceptions and knowledge of the task and context and the self in relation to the task. Phase 2 concerns various monitoring processes that represent metacognitive awareness of different aspects of the self or task and context. Phase 3 involves efforts to control and regulate different aspects of the self or task and context.

Finally, Phase 4 represents various kinds of reactions and reflections on the self and the task or context.

The four phases do represent a general time-ordered sequence that individuals would go through as they perform a task, but there is no strong assumption that the phases are hierarchically or linearly structured in such a way that earlier phases must always occur before later phases. Monitoring, control, and reflection occur dynamically as the student progresses through the task, with plans and goals of the forethought phase being modified and altered based on feedback from the monitoring, control, and reflection processes. Moreover, Pintrich (2000b) recognized that not all academic learning follows the four identified phases. Students can learn academic material in tacit or unintentional ways without self-regulating their learning in such an explicit manner. It is important to note that Pintrich developed more of a theoretical framework for self-regulated learning rather than a thoroughly tested empirical model. For instance, Pintrich's monitoring and control phases are quite difficult to differentiate (Pintrich et al., 2000). Although there is a conceptual difference between the two phases, it is hard to empirically separate them, as monitoring, or self-observation, and control of cognitive processes seem to occur simultaneously.

Significantly, these planning, monitoring, control, and reflection processes can be applied to the four areas for regulation outlined by Pintrich (2000b) - cognition, motivation, behaviour, and context - listed in the columns in Table 2.1. In other words, under this framework, there is the possibility for "regulation" scales in each of these areas, not just one global metacognition or regulation scale. C*ognition*, *motivation/affec*t, and *behaviour*, reflect the traditional tripartite division of different areas of psychological functioning (Snow, Corno, & Jackson, 1996), and reflect aspects of students' own cognition, motivation, and behaviour that they control or self-regulate. C*ontext* reflects the importance of other individuals in the environments, such as teachers, peers, and parents, in "other" regulating students' cognition, motivation, and behaviour by directing and scaffolding students, providing them with tools and techniques, and showing how and when to do a certain task. It follows that context, which encompasses social interactions along with task characteristics, can facilitate or hinder students' ability to self-regulate. Therefore, students' ability to self-regulate includes their capacity to control and regulate the context adaptively (Pintrich, 2000b). It is clear from Table 2.1 that regulation cuts across cognition, motivation/affect, behaviour, and context domains, and is not a separate domain of its own or merely a category of strategy use.

A consideration of how this regulation occurs in the four phases outlined by Pintrich (2000b) yields interesting insights. In the *Forethought, Planning and Activation* phase, the self-regulatory activities that may take place in the regulation of cognition are target goal setting, prior content knowledge activation, and metacognitive knowledge activation. The regulation of motivation/affect is made up of goal orientation adoption, efficacy judgments, perceptions of task difficulty, and both task value and interest activation. Planning for time, effort, and self-observations may take place in the regulation of behaviour, and perceptions of task and context may occur in the regulation of context. The *Monitoring* phase involves (metacognitive) awareness and monitoring of cognition, motivation, affect, effort, time use, need for help, and changing task and context conditions. It also includes the self-observation of behaviour. The *Control* phase consists of the selection and adaptation of (cognitive) strategies for learning, thinking, and managing motivation and affect. It also includes the regulation of effort, persistence, help-seeking, and changing task and context. The final phase, *Reaction and Reflection*, is made up of cognitive judgments, attributions, affective reactions, making appropriate choices, and evaluations of task and context.

As shown above, Pintrich's model of regulation is a framework for understanding self-regulated learning in the academic domain. His model outlines the various elements and processes that are involved when self-regulated learning takes place. The Pintrich framework is straightforward and makes research findings about self-regulated learning accessible and understandable given his comprehensive coverage of complex constructs and ideas that can be studied empirically.

Winne and Hadwin's model of self-regulated learning. Winne defined self-regulated learning as metacognitively guided behaviour that enables learners to adapt and control the way they use cognitive strategies and tactics when performing tasks (Lipnevich & Smith, 2007; Puustinen & Pulkkinen, 2001; Winne, 1996). Winne and colleagues proposed a model of self-regulated learning (e.g., Perry & Winne, 2006; Winne, 2001, 2011; Winne & Hadwin, 1998, 2008; Winne & Perry, 2000; see Figure 2.1) that includes four phases:

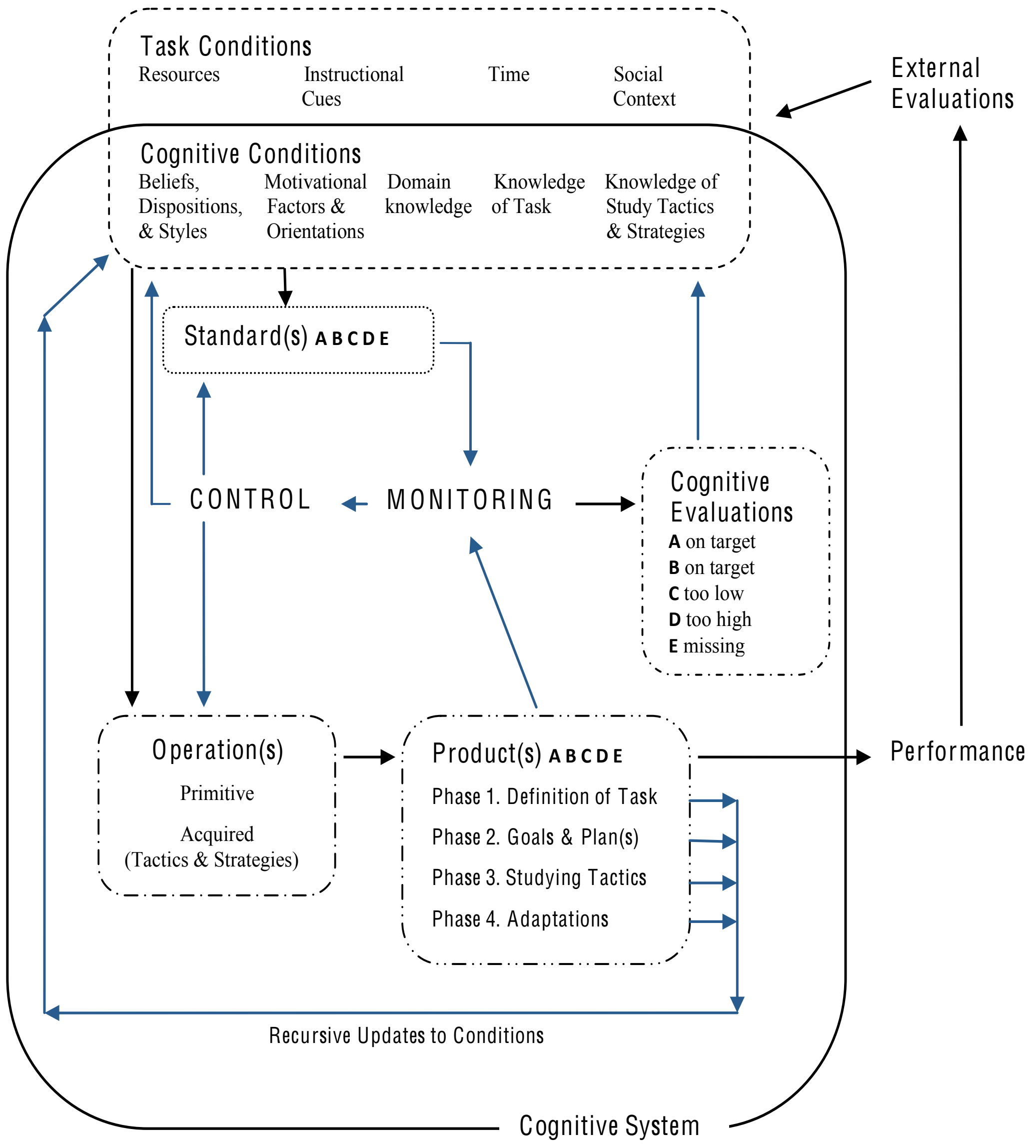

Figure 2.1. Winne & Hadwin's model of self-regulated learning

Phase 1 consists of defining the task. In this phase, learners generate perceptions of the task by interpreting task conditions (contextual constraints and affordances that involve, e.g., time limits, material resources, help available) and cognitive conditions (e.g., knowledge of the task domain, memories of challenges experienced with similar tasks and strategies that proved effective).

Phase 2 involves setting goals and planning how to reach them. Learners create goals relative to their model of the task (e.g., to increase knowledge about a particular topic). Then, they select cognitive operations operationalized as study tactics and learning strategies that they predict can contribute to achieving these goals.

Phase 3 focuses on enacting tactics. Learners engage in learning by applying their chosen tactics and strategies. As they do, chosen tactics and strategies create provisional updates to the initial knowledge and beliefs (e.g., Am I learning more about this topic? Is this strategy as helpful as I thought it would be?), "steps" toward the ultimate goal of the task.

Phase 4 involves adapting metacognition. Each cognitive operation a learner applies constructs products (knowledge, research reports, models or diagrams). When evaluations of products are available, either from the environment (e.g., a peer's comment or a computer's beep) or in the learner's working memory, learners may choose to stay with or revise those products. As well, they may adjust their model of the task and adapt goals and strategies accordingly.

Each phase has the same general structure and consists of conditions, operations, products, evaluations and standards (Winne & Hadwin, 1998). *Conditions* contain information about cognitive conditions and task conditions and determine the way the task will be engaged and carried out. *Operations* refer to the cognitive processes and strategies that students employ when attempting a task, and *products* are defined as information created by operations in changing conditions. Products are divided into internal (e.g., inferences) or external (observable performance) ones, and a different product is created at each stage. *Evaluations* represent internal and external feedback about the products, and *standards* consist of the criteria against which the products are gauged. Internal feedback about the discrepancy between products and standards at each phase serves as a basis for future actions and adjusts conditions of previous phases (Butler & Winne, 1995; Winne & Perry, 2000).

Similarly, each phase of self-regulated learning pivots on metacognitive monitoring and metacognitive control (Butler & Winne, 1995; Winne, 1995, 2001). Monitoring is a generic cognitive operation that compares features of a current product - the target of monitoring - to a list of standards that describe the qualities or properties of an ideal target, that is, a goal.

Metacognitive monitoring is an instance of generic monitoring that is distinguished by the topic that is monitored. Metacognitive monitoring concerns topics about qualities or properties of the subject matter or about learning events. This stands in contrast to monitoring topics that are the subject matter. Learners also can metacognitively monitor properties of cognitive operations they use with respect to standards. Effort and response latency are examples.

Metacognitive control refers to the act of deciding what to do based on evaluating the results of metacognitive monitoring. Learners can exercise metacognitive control through making basic choices in how to manage cognitive challenges (Winne, 2011). One such choice is that students need to decide how to interpret and respond to an environmental situation. In the case of failure, for example, learners can control their internal beliefs by deciding to interpret mistakes as opportunities to learn and improve. Also, students can control their external conditions to improve their metacognitive monitoring by allowing more time to study, or selecting an appropriate context for study. Another such choice made by learners is selecting cognitive operations for information and knowledge processing. An example of this would be learners using a key words strategy rather than memorizing highlighted material when studying a given chapter.

A final important aspect of Winne and Hadwin's model of self-regulated learning is the view that learning is progressive when four broad conditions are satisfied. First, learners need an accurate model of the task and access to information they are supposed to learn. Second, learners need expertise in a repertoire of effective study tactics and learning strategies to cope with challenges tasks present. Third, learners need to know or have access to standards for monitoring changes in subject matter knowledge, the fit of study tactics and learning strategies to tasks they are assigned, and properties of the cognitive operations that comprise study tactics and learning strategies. Fourth, learners need to be metacognitively active in monitoring and controlling (regulating) how they learn, that is, which study tactics they choose and patterns of tactics that comprise learning strategies.

An overall consideration of the model of self-regulated learning created by Winne and Hadwin leads to important insights regarding its contributions to scholarship in the field. Of note is the model's focus on students' monitoring of the relationship between their existing level of understanding and their learning objectives, and the regulation used to reach the goals in question. A number of researchers have employed the Winne and Hadwin model to assess the effectiveness with which students calibrate or monitor their improvements, and to evaluate their ability to regulate their learning strategies (Nesbit et al., 2006; Stahl, Pieschl, & Bromme, 2006; Winne & Jamieson-Noel, 2002). Research findings indicate that more often than not, the calibration of learning activities poses a number of difficulties for students (Winne & Jamieson-Noel, 2002), and that goal orientation (Nesbit et al., 2006) as well as task difficulty and epistemological beliefs (Stahl et al., 2006) seemingly mediate these activities.

Another important contribution made by Winne is his proposal that self-regulated learning has two properties: an aptitude and an event (Winne, 1997; Winne & Stockley, 1998; Winne & Perry, 2000). He suggested that an "aptitude" refers to a quasi-permanent personality trait that may be applied in a variety of contexts and in varying tasks, and may be used as a predictor of future behaviour. Variables related to context occupy a more prominent role when self-regulated learning is viewed as an event. Winne used a combination of methodological approaches (self-report questionnaires and trace methodology) to create and test the effectiveness of his model (Winne & Jamieson-Noel, 2002, 2003; Winne & Perry, 2000) in order to interpret whether self-regulated learning is an aptitude or an event. Winne's approach to self-regulated learning provides a unique contribution to the scholarly research in the field, providing both a model and a framework for conducting empirical research on self-regulated learning that is distinct from other approaches.

Zimmerman's model of self-regulated learning. Zimmerman (2000a) defined self-regulated learning as "self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals" (Zimmerman, 2000a, p. 14). His model of self-regulated learning is based on Bandura's (1986) social cognitive theory (Zimmerman, 1989, 1990a, 1990b, 1998b, 2000a, 2002) whereby self-regulation consists of triadic reciprocal processes among separable yet interdependent sources, personal, behavioural, and environmental events (Bandura, 1986; Zimmerman, 1989, 1990b). According to Zimmerman (1990b, 2000a), covert or personal self-regulation includes monitoring and adjusting cognitive and affective states. Behavioural self-regulation involves self-observation and strategic adjustment based on one's performance processes. Environmental self-regulation takes into account the observation and adjustment of varying environmental conditions or outcomes. The interaction of personal, behavioural, and environmental factors during self-regulation is a cyclical process as these factors typically change during learning and must be monitored (Bandura, 1986, 1997; Zimmerman, 1994). Such monitoring leads to changes in an individual's strategies, cognitions, affects, and behaviours (Schunk, 2001). This cyclical nature is captured in Zimmerman's self-regulated learning model.

From a social cognitive perspective, students' self-regulatory processes and motivational beliefs fall into three cyclical phases: forethought, performance, and self-reflection (see Figure 2.2). The forethought phase involves processes relating to task analysis (goal setting and strategic planning) and those relating to self-motivation beliefs (self-efficacy beliefs, outcome expectations, task interest and value, and goal orientation) that precede actions. The performance phase contains two processes: self control, which helps students to concentrate on a task and optimize their efforts through self-instruction, imagery (e.g., mental picture forming), attention focusing, and task strategies; and self-observation, which refers to tracking specific aspects of individuals' performances, the conditions that surround it, and the effects that it produces (Zimmerman, 2000a; Zimmerman &

Paulsen, 1995) through metacognitive monitoring and self-recording. The self-reflection phase falls into two major classes of processes: self-judgments and self-reactions. Self-judgments involve self-evaluating one's learning performance and attributing casual significance to the outcomes. Perceptions of satisfaction or dissatisfaction and associated affect regarding performance, and adaptive or defensive inferences about whether one needs to alter his or her self-regulatory approach during subsequent efforts to learn or perform, are involved in self-reactions.

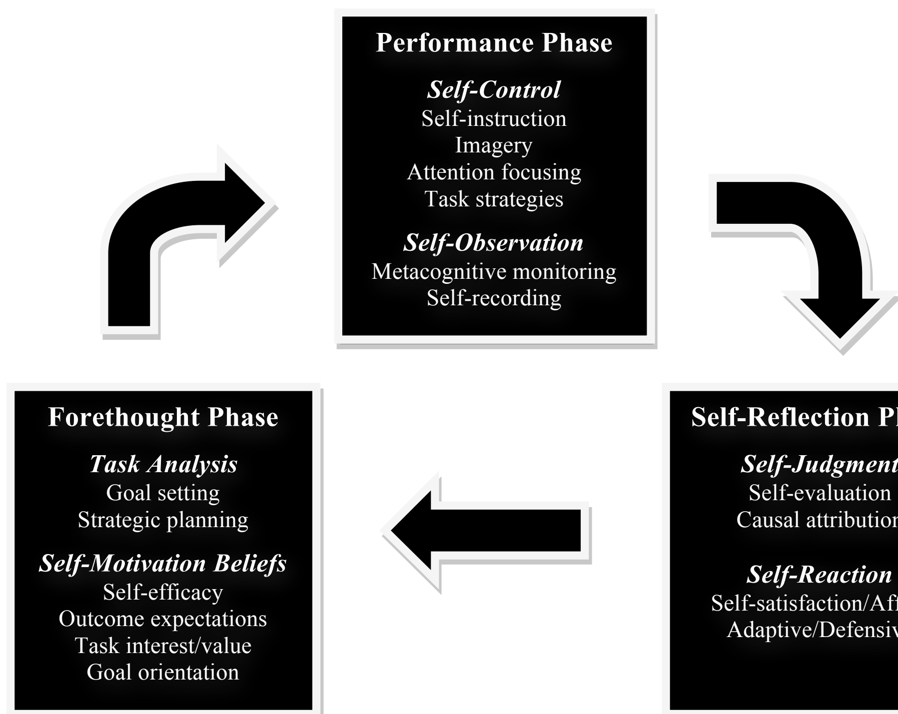

Figure 2.2. Zimmerman's model of self-regulated learning

Zimmerman's self-regulated learning model assumes significant correlations between variables within a particular self-regulated learning phase, and it assumes potentially causal influences of self-regulated learning processes across phases (Zimmerman, 2008b). Given that self-regulation is cyclical in nature, self-reflection affects forethought processes. Phrased differently, learners use the feedback they obtain from earlier learning experiences in order to adjust their selection of strategies and their goals for future endeavours. Given that personal, behavioural, and environmental factors are in a constant state of flux throughout the learning process, these adjustments are essential. It is important to note that the length of each self-regulatory cycle can differ, varying from minutes to years, depending on learners' goals and feedback as well as other self-regulatory processes (Zimmerman, 2008a).

Constructs in Zimmerman's model also have potentially causal influences across the phases of the model. A case in point is self-efficacy, referring to "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997; p. 3). Self-efficacy, according to Zimmerman, is at work during all phases of the self-regulatory process. High self-efficacy for learning in the forethought phase takes the shape of self-efficacy for continued progress in the performance phase and is also realized for achievement in the self-reflection phase. In other words, self-efficacy in the self-reflection phase provides the groundwork for modifying goals or setting new ones in other phases of Zimmerman's model (Schunk & Ertmer, 2000).

As a final word on the matter, much empirical research has examined Zimmerman's self-regulated learning model in a variety of learning contexts and with diverse learners in order to confirm its credibility and consistency, and the results are convincing (e.g., see Schunk & Zimmerman, 1997; Zimmerman, 2000b; Zimmerman & Bandura, 1994; Zimmerman & Martinez-Pons, 1988).

Comparison of the three models of self-regulated learning. Careful analysis of these three self-regulated learning models reveals that the theories in question contain common as well as unique features. The section that follows examines the similarities and differences in these models.

Theoretical background. At the outset, it is important to consider the theoretical background of each of the models under examination. Zimmerman (2000a) pointedly declares that it was Bandura's social-cognitive theory (Bandura, 1986) that served as the foundation of his model, focusing as it does on thinking and behaviour as socially based. In the same vein, Pintrich's framework is similarly rooted in social-cognitive thought, this despite the fact that it includes certain aspects of other theories as well (Schunk, 2005b). Winne and Hadwin's model, on the other hand, adopts a somewhat more eclectic approach to the matter of self-regulated learning, focusing primarily on the approach of information processing (Puustine, & Pulkkinen, 2001; Greene & Azevedo, 2007b).

Salient concepts in the definitions. There are several salient concepts in each self-regulated learning model. Pintrich (2000b) focuses on the impact of contextual as well as personal qualities on the carrying out of self-regulatory strategies, arguing that self-regulated learning is self-constructed. Both Zimmerman (2000a) and Pintrich (2000b) perceive self-regulated learning as a goal-oriented process, and both suggest that monitoring, regulating, and controlling learning are made up of cognitive as well as social, motivational, and emotional factors.

Taking a different view, Winne (1996) describes self-regulated learning as a process controlled by metacognition, a process that attempts to adapt the use of cognitive strategies to task completion. When defining self-regulated learning, Winne indirectly suggests that self-regulated learners are goal-oriented and execute and modify their actions in accordance with what a given task requires, as well as pre-established criteria. Winne does not focus to any great degree on motivation or social learning theory. His emphasis is more on the cognitive aspects of learning but that does not refute the importance he gives to such constructs. A final issue of differing foci among the three scholars is that of context; while Zimmerman and Pintrich (Pintrich, 2000b; Zimmerman, 2000a) argue that learners modify their self-regulatory skills based on context, Winne does not broach the matter (Winne, 1996).

Phases included in the models. The authors all concur that self-regulated learning is a cyclical process, and that each phase of this process impacts and is impacted by the phase that follows it. In each of the models of self-regulated learning, there are, in fact, three stages that occur in a sequential order: a preparatory phase, a performance (or task completion) phase, and a reflective appraisal phase.

Although all three scholars agree on the three distinct phases of self-regulated learning that make up their models, there are nonetheless important unique features that characterize each. For example, unlike Zimmerman, Pintrich, Winne and Hadwin incorporate into their models other intermediate phases in the self-regulated learning process. Indeed, although all three scholars agree on the forethought stage, one in which the plans that are to be carried out are created, Winne and Hadwin identify the definition of task and planning as two distinct processes occurring during this phase. Another unique factor of note among the three scholars concerns the performance stage, the phase of self-regulated learning in which the plan is carried out. For Pintrich it is during this phase that monitoring occurs, and this monitoring leads to modifications in the execution of the plan and changes in learner performance. As viewed by Pintrich, then, monitoring and control processes occur only during the task performance stage and not during the other stages. In opposition to this, the idea of there being an overriding process of metacognitive monitoring (and concomitant internal feedback), one that can occur during all phases of self-regulated learning, is a unique aspect of Winne and Hadwin's model. It marks it as different from those of both Pintrich and Zimmerman, who suggest that monitoring invariably occurs in the performance stage, while feedback always takes place in the reflective stage.

Final thoughts in comparing the models. The above consideration of the three models has demonstrated that their approaches to the matter of self-regulated learning differ in some key ways. Despite this, it must be mentioned that the three models nonetheless share a number of fundamental assumptions (Boekaerts & Corno, 2005; Pintrich, 2000b, 2004). These three scholars all agree that self-regulated learners engage actively and constructively in the meaning generating process, and adapt their thoughts, feelings, and actions as circumstances require in order to affect their learning and motivation. The three theorists similarly concur that biological, developmental, contextual, and individual difference constraints can interfere with or support efforts at regulation. The scholars likewise agree that students possess the ability to set goals, criteria, or standards to self-direct their learning. Similarly, they all assume that achievement effects are mediated by the self-regulatory activities that students engage in to reach learning and performance goals.

Social collaboration in developing self-regulatory skills and strategies. Thus far in the discussion, the researcher has described the "self" in self-regulated learning as choices that an individual makes to improve his or her own learning. Social collaboration, on the other hand, refers to the combined efforts of learners and teachers, tutors, or peers to augment the development of skills and strategies to support learners' for self-regulated learning (Zimmerman, 2004). Social collaboration provides opportunities for learners, teachers, tutors, and peers to interact in ways that help define the academic problem, select strategies, and evaluate performance. In social collaboration, students play a proactive role in developing their own academic plan, and this fosters a commitment to executing that plan. A body of evidence indicates that social collaboration approaches are highly effective (Butler, 1998b; Cleary & Zimmerman, 2004; Graham & Harris, 1989a, 1989b; Pressley, EI-Dinary, Wharton-McDonald, & Brown, 1998).

Problem-based learning is a branch of social collaboration that emphasizes learners' self-regulatory development (Evensen & Hmelo, 2000; Zimmerman, 2004). Problem-based learning, used extensively by medical educators, involves small groups working and learning as a team to solve undifferentiated medical problems. Learners assign subtasks to group members, share information and cognitively model thinking through their individual subtasks (Barrows, 1985, 1994, 2000; Barrows & Pickell, 1991; Barrows & Tamblyn, 1980; Norman, l988; Norman & Schmidt, 1992). Problem-based learning appears effective in preparing medical learners to better self-regulate their effectiveness in naturalistic settings (Blumberg, 2000; Dolmans & Schmidt, 2000; Evensen, 2000; Hmelo & Lin, 2000).

Through fostering specific self-regulatory skills and strategies, the socialization process outlined above provides the foundation for self-regulated learning to develop. Social regulation is systematically decreased as students acquire their own self-regulatory skills as a result of interacting with expert models. It is important to note that as learners develop self-regulatory skills, their social skills do not suffer; on the other hand, these individuals become more socially resourceful (Newman, 1994; Zimmerman & Martinez-Pons, 1986). According to Zimmerman (2000a, 2004), there are four stages in students' development of self-regulatory competence, starting with observing expert models and finishing with self-regulation of personal outcomes in dynamic contexts (see Table 2.2). Students do not always begin the process at the first level, nor do they invariably remain and operate at the top level once they have reached it (Zimmerman, 2000a, 2004). The multilevel model is used to document the progression and cyclical nature of self-regulation learning. As learners become proficient at each skill level in the sequence they learn more easily and more effectively (Zimmerman, 2000a, 2004).

Table 2.2

Multi-Level Features of Self-Regulated Learning

Levels of Regulation	Features of Regulation			
	Sources of Regulation	Sources of Motivation	Task Conditions	Performance Indices
1. Observation	Modeling	Vicarious reinforcement	Presence of models	Discrimination
2. Emulation	Performance and social feedback	Direct/social reinforcement	Correspond to model's	Stylistic duplication
3. Self-control	Representa-tion of process standards	Self-reinforce-ment	Structured	Automaticity
4. Self-regulation	Performance outcomes	Self-efficacy beliefs	Dynamic	Adaptation

Trends and research foci in self-regulated learning. Having examined the three primary self-regulated learning models and the role of social collaboration in the development of self-regulatory skills, it is now time to shift the focus to innovative research being conducted in the field. The first such research focus involves identifying the very components that make up self-regulated learning, often through a comparison of good and poor self-regulators (Boekaerts, Pintrich, & Zeidner, 2000; Schunk, 2005a). Researchers have determined that the elements of self-regulated learning include learners' goal orientation, self-efficacy, interest in and value of tasks, affect, and the use of effective learning strategies (e.g., goal setting, self-evaluating, self-monitoring) (e.g., Ertmer, Newby, & MacDougall, 1996; Linnenbrink & Pintrich, 2002, 2004; Pintrich, 2000a, 2000b, 2003; Pintrich

& Zusho, 2002; Schunk, 2001; Wolters & Rosenthal, 2000; Wolters, Yu, & Pintrich, 1996; Zimmerman, 2000a; Zimmerman & Martinez-Pons, 1990). Research in this area, which has attempted to clarify self-regulatory processes, has expanded the original focus of self-regulated learning from considering only behaviours to including cognitive, motivational, and contextual factors as well (Pintrich, 2000b; Pintrich & Zusho, 2002; Schunk, 2005a).

Another distinct research trend in self-regulated learning is the examination of the relationship between self-regulation, motivation, and learning (Pintrich, 2000b; Schunk, 2005a). Investigators have concluded that there are significant connections among these three constructs (e.g., Chapman & Tunmer, 1995; Pintrich, Anderman, & Klobucar, 1994; Pintrich & De Groot, 1990; Pintrich, Roeser, & De Groot, 1994; Pintrich & Schrauben, 1992; Pokay & Blumenfeld, 1990; Schunk, 1996; Schunk & Swartz, 1993; Wolters et al, 1996; Zimmerman & Martinez-Pons, 1990). The most important of these links appears to be that learners with superior self-regulatory skills tend to be more motivated academically, and tend to demonstrate better learning (Pintrich, 2000b, 2003; Schunk, 2005a, 2005b). This connection is noteworthy for both theoretical purposes as well as for practical application in the classroom, given that it indicates that motivational and cognitive factors interact with each other in a complex manner to bring about learning (Schunk, 2005b).

Yet another major line of research into self-regulated learning has examined the effects of interventions seeking to improve students' self-regulatory skills and school achievement (Schunk, 2005a) across various subjects areas, including reading comprehension (e.g., Palincsar & Brown, 1984; Paris, Cross, & Lipson, 1984; Pressley et al., 1994), writing (e.g., Bereiter & Scardamalia, 1987; Englert, Raphael, Anderson, Anthony, & Stevens, 1991; Harris & Graham, 1992, 1996), mathematics (e.g., Lester, Garofalo, & Kroll, 1989; Schoenfeld, 1985, 1992; Verschaffel et al.,1999), and learning strategies (e.g., Hofer, Yu, & Pintrich, 1998; VanderStoep & Pintrich, 2003). In these interventions, students are frequently instructed in how to establish goals, employ effective task strategies, monitor progress, take notes, organize their studying, and establish a productive work environment, as well as a number of other skills. Interventions typically yield positive results, transfer beyond the training context, and generalize over time (Schunk, 2005a; Schunk & Ertmer, 2000).

Collectively, these trends and research foci in the study of self-regulated learning have improved scholars' understanding of academic self-regulation and have had important implications for school practices. Studies of computer-based learning environments (CBLEs) are a most noteworthy addition to the above-cited research trends into self-regulated learning. CBLEs refer to structured learning environments that are designed for instructional purposes that use computers as key learning tools to support students in reaching learning objectives (Azevedo, 2005a; Lajoie & Azevedo, 2006). Significantly, educational research has identified students' self-regulatory learning skills as the key mediators in enhancing academic performance within less structured CBLEs (Azevedo, 2005b; Lajoie & Azevedo, 2006). Given the importance of the role of self-regulated learning in CBLEs, the relationship between these two concepts will now be examined.

Self-regulated learning in CBLEs. Empirical studies of different types of

CBLEs, including hypermedia, intelligent learning environments, hypertext, microworlds, and simulations, have shown that maximal learning takes place if self-regulated learning occurs (Azevedo, 2005b; Graesser, McNamara, & VanLehn, 2005; Quintana, Zhang, & Krajcik, 2005; Shapiro & Neiderhauser, 2004; White & Frederiksen, 2005). Students are required to regulate their learning when operating in a CBLE, meaning that they must make decisions about what to learn, how to go about learning it, how long to devote to the learning process, how to evaluate other instructional material, and whether or not they comprehend the subject matter (Azevedo, 2005a, 2005b; Azevedo & Cromley, 2004; Azevedo, Greene, & Moos, 2007). More pointedly, students must examine the learning situation, establish meaningful learning goals, choose which strategies to employ, evaluate the effectiveness of the strategies in responding to their learning objectives, and assess their developing comprehension of the subject matter (Azevedo et al., 2007; Greene & Azevedo, 2007b). Similarly, they must monitor their comprehension and make modifications to their plans, objectives, strategies, and effort in accordance with varying contextual conditions (e.g., cognitive, motivational, and task conditions) (Azevedo et al., 2007; Greene & Azevedo, 2007b; Moos & Azevedo, 2006; Pintrich, 2000b; Winne, 2001; Zimmerman 2000a, 2001). Research indicates, however, that the majority of students, even undergraduates, experience difficulty when attempting to self-regulate their learning with CBLEs, hindering their mastery of challenging subjects (Azevedo, Cromley, Winters, Moos, & Greene, 2005). As a consequence, investigators in this field have started to examine the specific self-regulatory processes related to learning in CBLEs, and the way in which aspects of self-regulated learning can be facilitated in CBLEs (Azevedo, 2005b; Winters, Greene, & Costich, 2008).

The first area of interest related to the self-regulated learning process in CBLEs is learners' prior knowledge, examined in numerous studies due to its potentially pivotal role in the planning phase of self-regulated learning (Pintrich, 2000b; Winters et al., 2008). Moos and Azevedo (2008b), for example, examined the relationship between students' prior domain knowledge and the proportion of self-regulated learning processes used while learning with hypermedia. The researchers found that undergraduate students with high prior domain knowledge used significantly more planning and monitoring behaviours than did students with low prior knowledge; on the other hand, students with low prior knowledge tended to use more strategies. Through an analysis of the process data, the researchers also found that students with low prior knowledge employed but a few specific strategies, such as summarizing and note taking, and did not often practice other strategies, such as making inferences or elaborating on their knowledge. Researchers examining the role of prior knowledge have concluded that possessing high prior knowledge enables learners to self-regulate more effectively in CBLEs in that they are more motivated, and are better able to plan and monitor their learning and utilize active strategies, leading to improved learning outcomes (e.g., MacGregor, 1999; Moos & Azevedo, 2008b).

Learners' self-efficacy is another important factor related to self-regulated learning in CBLEs. Bandura (1986, 1997) describes a close alignment between self-regulation and self-efficacy, and researchers have documented this alignment among students using CBLEs (e.g., Joo, Bong, & Choi, 2000; Williams & Hellman, 2004). Like past research carried out in non-CBLE settings, Joo et al.

(2000), in their study of middle school students, determined that self-efficacy for self-regulated learning positively related to academic self-efficacy, self-reported strategy use, and Internet efficacy in web-based instruction. Academic self-efficacy, in turn, was a predictor of academic performance.

The connection between goal orientation and the self-regulated learning process in CBLEs is another area of interest among scholars. Nesbit et al. (2006) used a CBLE called gStudy (Winne, Hadwin, Nesbit, Kumar, & Beaudoin, 2005) to obtain trace data and investigate undergraduate students' study tactics (e.g., note taking and highlighting) as they related to their achievement goal orientations, such as mastery or performance approach or avoidance (Elliot & McGregor, 2001). Achievement goal orientation is "a future-focused cognitive representation that guides behaviour to a competence-related end state that the individual is committed to either approach or avoid" (Hulleman, Schrager, Bodmann, & Harackiewicz, 2010; p. 423). The researchers found that students' mastery goal orientations (approach and avoidance) negatively correlated with amount of highlighting; mastery approach, on the other hand, correlated positively with the quantity of words in elaborative notes. This indicates a relationship between mastery goal orientation and self-regulated learning strategies.

In a similar vein, researchers have looked at the relationship between goal structure and self-regulated learning in CBLEs (e.g., Moos & Azevedo, 2006; Schunk & Ertmer, 1999). Goal structure refers to the expectations embedded in the design of learning activities (Ames, 1992), and includes mastery, performance-approach, and performance-avoidance (Elliot & Harackiewicz, 1996). Findings are mixed as to the role goal structure plays in students' use of self-regulatory strategies. Moos and Azevedo (2006), for instance, manipulated the type of learning goal given to undergraduate students in order to understand the effect on their learning, motivation (task value, extrinsic and intrinsic motivation), and self-regulated learning processes. The results indicated that there were no significant differences on the learning measure, or on the motivational variables. As regards self-regulated learning processes, however, it was found that individuals given a performance-avoidance goal engaged in more planning processes when compared to learners provided with other learning goals. No significant differences were found regarding groups' monitoring, strategy use, and management of task difficulty and demands.

Another important area of research is the use of effective strategies in the various phases of self-regulated learning in CBLEs (e.g., Greene & Azevedo, 2007a; Greene, Moos, Azevedo, & Winters, 2008; Whipp & Chiarelli, 2004). Azevedo and colleagues (Azevedo, Guthrie, & Seibert, 2004; Greene & Azevedo, 2007a; Greene et al., 2008) employed a mixed-method approach that combined process data (think-aloud protocols; Ericsson & Simon, 1993) with learning outcomes as students operated in hypermedia and simulation learning environments. Pintrich's (2000b) framework was employed to inform the coding and categorization of process data in accordance with the areas and stages of self-regulated learning. The investigations carried out by Azevedo and his colleagues have indicated that the frequency of use of particular self-regulated learning processes (e.g., planning, metacognitive monitoring, using efficient strategies, and engaging in help-seeking behaviour) appears to be consistently linked to learning gains, and these processes are therefore viewed as effective strategies for learning in CBLEs (Azevedo, Guthrie, et al., 2004; Azevedo, Winters, & Moos, 2004; Moos & Azevedo, 2006).

For example, Azevedo, Guthrie, et al. (2004) compared undergraduate students who made large gains in conceptual understanding during the task to students who made little or no gain, and made valuable observations about the use of self-regulatory strategies in the two groups. The researchers found that a higher proportion of students who made large gains engaged in planning and forethought activities, monitored their understanding, planned their time and effort, and used learning strategies such as summarizing, making inferences, re-reading, hypothesizing, elaborating knowledge, and selecting a new informational source. On the other hand, students with smaller gains almost never engaged in planning, did not spend much time monitoring their learning, engaged in help-seeking to handle task difficulty and demands, and employed a greater variety of learning strategies, such as goal-free searching, copying information, and the same strategies used by the students who made large gains.

Finally, a body of research has also examined the relationship between learner control in CBLEs and self-regulated learning. The findings of this research indicate that high-self regulated learners perform better in learner-controlled CBLEs, whereas low self-regulated learners have better performance outcomes in program-controlled CBLEs (e.g., Eom & Reiser, 2000; McManus, 2000; Young, 1996). Eom and Reiser (2000), for example, observed that middle school students with low self-regulated learning skills had superior performance on a learning outcome measure when in the program-controlled computer-based instructional program (materials presented in a fixed order and with the same sequence of instructional events) than when in the learner-controlled version (the order and the sequence of materials decided by learners). It was found that in the learner-controlled version, students with high self-regulatory skills had better scores than those with low self-regulatory skills.

Co-regulation vs. self-regulated learning. Along with examining the relationship between learners' self-regulated learning and CBLEs, recent research has begun to investigate the role that co-regulation plays in one's self-regulated learning activity and capacity. Co-regulation is "a transitional process in a learner's acquisition of self-regulated learning, within which learners and others share a common problem-solving plane, and self-regulated learning is gradually appropriated by the individual learner through interactions" (Hadwin & Oshige, 2011; p. 247). Despite the fact that various perspectives on co-regulation exist, all share a common grounding in Vygotsky's (1978) views of higher psychological processes being socially embedded or contextualized, and all are grounded in Wertsch and Stone's (1985) belief that these processes are internalized via social interaction (Hadwin & Oshige, 2011; McCaslin, 2009).

Co-regulation acknowledges that each individual brings into the learning situation different types of self-regulatory challenges and expertise, and through interactions with each other individuals advance their self-regulatory skills (Hadwin, Jarvela, & Miller, 2011). Co-regulation typically involves a student and another individual, such as a peer or a teacher, who shares in the regulation of the student's learning, and they co-regulate each other through prompting a regulatory process, strategy, or belief. While co-regulation is taking place, all learners take on the roles of expert and novice through the various aspects of the common activity. Learners share cognitive demands such as metacognitively monitoring, evaluating, and regulating the task processes, thereby making it easier to accomplish tasks. The view of co-regulation on the social dimension stands in contrast to self-regulated learning models that focus on self-regulation as developing within the learner, assisted by the modeling and feedback of others. In self-regulated learning, the social context is viewed as one of the components in the triadic process of self-regulation.

There are three broad areas of research into co-regulated learning, and it is not surprising that this research focuses primarily on interactions or dynamic processes between learners and others as regards regulated learning processes (Hadwin et al., 2011). The first area examines interactions and transactions in speech as learners move toward independent self-regulated learning (e.g., Flem, Moen, & Gudmundsdottir, 2004; Hadwin, Wozney, & Pontin, 2005; Karasavvidis, Pieters, & Plomp, 2000; Winsler, Diaz, Atencio, McCarthy, & Chabay, 2000; Winsler, Diaz, McCarthy, Atencio, & Chabay, 1999). For example, Hadwin et al. (2005) investigated the transition of self-regulatory control from teacher to graduate student during naturalistic instructor-student conferences/meetings. These researchers analyzed teacher-student discourse and found a decrease in teacher-directed regulation and an increase in student-directed regulation over time. They also found a shift in emphasis from task understanding to enacting strategies in teacher-student dialogue with the passage of time. Finally, the findings showed a decrease in co-regulated learning discourse about cognition and more co-regulatory and self-regulated learning discourse about metacognitive processes over time.

The second area of co-regulated learning research emphasizes peers regulating each other in the context of collaborative work (e.g., Iiskala, Vauras, & Lehtinen, 2004; Iiskala, Vauras, Lehtinen, & Salonen, 2011; Vauras, Iiskala, Kajamies, Kinnunen, & Lehtinen, 2003; Whitebread, Bingham, Grau, Pasternak, & Sangster, 2007). For example, Iiskala et al. (2011) investigated "shared metacognition" in the context of collaborative problem-solving activities. Four Grade 4 dyads were videotaped while solving a computer-based mathematics problem. After analyzing verbal interactions (transactions) between the pairs, episodes of socially shared metacognition were identified and their function and focus analyzed. There were significantly more and longer episodes of socially shared metacognition in difficult problems as compared to moderately difficult and easy problems. These episodes served to facilitate or inhibit activities and their focus was on the situation model of the problem or on mathematical operations. Metacognitive experiences were found to trigger socially shared metacognition.

The third area of co-regulated learning research focuses on the ways in which social environments (cultures) influence co-regulated learning (e.g., Lajoie & Lu, 2011; McCaslin & Burross, 2011; McCaslin et al., 2006; Stone & Gutierrez, 2007). For example, in their study of Grade 3-5 classrooms, McCaslin and Burross (2011) investigated the instructional opportunities that existed in the classroom, how learners participated in and adapted to classroom demands, and learners' performances on standardized tests. Through systematically transitioning the focus of analysis between instructional influences and personal or individual influences, the researchers looked at relationships between the social and the personal. Findings from classroom observations and students' self-monitoring reports showed that learners adapted or responded to various classroom demands in different ways. Children in Grades 3 to 5 coming from economically disadvantaged schools or cultures, struggling with mobility, poverty, and low performance on standard tests, demonstrated positive adaptation to classroom tasks, particularly in the context of direct instruction.

Research into co-regulated learning is still in the beginning stage when compared to research into self-regulated learning. In research carried out to date, investigations conducted in the field have focused on learners in different age groups (e.g., preschoolers, graduate students), have examined a variety of interpersonal interactions (e.g., teacher-student, parent-child), and have applied a range of task types (e.g., individual or joint/shared tasks, classroom activities) in the contexts being analyzed (Hadwin et al., 2011). With regard to actual learning constructs being examined, co-regulation research conducted so far has examined areas ranging from metacognitive monitoring and control through to phases in the self-regulatory process such as understanding tasks and setting goals. The research done into co-regulation thus far has provided important insights into the field, and has also shed light on how co-regulated learning and self-regulated learning intertwine and relate to one another.

Summary. The increased attention given to self-regulated learning by researchers in various fields has clearly made it the object of much scholarly investigation. Research into self-regulated learning continues to have a significant impact on education in that it provides scientific information on how students become masters of their own learning processes (Zimmerman & Schunk, 2011).

Through an examination of good and poor self-regulators, researchers have determined that the elements of self-regulated learning include learners' goal orientation, self-efficacy, interest in and value of tasks, affect, and the use of appropriate learning strategies. Scholars have also found that learners with better self-regulatory skills are apt to be more academically motivated, and tend to have superior learning. Research has also determined that self-regulated learning interventions typically produce positive results, transfer beyond the training context, and become generalized with the passage of time. With the growth of technology in education in recent decades, scholars have also begun to examine self-regulatory processes as they relate to learning in CBLEs. The findings of their investigations have determined that learners' prior knowledge, self-efficacy, goal orientation, and the use of suitable strategies in the various phases of self-regulated learning have an effect on learning with CBLEs. Findings have also suggested that the degree of learner control and the goal structure embedded in learning activities similarly play a role in learners' performance in CBLEs. Finally, recent research into co-regulated learning has provided new perspectives on the interaction of social practices with individual engagement and self-regulatory processes.

Computer-Supported Collaborative Learning

Introduction to computer-supported collaborative learning (CSCL). The term "computer-supported collaborative learning" (CSCL) was first used in the late 1980s by O'Malley and Scanlon, and was acknowledged by Koschmann as a significant field of research focus in 1996 (Lipponen, Hakkarainen, & Paavola, 2004; Resta & Laferriere, 2007). CSCL refers to an environment created to support collaboration between learners to enhance their learning processes (Kreijns, Kirschner, & Jochems, 2003) and facilitate collective learning (Pea, 1994), or group cognition (Stahl, 2006), all through the use of technological tools. CSCL supports interactions among learners using technology, be it asynchronous or synchronous, on campus or globally. CSCL is an interdisciplinary field of research that examines the way in which technology promotes the sharing and creation of knowledge and expertise through peer interaction and group learning processes (Resta & Laferriere, 2007).

CSCL has as its foundation the socio-constructivist aspects of learning, which focus on both individual thinking and socially distributed knowledge construction (Koschmann, 1996; Stahl, Koschmann, & Suthers, 2006). It is suggested that by engaging in collaborative inquiry-based activities, and using expert models in a particular discipline, students can build complex disciplinary knowledge and skills (Brown, Collins, & Duguid, 1989; Edelson, Gordin, & Pea, 1999; Linn, Bell, & Hsi, 1998). Through the use of CSCL, learning communities can be created in which students have the opportunity to collaboratively make representations, develop explanations of the subject studied, and participate in expert-like practices of knowledge construction (Salovaara & Jarvela, 2003; Scardamalia & Bereiter, 1994). CSCL can also facilitate the learning of individual students through structuring the inquiry, providing tools for keeping an activities record, and by highlighting crucial phases of the process by employing tools that direct the student's metacognitive awareness and enhance reflection (Pea, 1993; Salovaara & Jarvela, 2003).

The present investigation uses a CSCL approach to examine self-regulated learning in journal clubs. In the next section the researcher describes one of the underlying premises of CSCL, the premise being that technology can promote distributed cognition (or shared knowledge).

Distributed cognition: The theory behind CSCL. Distributed cognition refers to the socially distributed (or shared) nature of cognition (Hakkarainen, Palonen, Paavola, & Lehtinen, 2004; Hutchins, 1991, 1995; Lehtinen, 2003; Pea, 1993; Perkins, 1993; Resnick, 1991; Resnick, Saljo, Pontecorvo, & Burge, 1997; Salomon, 1993). Distributed cognition is the process whereby cognitive resources are shared socially to expand individual cognitive resources or to achieve something an individual agent could not achieve alone (Lehtinen, 2003). Cognitive processes may be distributed between humans and machines, a phenomenon known as physically distributed cognition (Norman, 1993; Perkins, 1993), or between cognitive agents, an occurrence called socially distributed cognition (Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen, 2000). Distributed cognition forms systems, as pointed out by Salomon (1993), which are made up of an individual agent, the agent's peers, teachers, and socio-culturally formed cognitive tools.

One important aspect of distributed cognition is rooted in the fact that human beings possess finite cognitive resources like memory, time, or computational power; without outside aids, humans possess only limited memory and reasoning abilities (Lehtinen et al., 2000). Indeed, one uses the outside world and other learners as sources of knowledge and as extensions of one's cognition (Sweller, 2006; Sweller & Sweller, 2006). The use of socio-culturally developed cognitive tools and artifacts is essential for a successful process of inquiry (Resnick et al., 1997), as these tools enable learners to decrease the load of cognitive processing and handle more complicated problems (Pea, 1993; Salomon, Perkins, & Globerson, 1991).

Several of these cognitive problems cannot be addressed individually, but can be solved by putting together the knowledge and skills of numerous agents (Hatano & Inagaki, 1991; Hutchins, 1995; Lehtinen et al., 2000; Norman, 1993; Roschelle, 1992). In fact, the basic source of cognitive growth is social communication (and scientific argumentation in the context of science), this growth being the ‘resultant’ of a communicative act for Mead (1977), and “the zone of proximal development” in Vygotsky’s (1978) framework. The zone of proximal development refers to “the distance between the actual developmental 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 more capable peers” (Vygotsky, 1978, p. 86). It is through social interactions, for example, that all the limitations, contradictions, and inconsistencies of a learner’s explanations become apparent, as one is forced to see one’s conceptualizations from a different point of view. Also through social interactions, specifically through verbalizing one’s conceptions and comparing them with those of others, the matter of finite cognitive resources can be dealt with effectively by distributing the load to several learners. Finally, social interactions can bring about profound conceptual comprehension, as verbalizing one’s ideas leads to a much deeper understanding of them (Bielaczyc, Pirolli, & Brown, 1994; Brown & Palincsar, 1989; Collins & Brown, 1988; Hatano & Inagaki, 1993).

Social interactions similarly foster cognitive growth through the process of externalization. The cognitive value of externalization lies in the fact that it makes visible internal thought processes (Collins, Brown, & Holum, 1991; Lehtinen, 2003; Lehtinen & Repo, 1996; Lesgold, 1998), meaning that these processes can be publicly analyzed and emulated. For example, metacognitive processes that cannot be observed suddenly take form and become perceptible (Brown & Campione, 1996; Brown & Palincsar, 1989); such desirable cognitive practices may then be copied by others, leading to the conceptual advancement of learners.

As regards the make up of a group of learners, research indicates that distribution of expertise and cognitive diversity leads to cognitive growth and knowledge advancement. Dunbar (1995) and Kitcher (1989, 1993) found that cognitive division of labour is crucial in advancing science, and the distribution of cognitive efforts permits the group of learners to be more flexible and to reach better results than they otherwise might. In their studies, Dunbar (1995) and Hutchins (1991, 1995) also suggested that groups that were made up of individuals with similar but different expertise were more creative and more effective than were groups with identical expertise.

Several pedagogical models utilize a distributed cognition approach, be it with or without technology. For example, Community of Learners (Brown & Campione, 1994, 1996), Communities of Practice (Barab & Duffy, 2000; Engestrom & Cole, 1997; Lave & Wenger, 1991; Wenger, 1998, 2000), as well as Cognitive Apprenticeship (Collins et al., 1991; Collins, Brown, & Newman, 1989; Lajoie, 2009; Lajoie & Lesgold, 1989) describe how the sociology of the group provides the cognitive diversity that can lead to knowledge advancement and cognitive growth. More specifically, in Community of Learners (Brown & Campione, 1994, 1996), cognitive diversity is formalized by distributing expertise within the community, where different participants take on different expert roles. In this community, conceptual advancement is facilitated by nurturing each student's own expertise. Students participate in a self-regulated and collaborative inquiry, and the group as a whole is responsible for task completion. Students monitor the progress of their distributed inquiry themselves, being guided in the process. Through participating in Community of Learners, students are therefore able to transcend their current level of cognitive achievement through collaborating with peers and through using helpful cognitive artifacts.

Distributed cognition theories suggest that socio-cultural cognitive systems are different from individual learners in terms of cognitive and epistemic traits (Hutchins, 1995). In order to foster the development of higher-level processes of inquiry, all elements of the learning process, which include goal setting, forming research questions, giving explanations or searching for information, can be shared or distributed among learners. The process of inquiry may be facilitated by a technologically advanced collaborative learning environment adhering to cognitive principles, and may facilitate the development of a learning community's knowledge and changes in participants' epistemic states. Collaborative inquiry in these new environments could inspire learners to work to the best of their abilities.

Although the focus of distributed cognition is on cognition as a socially distributed process, it is important to consider what the theory says about changes that occur in individual cognition. From a dynamic interaction perspective, distributed and individual cognition interact and affect each other reciprocally (Salomon, 1993; Salomon et al., 1991). Salomon et al. (1991) suggested that distributed cognitive processes augment one's cognitive competencies and they will in turn affect one's future distributed activities.

When considering this issue, Perkins (1993) focused on the significance of individual cognition in distributed cognitive processes, taking this approach because epistemological (or higher-order) knowledge is not represented anywhere in a distributed cognitive system. Epistemological knowledge (i.e., knowledge about strategies of inquiry, patterns of explanation, and forms of justification), he argues, cannot become distributed because it is always required for carrying out complex inquiry processes. The higher-order knowledge possessed by many weaker students is inadequate to regulate their learning in various knowledge domains (Perkins, 1993; Perkins & Simmons, 1988). Perkins (1993) proposed that to overcome the cognitive processing load and learn effectively, epistemological knowledge must be developed within the learner and not, in the words of Perkins, "physically downloaded." As argued by Lehtinen et al. (2000), a way of dealing with the matter might be to develop learners' epistemological knowledge within, and have it "physically downloaded" as well. Lehtinen et al. (2000) likewise suggest that a significant part of epistemological knowledge may also be implemented in a learning environment supported by technology, and in the related cognitive practices as well.

As established above, distributed cognition facilitates the growth of learners' metacognitive skills. As participants interact socially, they are compelled to view their conceptions from the stances of their peers, which fosters a greater awareness of one's own beliefs and knowledge (Lehtinen et al., 2000). Collaborative learning is such that thought processes are externalized as public discourse; this gives learners insight into the thought processes of others, thereby nurturing the growth of metacognitive skills. A metacognitive environment furnishes activities and structures that promote the monitoring of one's understanding as well as the understanding of one's peers, and reflects improved learning (Brown & Campione, 1996). Moreover, CSCL seems to engage students in inquiry over long spaces of time, and furnishes socially distributed cognitive resources for comprehension monitoring and other metacognitive activities. According to Hatano and Inagaki (1993), active participation in comprehensive activity may promote advanced conceptual comprehension, and may also support the development of new metacognitive beliefs about knowing and the significance of understanding.

Research into the effects of CSCL. In recent years, a number of empirical studies have charted the effects of CSCL on students' learning, including the processes of students' conceptual understanding, self-regulated learning and motivation, and social collaboration. In the section that follows, the researcher reviews literature on each of these contributions with particular emphasis on the link between CSCL and improved student learning.

Conceptual understanding. Research conducted on the impact of CSCL on conceptual understanding shows that CSCL can foster a deeper understanding in different subject matters, particularly science. This environment can improve students' understanding of science concepts by giving them the tools they require for organizing, representing and visualizing knowledge (e.g., Barron et al., 1998;

Lamon et al., 1996; Pea et al., 1999; Roschelle & Pea, 1999). For example, a study conducted by Barron et al. (1998) concluded that among Grade five students, the learning of complex, scientific concepts was enhanced by project-based activities in which technology was employed in introducing the learning task, structuring the problem-solving process, revising the work, as well as creating visual representations of the problem.

Self-regulated learning and motivation. A number of researchers have investigated the effects of CSCL on self-regulated learning (e.g., Lajoie & Lu, 2011; Salovaara & Jarvela, 2003; Winters & Azevedo, 2005). Lajoie and Lu (2011), for example, examined the complex interactions that take place during a simulated medical emergency that foster learning and co-regulation in two collaborative learning conditions. Students were assigned either to a traditional whiteboard or an interactive whiteboard group. The researchers found that individuals in the interactive whiteboard condition engaged in more adaptive decision-making behaviour in the early stages of the intervention. Overall levels of metacognitive activity, however, were found to be similar in both conditions, although there was a variation in the pattern and timing of metacognitive categories. In particular, the whiteboard group engaged in greater planning and orienting than did the traditional group in the initial stages of the problem. Early engagement and co-regulation took place in the interactive whiteboard group, leading to shared understandings and then to effective patient management later on.

Another research strand in the effects of CSCL on self-regulated learning has determined that students working in a CSCL environment frequently used low-level self-regulated learning strategies but not higher-level self-regulatory strategies (e.g., Azevedo, Winters, et al., 2004; de Jong, Kolloffel, van der Meijden, Staarman, & Janssen, 2005; Salovaara & Jarvela, 2003). One such study is that of Azevedo, Winters, et al. (2004), who explored low-achieving high school students' self-regulated learning as they worked in dyads. The researchers found that the small yet statistically significant gains students made in understanding the subject matter were related to the self-regulatory behaviours observed in the dyads and the teacher's scaffolding and instruction. Analysis of student discourse showed that learners spent a great deal of their time on only a few strategies to learn about the topic, such as following procedural tasks, evaluating the content, and searching, rather than engaging in planning, monitoring, and handling task difficulties and demands. Similarly, in a qualitative study examining the processes of self-regulation for students using a CSCL environment, de Jong et al. (2005) analyzed middle school students' online discussions looking for evidence of self-regulatory processes. These students worked collaboratively at a distance in three dyads on a divergent task within a CSCL environment called Active World. The researchers found that student dyads regulated each other's learning mainly through maintaining common ground and monitoring their task performance, but few other regulation strategies, such as orienting, planning, testing and evaluation, took place.

Other scholars have compared students' use of cognitive learning strategies when working in different learning contexts, including CSCL environments (e.g., Jarvela & Salovaara, 2004; Salovaara, 2005). In a three-year longitudinal study, Salovaara (2005) investigated high-school students' use of cognitive learning strategies in inquiry-based CSCL. The results of a process-oriented interview indicated that the learners who engaged in the inquiry-based CSCL activities reported deeper-level cognitive strategies such as monitoring, creating representations and sharing information collaboratively. The students in the comparison group reported more surface-level strategies, such as memorization. However, the findings regarding the usefulness of CSCL inquiry on cognitive learning strategies were not consistently positive. The researcher found that the students in the comparison group reported significantly more strategies in the category of content evaluation.

A growing body of literature offers evidence that CSCL fosters motivation by restructuring the motivational interpretations of non-task-oriented students, and by increasing their level of task engagement (e.g., Cohen & Scardamalia, 1998; Jarvela, 1996; Rahikainen, Jarvela & Salovaara, 2000). One such study is that of Cohen and Scardamalia (1998), who examined the collaborative activity of Grade 5-6 students as they solved computer-simulated physics problems. The researchers found that CSCL facilitated students' collaborative knowledge building, and students engaged in more monitoring and reflective activities than they did when engaging in face-to-face only interaction. Their findings also suggested that there was a positive influence of CSCL on students' motivation, such as task-related engagement (more monitoring and regulation of other students' ideas and actions).

Social collaboration. Numerous studies have focused on social collaboration (discourse processes) in CSCL environments. The findings of this research speak of increased activity of collaboration and improved quality of students' communication when a CSCL environment is implemented in the classroom (e.g., Hewitt, 2002; Lajoie et al., 2006; Linn et al., 1998; Meyer, 2003). An example is the work of Lajoie et al. (2006), who investigated the use of technology in higher education to support an international collaboration between two graduate seminars, one in Mexico and the other in Canada, on the topic of cognition and instruction. The researchers employed WebCT, a Web-based course management system that provides communication tools, to allow collaboration between and within the two groups. Results revealed that students in both seminars showed high levels of critical thinking in the sorts of discussions they engaged in, and in the kinds of questions they asked others.

Another study making the case that CSCL promotes social collaboration is that of Meyer (2003), who compared the experiences of graduate students in threaded discussions to their experiences in face-to-face discussions, and also examined the threaded discussions for evidence of higher-order thinking. Results suggested that using threaded discussions increased the time students spent on class objectives, provided students with extra time for reflection on issues related to the course, and led to higher-order thinking. The face-to-face format, however, had value as well as a result of its immediacy and energy.

Despite the above-mentioned evidence arguing the benefits of CSCL for students' learning, some research has pointed to the possible constraints of this environment. One potential limitation is that when the same CSCL environment is created in different classrooms, the activity and quality of learners' contributions can vary significantly (e.g., Hakkarainen, Lipponen, & Jarvela, 2002). As pointed out by numerous researchers, if students are not given adequate systematic training or scaffolding, they may have difficulties in attaining high-level argumentation in virtual environments (Marttunen & Laurinen, 2001; Nussbaum, Hartley, Sinatra, Reynolds, & Bendixen, 2002). In a similar vein, as suggested by Hakkarainen, Jarvela, Lipponen, and Lehtinen (1998), students may not benefit from CSCL if they are unable to adopt appropriate practices for this new learning context. CSCL environments have altered learning practices in terms of learning goals, task structure and learner and teacher roles, and in order to benefit from the possibilities offered by CSCL and an inquiry learning culture, students must modify their learning practices to face the challenges brought about by the new setting.

In summary, the literature reviewed indicates, by and large, that CSCL has a positive effect on student learning. More specifically, scholars agree that CSCL environments improve students' conceptual understanding, self-regulated learning and motivation, and social collaboration. At the same time, some researchers have argued that these benefits will not come to fruition if students do not receive the necessary training and scaffolding, or if they are unable to alter their learning goals, adapt their learning strategies, and change their view of student and teacher roles. Despite these genuine concerns, by all accounts the CSCL environment is an effective learning context that can provide students with the opportunity to develop the necessary skills to become lifelong learners.

Conclusion: Research Hypotheses

After reviewing the literature related to the three main constructs in this study, critical analysis, self-regulated learning and CSCL, it is clear that there are several definitions of each construct. It is of the utmost importance in the current research to reach a sound working definition of each term that is appropriate for the investigation. The definitions of the three constructs in the literature that are relevant to this study are as follows:

1. Critical analysis: Critical analysis refers to the ability to dissect medical literature, assess and interpret the evidence, analyze the strengths and weaknesses of studies, relate the results to one's work, and adjust one's professional approach accordingly (Krueger, 2006; Last, 2001).

2. Self-regulated learning: Zimmerman's model of self-regulated learning is employed in this study, and the construct is thus defined as "the process by which learners personally activate and sustain cognition, affects, and behaviours that are systematically oriented toward the attainment of learning goals" (Schunk & Zimmerman, 2008, p. vii).

3. CSCL: CSCL is defined as an environment created to support collaboration between students to enhance their learning processes (Kreijns et al., 2003) and facilitate collective learning (Pea, 1994), or group cognition (Stahl, 2006), all through the use of technological tools.

The purpose of this dissertation is to explore the relationship between medical undergraduate students' self-regulated learning skills and their critical analysis performance in a journal club activity with respect to CSCL. In order to do this, the present study will use a mixed method, quantitative and qualitative research design (Creswell, 2005; Johnson & Christensen, 2004). Quantitative and qualitative data will be collected simultaneously, and will then be merged and analyzed to understand how critical analysis can be developed through the self-regulated learning process participants undergo in a technology-rich, collaborative learning environment.

To this end, the following research questions will be addressed:

1. Is self-regulated learning related to medical students' critical analysis performance? There are no studies that examine the relationship between self-regulated learning and critical analysis. This research will provide a deeper understanding of how students regulate their cognition, behaviour, affect, and environment within disciplinary-based practices. More specifically, the researcher will examine whether medical students monitor and adaptively control the cognitive and affective processes that mediate critical analysis.

Research has demonstrated that students' self-regulated learning has a positive effect on their reading comprehension and achievement (e.g., Butler, 1995, 1998b; Housand & Reis, 2008; Pressley et al., 1998; Schunk & Zimmerman, 2007; Smith, Borkowski, & Whitman, 2008; Souvignier & Mokhlesgerami, 2006). Research has also indicated that learners' metacognitive regulatory strategies, such as planning, monitoring, information management strategies, and evaluation of learning, are positively related to the development of critical thinking (Ku & Ho, 2010; Magno, 2010). Since critical analysis, as defined in the present study, requires that participants have both strong reading comprehension skills and critical thinking abilities, self-regulated learning can be seen as having a positive effect on critical analysis. Given this, it can be hypothesized that participants' self-regulated learning scores are positively related to their post-test critical analysis performance while statistically controlling for the effects of pre-test critical analysis performance.

2. Does participation in computer-supported collaborative learning influence

self-regulatory processes? If so, how? Empirical evidence indicates that CSCL has a positive effect on students' self-regulated learning skills (e.g., Azevedo, Winters, et al., 2004; de Jong et al., 2005; Jarvela & Salovaara, 2004; Lajoie & Lu, 2011; Salovaara, 2005; Salovaara & Jarvela, 2003; Winters & Azevedo, 2005). Based on this assumption, the hypothesis for this research question is that students who participate in the experimental group (CSCL condition) will have significant gains in their post-test self-regulated learning measure outcome when compared to students in the control group (individual learning condition).

The qualitative data, audio and video taping of pair discussions, will be collected and analyzed to allow the researcher to understand how CSCL influences participants' self-regulated learning skills. It is predicted that participants in the experimental group will make frequent use of self-regulated learning strategies, if the hypothesis for research question 2 is correct.

3. Does participation in computer-supported collaborative learning influence the use of annotation tools? The findings from empirical studies show that learners usually use only a small number of the tools provided to them when working alone in CBLEs (Narciss, Proske, & Koerndle, 2007; Proske, Narciss, & Koerndle, 2007; Winne & Jamieson-Noel, 2002). Unlike previous studies, however, the present research examines learning processes in a collaborative setting. Collaborative settings have been found to be effective learning contexts where students learn from each other and develop self-regulated learning skills (Butler, 1998b; Cleary & Zimmerman, 2004; Pressley et al., 1998). It is therefore hypothesized that participants working in the collaborative context (experimental group) in this study will differ significantly from their counterparts who work

alone (control group). More specifically, the researcher anticipates that the experimental group will increase their use of annotation tools from pre-test to post-test. To test the hypothesis, the process data, video taping of participants' reading activities, will be collected and analyzed to help the researcher understand whether CSCL influences participants' use of annotation tools.

4. Does computer-supported collaborative learning influence individuals' self-regulated learning in terms of the development of critical analysis? If so, how? Educational research has suggested that students must use specific self-regulatory processes related to planning, monitoring, and strategies in order to succeed in learning with CBLEs (Azevedo, 2005b; Moos & Azevedo, 2008a; Winters et al., 2008). Learners' self-regulatory skills can therefore be identified as the key mediators between the potential of CBLEs and learning performance (Azevedo, 2005b; Graesser et al., 2005; Lajoie & Azevedo, 2006; Quintana, et al., 2005; Shapiro & Niederhauser, 2004; White & Frederiksen, 2005). To shed light on how these interactions play out in a medical context, research question 4 examines how CSCL achieved its intended effects in regards to (1) improving students' self-regulated learning skills, and (2) enhancing students' critical analysis performance. The hypothesis for this research question is that (1) the intervention, CSCL, will have a statistically significant positive effect on self-regulated learning (SRL), (2) SRL will be associated with the outcome of interest, critical analysis (CA), after controlling for the intervention effect, and (3) the influence of CSCL on CA through SRL will be statistically significant (see Figure 2.3).

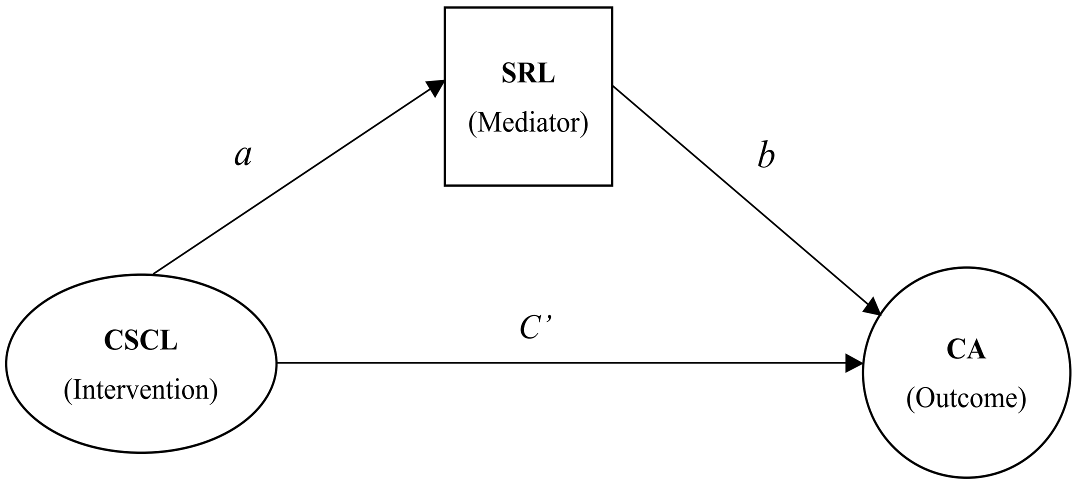

Figure 2.3. Mediation model of hypothesized relationships among constructs

Audio and video taping of pair discussions and information from the Collaboration Feedback Sheet will be examined to permit the researcher to understand how CSCL affects participants' critical analysis skills. If the hypothesis for research question 4 is correct, it is predicted that participants in the experimental group will frequently engage in high-level co-regulation and will demonstrate high-level critical analysis skills.

5. What is the nature of group dynamics as students engage in self-regulated learning in a computer-supported collaborative learning environment? The goal of this exploratory question is to understand the dynamics within small groups as students self-regulate in a technology-rich collaborative setting. To this end, all utterances from group discussions will be categorized into various communicative activity patterns.

A review of the studies conducted by scholars has demonstrated that a great number of important insights have been reached regarding critical analysis, self-regulated learning, and CSCL. There are significant gaps in the research that have not been explored, however, such as the relationship among these three constructs, particularly within the context of medical education. Through asking and addressing the research questions outlined above, this dissertation makes an important contribution to scholarship in that it examines these very matters. More precisely, it advances theory across the three areas under investigation by broadening the scope of the study of self-regulated learning, CSCL, and critical analysis to encompass new territory.

Chapter 3

Methodology

This chapter begins with a general description of the participants who were involved in the project, followed by a detailed account of the materials (including context and measures) used in the data collection process. Subsequent to this, an overview of the research design of the study is given followed by a description of the data collection procedure and intervention activities. Finally, both the quantitative and qualitative data analytic procedures used in this study are explained.

Participants

Every effort was made to recruit the maximum possible number of second-year undergraduate students from the Faculty of Medicine at McGill University for the study. Due to busy schedules, a number of these individuals chose not to volunteer for the research, resulting in an initial sample of 29 participants. Of the 29, however, 15 were ultimately unable to maintain their participation throughout the entire study due to demanding internships and other obligations related to their medical training. In the end, 14 students (six males and eight females) aged 21 to 28 years completed their participation in the research. Seven of the participants had completed the Pre-Med program and others had obtained degrees in related fields prior to the research.

Participants were recruited for this study to help them learn how to develop the analytical skills required to “read around their patients” critically. They were invited to engage in a journal club activity as part of a pilot course at a large teaching hospital while doing their two-month pre-clerkship. Tables 3.1 and 3.2

respectively show a detailed breakdown of participants' educational background in research-related knowledge and their research experience.

Table 3.1

Participant Educational Background in Research-Related Knowledge

Course	Yes	No
Research methods	7	7
Epidemiology	11	3
Statistics	9	5

Table 3.2

Participant Research Experience

Area	None	Almost none	A little	Moderate	A great deal
Conducting research	4	4	2	4	0
Reading research articles	1	3	6	4	0

Materials

Context. The research took place in the university's education computer laboratory, which is divided into two rooms, one housing a PC laboratory and the other an Apple laboratory. The PC lab was the main location for the pre- and post-tests, the medical instructor's debriefings, and the control group reading and writing activities. The Apple lab was used for the experimental group collaborative activities (i.e., the intervention). Both laboratories provide connections to the Internet and the university server computer resources.

Based on the assumption that learners mediate instruction and self-regulate learning, and in order to gather fine-grained, time-sequenced data that trace these processes, a learning environment rich in technology was created to allow students to read and annotate medical journal articles individually or collaboratively using a variety of software. First, Adobe Acrobat 9 Professional software provided participants an authentic reading context equipped with a number of annotating tools, including note-taking tools (e.g., sticky note, callout, and text box features), highlighting tools (e.g., highlight, underline, and cross out features), and symbol functions (e.g., cloud, arrow, rectangle, oval, and pencil features). These tools permitted students to read and annotate online journal articles (PDF files) in the same way as one would when reading hard copies of articles. According to Winne and Perry (2000), students approach difficult tasks by selecting specific study techniques, such as underlining, note taking, and labeling, that they believe are the most appropriate for the situation, then coordinating those techniques as a strategy to accomplish the tasks. It was therefore hypothesized that the use of various annotation tools would be one of the self-regulatory strategies used by students while reading. This software also supported real-time collaboration on PDF versions of journal articles with synchronized document views and chat, and provided the opportunity for participants in any given dyad to compare and highlight the differences between their annotated versions of the same article. Adobe Acrobat 9 Professional software was not designed for self-regulated learning specifically; however, the researcher was able to capture students' use of self-regulated learning strategies using screen-capturing devices. Second, Camtasia (for PC) and ScreenFlow (for Apple) screencasting software were employed to capture students' learning processes as they interacted with the reading content and tools. The screen capture software allowed the researcher to keep a record of which tools learners used to interact with material and how the tools were used, generating traces of study activity. Camtasia and ScreenFlow were also used to audio and video tape students' actions and discussions during their collaboration. Finally, participants had access to the Internet, enabling them to look up information and seek help while completing their tasks.

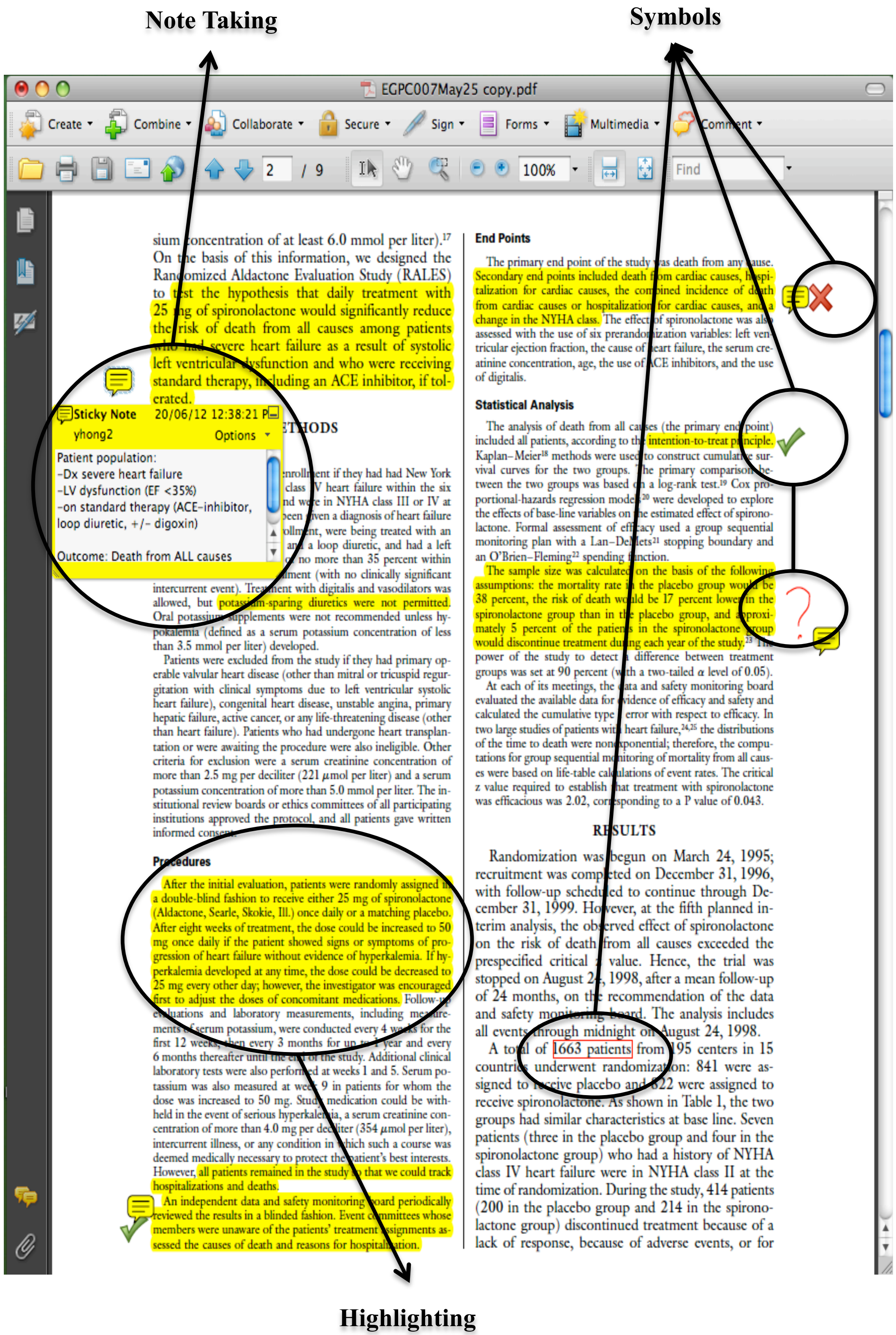

Figure. 3.1. Adobe Acrobat 9 Professional software interface

Measures. Participants completed a number of self-reports to assess their: (1) motivational beliefs, task analysis (goal setting, strategic planning, and affect), and performance self-evaluation; (2) critical appraisal skills; and (3) experiences of computer-supported collaborative learning. Surveys included the *Self-Regulated Learning Questionnaire*, the *Critical Appraisal Checklist*, and the *Collaboration Feedback Sheet*. These measures were modified to be task specific for the purposes of this study and were based on other measures that had been found in the literature. A detailed description of each measure is provided below.

Self-regulated learning questionnaire. This self-report instrument was developed based on constructs in Zimmerman's (2000a, 2008b) three-phase self-regulated learning model (see Chapter 2 for details). Items from this survey were adapted from the Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1991, 1993) and the On-Line Motivation Questionnaire (Boekaerts, 2002) since no existing questionnaires could be used for the purposes of this study.

The Self-Regulated Learning Questionnaire consisted of two parts. The first part, the Forethought Questionnaire, was completed after the learning task was introduced and before the participants began the actual task. Students were given an introduction to the Adobe software and annotation tools that they were to use when reading journal articles, and were given the opportunity to practice annotating a sample article. They were also asked to glance at the Critical Appraisal Checklist to form an impression of the actual task, and then indicated the motivational beliefs and emotions that were elicited by that task. They were also asked to report on their goals and strategic planning regarding the actual task.

The second part of the questionnaire, the Reflection Questionnaire, was completed as soon as the actual task was finished. At that point, students reported on their emotional state and perceptions of their performances. They also attributed their performances to one or more causes.

Forethought questionnaire. The first part of the Self-Regulated Learning Questionnaire (administered at task outset) included 24 self-report items and consisted of two major scales, Self-Motivation Beliefs and Task Analysis (see Appendix A). This part of the questionnaire was used to assess participants' motivational beliefs, goal setting, strategic planning, and emotions regarding the tasks before beginning them.

The Self-Motivation Beliefs scale was made up of 21 items, and each used a 5-point scale anchored by *not at all true* (1) and *very true* (5). This scale was comprised of four subscales: self-efficacy (e.g., "I am confident in my ability to identify the strengths and weaknesses of the research"), intrinsic goal orientation (e.g., "It is very important for me to try to understand the content of a medical journal article, regardless of the level of difficulty"), extrinsic goal orientation (e.g., "Showing others that I have the ability to read critically is very important to me"), and task-related motivational beliefs, a combined subscale that included outcome expectations (e.g., "I will be able to improve my critical appraisal skills if I make a strong effort"), intrinsic interest (e.g., "I personally enjoy reading medical journal articles"), and task values (e.g., "I consider the critical reading of medical journal articles very useful").

The Task Analysis scale included three subcategories: goal setting (e.g., "Do you have a goal for this task? If so, what is it?"), strategic planning (e.g., "What strategies will you use to help you accomplish the task?"), and affect (e.g., "How do you feel right now, just before starting the task?"). There was only one open-ended question in each of the first two subcategories, and one multiple-choice question for affect.

Reflection questionnaire. The second part of the Self-Regulated Learning Questionnaire (administered at task completion) included 13 self-report items and consisted of two major scales: Self-Judgment and Self-Reaction (see Appendix B). This part of the questionnaire was used to assess students' perceptions of their own performances after having completed the learning tasks.

The Self-Judgment scale was made up of five items, and each used a 5-point scale anchored by *not at all true* (1) and *very true* (5). This scale contained two subscales: self-evaluation (e.g., "Regarding the goal(s) I set for myself, I accomplished the task very well") and causal attribution (e.g., "I think I did well on this task because I am good at this type of task").

The Self-Reaction scale included three subscales: self-satisfaction, adaptive/defensive, and affect. The self-satisfaction subscale was made up of four items using a 5-point scale, (e.g., "I am very satisfied with my ability to identify the strengths and weaknesses of the article"). The adaptive/defensive subscale was comprised of three items with open-ended questions (e.g., "Based on this experience, the next time you read a medical article, is there anything you will improve/change in order to perform the task better?"). The affect subscale consisted of one multiple-choice item (e.g., "How do you feel now that you have completed the task?").

Critical appraisal checklist. The Critical Appraisal Checklist consisted of 19 multiple-choice questions and seven open-ended questions (see Appendix C). This generic checklist was designed to measure students' ability to critically analyze medical journal articles, and was adapted from a number of tools that were created for that express purpose (e.g., Randomized Controlled Trial Appraisal Tool from the Critical Appraisal Skills Program, Critical Thinking Tools from the Centre for Evidence-Based Social Services, and EBL Critical Appraisal Checklist).

The 19 multiple-choice questions dealt with participants' observations of the aims, sampling, data collection, data analysis, results, and conclusion found in each of the articles they read. Choices included *Yes*, *No*, *Don't know*, or *NA*, and each correct answer was given a value of one point.

The seven open-ended questions were used to elicit students' personal opinions of the strengths and weaknesses of the studies, how they felt they could improve the studies' weaknesses, and their beliefs as to how they could use the results of the studies in their own practices. Each question was accorded a value of two points. Based on answer keys provided by the medical instructor (see Appendix D & E), a rubric was developed to evaluate students' answers to the seven open-ended questions (see Appendix F).

Collaboration feedback sheet. The Collaboration Feedback Sheet contained six open-ended questions (see Appendix G) and was created to obtain students' reflections on their own learning while engaging in computer-supported collaborative activities. The first two questions focused on the changes in participants' annotation skills after their collaboration (e.g., "What have you learned about annotation skills from working with your partner?"). The third and the fourth questions targeted the influence of the intervention on students' critical appraisal skills (e.g., "From working with your partner, what have you learned about critical analysis?"). The last two questions elicited students' opinions as to the importance of technology in, and its influence on, their collaborative learning experience (e.g., "What is your opinion of the role played by technology in the collaborative process?").

Research Design

This research used a mixed method design, and both quantitative and qualitative data were collected. The quantitative data was to help the researcher examine the correlations among variables, and the qualitative data to help the researcher to understand the phenomena that emerged from quantitative analysis. The design of the quantitative analysis was a repeated-measures regression design[1] (i.e., S(C2) x A3 x T2) in which students were nested in condition (i.e., control and intervention) and crossed with journal article (i.e., A1, A2, A3) and test (i.e., pre- and post-test). The main dependent variables were self-regulated learning and critical appraisal. The development of students' self-regulatory skills and critical analysis skills were examined on a variety of measures and in various forms (verbal, written, individual, and group). The main source of evidence for both skills, however, consisted of self-reported questionnaires and trace data as participants engaged in pre- and post-test phases. The focus was on self-regulated learning and critical appraisal as they pertained to the three phases of

[1] Several types of analyses were carried out, but hierarchical regression was chosen. Although the sample size was not sufficient to meet the minimum requirement of 30 cases per variable, this analysis provided the best evidence for trends in the data.

Zimmerman's self-regulated learning model: forethought, performance, and self-reflection. To explain the development of self-regulatory strategies and critical analysis skills in a computer-supported collaborative environment, qualitative data, including experimental group members' pair discussions and reflections on the computer-supported collaborative learning process, were also obtained. The dialogues of each dyad were transcribed, and then inductive open coding (Strauss & Corbin, 1998) and deductive content analysis (Yin, 2003) were used to identify utterances related to the development of self-regulated learning and critical analysis skills. Finally, pattern analysis was used to identify the sequence of interactive events associated with co-regulation and communicative activities.

This study consisted of three phases (see Figure 3.2): (1) a pre-test phase in which students' task-specific self-regulatory skills and critical analysis skills were assessed as a baseline; (2) an intervention phase in which students learned critical analysis skills individually or collaboratively; and (3) a post-test phase in which students' task-specific self-regulatory skills and critical analysis skills were assessed in light of their having participated in the research.

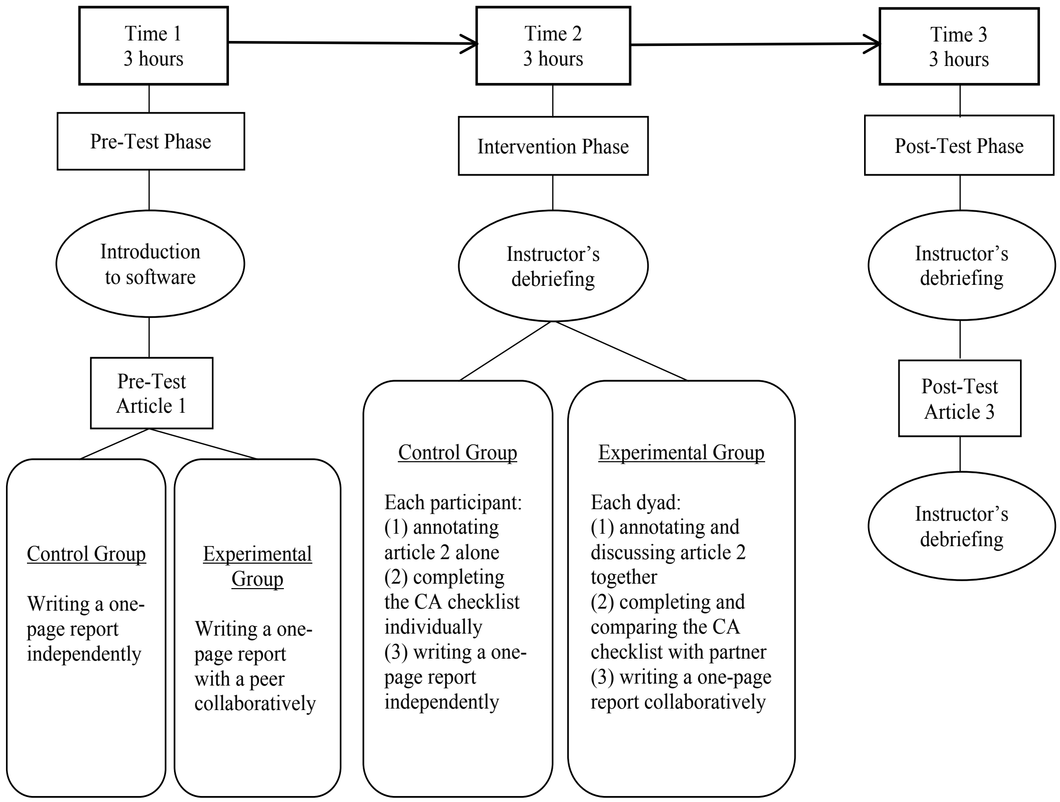

Figure 3.2. Three phases of research with timeline

Participants were randomly assigned to one of two conditions: (1) a *collaboration* condition (i.e., intervention) in which participants worked in small groups (including dyads and triads) to read an article, complete critical appraisal checklists, and write one-page reports, or (2) a *contro*l condition in which students worked alone, not in a collaborative context. Eight of the participants were randomly assigned to the collaboration condition while six participants were assigned to the control condition.

The "read around your patients" training course in which the research was carried out convened three times during participants' seven-week pre-clerkship, each session lasting three hours. A learning environment rich in technology and based on collaboration was created in a computer laboratory in which each participant was provided with a computer equipped with Internet access as well as technological support (see “Context” section in this chapter). The medical instructor chose the course content, while the researcher served in a supportive role assisting students with computer-based learning tools that facilitate both individual and collaborative learning.

The data collection procedure involved in this study took place during the pre-test phase, intervention and control activities, and post-test phase. Due to hectic schedules, however, not every participant could always be in attendance. Given this, the lecture component of each session was video taped and later shown to absentees, who were also given the opportunity to complete the other tasks they had missed, in order to ensure that all participants had the same learning experience.

The technology used during the data collection process, Camtasia and ScreenFlow, permitted the researcher the opportunity to trace and collect detailed evidence of participants’ self-regulation strategies with computerized content. It also allowed for the capturing of participants’ actions and discussions while performing the tasks online. Along with technology, self-report questionnaires focusing on participants’ self-regulated learning and critical analysis skills were used to measure changes in those areas. Five kinds of data were collected over the course of this study: (1) students’ self-reported survey responses, (2) students’ annotations while reading articles, (3) participants’ scores on the Critical Appraisal Checklists, (4) the verbal transcripts of video data of students’ discourse while working collaboratively with their partners, and (5) students’ reflections upon the computer-supported collaborative learning experience. In order to answer the research questions, both quantitative and qualitative analysis techniques were applied when examining the data.

Procedure

Prior to the commencement of the research, the medical instructor involved in this study, as well as the researcher, presented a general overview of the study to second-year undergraduate medical students at their whole-class sessions and asked those who wished to participate to complete a consent form (see Appendix H). To ensure that no student would feel pressured to take part, the medical instructor left the premises while students decided whether to provide consent to participate in the study.

The medical instructor chose three articles (randomized controlled trial studies) from the New England Journal of Medicine based on the learning objectives of the internal medicine pre-clerkship course. These articles were carefully chosen based on their interest to participants and relevance to their learning needs and future professional practice, as well as the fact that the students were unfamiliar with the articles. The pre-test (article 1) and post-test (article 3) were comparable in terms of word count, number of tables and figures, and the Flesch-Kincaid readability scores, as shown in Table 3.3.

Table 3.3

Word Count, Number of Tables/Figures and Flesch-Kincaid Readability for Pre- and Post-Test Readings

Article	Word count	Tables / Figures	Flesch-Kincaid readability
Article 1 (pre-test)	3798	4 / 2	17.8
Article 3 (post-test)	3697	3 / 2	16.6

The research took place as a pilot extension of a pre-existing course in evidence-based medicine, a course that teaches students how to formulate an answerable clinical question, search the literature, and analyze the validity and reliability of what is found. The pilot course consisted of three 3-hour sessions (see Figure 3:1) spread out over three consecutive weeks, and took place in the education computer laboratory. Pre- and post-tests, debriefings, and the control group reading and writing activities all occurred in the PC lab, while the experimental group collaborative activities took place in the Apple lab. The collaborative work took place in a separate lab because participants in the experimental group, who were required to discuss the tasks they were completing, might otherwise have disturbed their counterparts in the control group. All of the instructor's debriefings, students' reading and annotation processes, and pair discussions were audio and video taped in order to capture participants' actions and discussions while performing the tasks online.

Day 1 activities. Students were first administered a research background questionnaire (see Appendix I) to gather information about their education and confidence levels in research. The researcher then introduced the Adobe Acrobat

Professional software to students and asked them to read a practice article using the software in order to familiarize themselves with the annotation tools and the task. Subsequent to that, the medical instructor gave a brief introductory overview of the study.

Pre-test. As a pre-test, students were administered the Self-Regulated Learning - Forethought Questionnaire (see Appendix A), to be completed independently, in order to assess their motivational beliefs, goal setting, strategic planning, and emotions regarding the task before beginning it. Following this, students used the software to individually read and annotate article 1, "The effect of spironolactone on morbidity and mortality in patients with severe heart failure." Participants then completed the Critical Appraisal Checklist (see Appendix C) independently, the objective of which was to evaluate their ability to critically analyze medical journal articles. Next, students independently completed the Self-Regulated Learning - Reflection Questionnaire (see Appendix B) in order to measure their perceptions of their own performances after having accomplished the task.

Intervention 1. The final activity of Day 1 involved students in the control group staying in the PC Lab to write a one-page report independently to answer the following questions:

(1) Having read this article, what did you get out of it?

(2) What did you have difficulty understanding in the article?

(3) What clinical question can this article help you answer? How and why did you choose that clinical question?

(4) When you start your clerkship, how will you read around your patients?

While participants in the control group were carrying out this task, students in the experimental group moved to the Apple lab and were asked to find a partner with whom to collaboratively complete the same one-page reports with identical questions to answer. These students were then asked to complete the Collaboration Feedback Sheet (see Appendix G) independently.

At the closing of Day 1, all students were asked to save their reports on the computers on which they had worked. The researcher then removed students' names from the reports they had written, replacing them with codes, and electronically sent the reports to the medical instructor for debriefing. As per the instructor's request, a related article, namely "Canadian Cardiovascular Society Consensus conference recommendations on heart failure 2006: Diagnosis and management," was sent to the participants as optional, non-study-related home reading.

Day 2 activities. The instructor first conducted a debriefing on "how to read around your patients," during which he touched upon the importance of the role critical appraisal skills played in the process. Also included in his debriefing was a discussion of article 1 and feedback on students' reports from Day 1.

Intervention 2. Students in the control group remained in the PC lab while those in the experimental group moved to the Apple lab.

Control group: PC lab. Subsequent to this, the control group independently read and annotated article 2, "Intensive versus conventional glucose control in critically ill patients," after which they completed the Critical Appraisal Checklist (see Appendix C) and wrote a one-page report.

Experimental group: Apple lab. The experimental group moved to the Apple lab and worked with the same partners as they had on Day 1. Each dyad read and annotated article 2 collaboratively, either by sharing a computer or by sitting at adjoining computers. In both cases, students consulted one another during the reading and annotating process. Following this, members of each dyad were asked to compare their annotations, discuss the article, and complete the Critical Appraisal Checklist (see Appendix C) together. Each pair then collaborated to write a one-page report while answering the same questions as they had on Day 1. Once they had finished, participants were asked to complete the Collaboration Feedback Sheet (see Appendix G) independently.

At the close of Day 2, as had been the case when working on the first article, participants were asked to save their reports on their respective computers in the laboratory. The researcher once again replaced students' names with codes on the reports and electronically sent them to the medical instructor for use in the next debriefing. As with the end of Day 1, the researcher electronically sent another article, this one entitled "Glucose control in hospitalized patients," to the participants as optional, non-study-related home reading.

Day 3 activities. Day 3 began with the medical instructor conducting a debriefing on article 2 and providing feedback on students' reports from Day 2.

Post-test. This was followed by the post-test, during which participants were administered the Self-Regulated Learning - Forethought Questionnaire (see Appendix A) to complete independently. Subsequent to this, they were asked to individually read and annotate article 3, "Dabigatran versus warfarin in the treatment of acute venous thromboembolism," and were asked to complete the Critical Appraisal Checklist (see Appendix C) independently. Next, students worked alone to complete the Self-Regulated Learning - Reflection Questionnaire (see Appendix B).

To conclude the pilot course, the medical instructor conducted a debriefing on what participants gleaned from article 3. He then proceeded to present the main points of another optional, non-study-related article, "Guide to good prescribing: A practical manual," because of its relevance to the third article they had read.

At the end of Day 3, at the request of the medical instructor, the researcher sent participants two articles for home reading, namely "Dabigatran was non-inferior to warfarin for preventing recurrent venous thromboembolism" and "Antithrombotic therapy for venous thromboembolic disease: American College of Chest Physicians evidence-based clinical practice guidelines (8^{th} edition)." The article that had been the subject of his presentation, "Guide to good prescribing: A practical manual," along with the PowerPoint he had created to accompany the entire pilot course, was also sent to students by the researcher.

Data Analysis

Four kinds of data were collected over the course of this study: (1) students' self-reported survey responses, (2) participants' scores on the Critical Appraisal Checklists, (3) the trace data of students' use of annotation tools during the reading process recorded by screen capture software, and (4) the verbal transcripts of audio and video recordings of students' discourse while working collaboratively with their partners. In order to answer the research questions, both quantitative and qualitative analysis techniques were applied when examining the data.

Quantitative analytic procedures. The main sources of quantitative data for this study included participants' self-reported responses on the Self-Regulated Learning Questionnaire, scores from the Critical Appraisal Checklist, and the frequency count of the annotation tools used by participants (process data). Four kinds of quantitative analytic techniques, reliability analysis, hierarchical regression, analysis of variance (ANOVA), and mediation analysis, were employed to allow the researcher to investigate the relationships among participants' self-regulated learning processes, critical analysis skills, and the computer-supported collaborative learning environment.

Reliability analysis. The goal of conducting a reliability analysis was to determine the internal consistency of the results of the Self-Regulated Learning Questionnaire used in this study. Cronbach's alpha was employed as a way of measuring the success with which an underlying construct was measured by a set of items. When Cronbach'a alpha was above 0.7, it provided support for the contention that all the items in a given subscale measured the same underlying construct.

Hierarchical regression. A 2-step hierarchical regression was applied to answer the first and second research questions in this study. The first goal of carrying out this analysis was to allow the researcher to specify a fixed order of entry for variables in order to control for the effects of covariates or to test the effects of certain predictors independent of the influence of others. The second goal was to gather information about the size and directionality of the effects of the predictors.

Analysis of variance (ANOVA). ANOVAs were employed to answer the third research question. The objective of conducting these analyses was to test whether the means of different types of annotation tools used by experimental and control groups at different times were equal.

Mediation analysis. In this study, a meditational analysis was performed to answer the fourth research question. The objective of carrying out this analysis was to examine the hypothesized causal sequence between the independent variable, learning condition, and the dependent variable, critical analysis skills, through the inclusion of the mediator variable, self-regulated learning.

Qualitative and process data analytic procedures. The main source of qualitative data for this study consisted of trace data of participants' use of annotative tools as well as audio and video taped recordings of the experimental group's pair discussions during the collaborative activities. As regards these recordings, verbal data from the four groups that carried out the intervention activities were examined within this context; given that the first and second groups met twice each, and the third and fourth groups met once each, this made for a total of six audio and video recordings. Analysis of these data consisted of a 5-step process.

Step 1: Transcribing the data and counting the frequency of annotation. In the first stage of data analysis, the verbal data from the recordings were transcribed by the researcher and by a volunteer with experience in the transcription of verbal data. At the same time, a frequency count was made of participants' use of the various annotative tools at their disposal while reading the articles.

Step 2: Verifying transcriptions. The second stage involved verifying the accuracy of transcriptions and documenting additional contextual information. The transcriptions were verified by the researcher and by the volunteer. A handful of errors were made in transcribing, and were corrected through the researcher and volunteer listening multiple times to the recordings. In addition to the verification of transcriptions, additional contextual information, such as participants pointing at the computer screen, nodding or shaking their heads, and typing without talking, among other things, was added to the transcriptions. The purpose of adding such information was to ensure that the most comprehensive picture possible was provided of participants' collaborative interactions.

Step 3: Segmenting the data. In the third stage of data analysis, the researcher segmented the transcriptions according to episode units (Chi, 1997). First, all non-content related conversations were removed, and remaining interactions were then divided into segments. In order to locate the beginning of each segment, the researcher identified the turn during which a given participant initiated a topic or action that was then responded to by a partner and discussed. To determine the close of each sequence, the researcher followed the thread of the interaction until identifying the location in which the participants were no longer specifically responding to the topic or action. Any speech segment that lasted only a very short period (less than 10 seconds) was combined with either the segment preceding or following it. To establish inter-rater reliability in segmenting, an independent rater segmented 100% of the transcription based on the criteria mentioned above. The percentage of agreement was 97 % and each disagreement was resolved through discussion.

Step 4: Macro coding of segments. The fourth stage of data analysis involved using a macro coding approach to examine the segment data. This coding approach was guided top-down, theory-driven by literature on collaboration or co-regulation (Volet, Summers, & Thurman, 2009). The purpose of this coding approach was to answer the research questions that lie at the heart of the research: to determine to what extent the computer-supported collaborative learning environment led students to genuinely engage in collaboration (co-regulation), to what degree this collaboration fostered critical analysis skills, and the extent to which self-regulated learning occurred in this context.

Co-regulation coding. The coding scheme used in this stage of the research was taken from the 2009 study of Volet et al.. In their study, Volet et al. argued that one may view groups of individuals as multiple self-regulating agents who regulate each other's learning on a social level in a collaborative environment. Based on this assumption, Volet and her colleagues developed a theoretical framework that integrates, as two continuous dimensions, the constructs of social regulation and content processing, and created a coding scheme for analyzing regulation in both the content domain and the social one.

The coding system developed by Volet et al. differentiates between discourse that deals directly with learning content (which comprises the four categories specified in the theoretical framework) and discourse related to other topics. *High-level content-processing* represents involvement in elaborating, interpreting, reasoning, building on or connecting ideas, explaining something in one's own words, or help seeking for understanding. *Low-level content-processing* refers to the clarifying of fundamental facts, meaning reading verbatim from a textual source or help seeking for details. *Individual regulation* indicates interactions that include only one speaker, with the possible exception of a trigger question or expressions of acknowledgement (e.g., “uh-huh”, “yeah”) from other participants. *Co-regulation* refers to interactions in which many group members make equal verbal contributions. A more detailed illustration of this coding scheme is provided in Appendix J.

Verbal interactions not fitting into any of the four categories were categorized as *Difficulties, Reading approaches/strategies*, or *Commentary on article*. It is important to bear in mind that the intervention activities did not only elicit students’ feedback on what they learned from the articles, but also asked them to share the difficulties they encountered while reading. Given this, it was useful to create a *Difficulties* category to code these comments. Moreover, participants sometimes made mention in their discussions of strategies they used while carrying out their reading tasks. A category called *Reading approaches/strategies* was thus created for verbal interactions that involved reflections upon approaches or strategies used while reading the articles. Finally, since a few participants expressed general impressions related to an article, it was useful to create a *Commentary on article* category for such statements.

In order to ensure the reliability of the coding system, an independent rater coded 20% of the segments (N = 20). After separately coding these segments and comparing the results, the percentage of agreement between raters was found to be 70%. Each coding discrepancy was resolved after a discussion, resulting in 100% agreement.

Step 5: Micro coding of utterances. In the fifth stage of data analysis, a micro coding approach was used to examine the participants’ discussions. The unit of analysis used in this stage was a sentence of verbal interaction. A total number of 1740 utterances were divided into task-related segments; however, 76 utterances were uncodeable for a variety of reasons (e.g., unintelligible sentences, nonverbal behaviour, etc.), and were thus discarded. This analyzing process involved both inductive open coding (Strauss & Corbin, 1998) and deductive content analysis (Yin, 2003). The inductive open coding procedure was bottom-up, and the categories (concepts) were derived from interacting with the data. The deductive content analysis procedure, on the other hand, was top-down, and was operationalized on the basis of literature on collaborative reasoning (Kumpulainen & Kaartinen, 2003). The purpose of this stage of analysis was to ascertain the proportion of self-regulated learning skills and critical analysis skills participants demonstrated while engaging in collaboration, and to understand the pattern of communicative activities participants used during the discussions.

Self-regulated learning coding. An open-coding procedure was applied to the analysis of verbal discussion with a particular emphasis on individuals' self-regulatory skills. Following this, a theory-driven, deductive analysis was carried out in order to categorize the codes emerging from the open coding. The coding scheme developed for and employed in the research was based on the models of self-regulated learning created by Zimmerman (2000a) and Pintrich (2000b); the scheme outlines how self-regulation might appear within a group setting (see Appendix K). The data were interpreted according to this coding scheme to identify instances of regulating cognition, motivation, and behaviour. The purpose of the analysis was to understand the types and frequency of self-regulated learning strategies demonstrated by participants while engaging in computer-supported collaborative learning.

Critical appraisal coding. The coding scheme for critical appraisal was developed in a bottom-up fashion because there were no pre-existing examples. All utterances were first open-coded, and then categories were generated. Following this, based on their similarity and dissimilarity, categories were grouped into broader, higher-order categories. The purpose of carrying out this analysis was to understand the types and frequency of critical analysis skills demonstrated by participants while engaging in computer-supported collaborative learning. A great deal of participants' verbal interaction occurred while they were typing the one-page report on the computer, the result being that, in each group, some of those utterances were initially made by one group member and were then repeated, either by that group member or the other, as the utterances were being typed. These repetitions were not coded a second time in any categories of critical analysis. A detailed description of the coding scheme is presented in Appendix L.

Communicative activities coding. Communicative activities were coded in order to identify the nature of the communication used by participants when interacting with each other during the collaborative tasks. The purpose of coding the communicative activities was to characterize how students expressed and shared their understanding of the articles, and how they interacted while completing the writing tasks. This information helped the researcher gain a better understanding of the relationship between collaboration and communication, and the extent to which this leads to the development of self-regulated learning and critical analysis.

The coding scheme for the communicative activities was created top-down, drawing largely on the study by van Boxtel (2000). The scheme was later modified and used in computer-mediated collaboration research (Saab, van Joolingen, & van Hout-Wolters, 2005; Lu & Lajoie, 2008). A total of six categories were created: (a) Informative, (b) Argumentative, (c) Elicitative, (d) Responsive, (e) Directive, and (f) Off task (see Appendix M). A number of the categories were divided into subcategories, an example of this being the Responsive category, which included both statements of agreement and disagreement between individuals. Similarly, the Argumentative category contained both clarification of misconceptions as well as the organization of understanding through the use of justifications, elaborations, and expansions on arguments. The measures in this scheme served to identify and categorize the character of participants' communication with each other, and were created to help understand group dynamics and communication.

In order to establish reliability at this stage, an independent rater received training on the coding schemes by the researcher, and coded 45% of the utterances together to familiarize the independent rater with the coding systems. The coding schemes were then fine-tuned based on the nature of the problems in the discussion. Subsequent to that, the researcher and the independent rater coded the remaining 55% of the utterances (N = 960) in the transcriptions independently. The percentage of agreement between the raters was 90% for the self-regulated learning coding, 85% for the critical appraisal coding, and 92% for the communicative activities coding. More specifically, the percentage of agreement was 97% for the Informative category, 91% for the Argumentative category, 92% for the Elicitative category, 93% for the Responsive category, 70% for the

Directive category, and 100% for the Off task category. Each coding discrepancy was resolved through discussion. The coding schemes were again modified based on the types of discrepancies that arose during the inter-raters' consultations.

Chapter 4

Results

Results pertaining to the effectiveness of the intervention on participants' self-regulated learning processes and critical analysis skills are presented in this chapter. The reliability of the Self-Regulated Learning Questionnaire is presented first, followed by the quantitative and qualitative results of each research question in order, and, finally, students' reflections upon the computer-supported collaborative learning experience.

Reliability of Self-Regulated Learning Questionnaire

The 5-point self-report instrument, the Self-Regulated Learning Questionnaire, was used to measure participants' self-regulatory strategies. This questionnaire included two parts: (1) the Forethought Questionnaire, which evaluated participants' motivational beliefs, goal setting, strategic planning, and emotions regarding the tasks before beginning them; and (2) the Reflection Questionnaire, which measured students' perceptions of their own performances after having completed the learning tasks. Given the small sample size of this study, the items from the Self-Regulated Learning Questionnaire were used to form several subscales (see Chapter 3 for details) in order to reduce the risk of inflating Type I error. Reliability analysis and Cronbach's alpha were employed for this purpose, and alpha values of .70 or greater were seen as an indicator of good reliability for the subscales. Table 4.1 presents the descriptive statistics for each of the self-regulated learning subscales, the composite scores, and the critical analysis measure. Table 4.2 illustrates Cronbach's alpha reliability for each of the self-regulated learning subscales.

Table 4.1

Mean and Standard Deviation for Self-Regulated Learning and Critical Analysis Measures between Groups

Scale	Experimental		Control	
	Time 1	Time 3	Time 1	Time 3
Self-Motivation Beliefs				
Self-efficacy	3.13(0.65)	3.38(0.58)	3.29(0.56)	3.42(0.30)
Intrinsic goal orientation	3.59(0.92)	3.84(0.74)	3.88(0.47)	3.92(0.38)
Extrinsic goal orientation	3.00(1.04)	3.28(1.05)	3.17(0.49)	3.13(0.61)
Task-related motivational beliefs	3.94(0.44)	4.15(0.41)	4.19(0.32)	4.22(0.31)
Self-Judgment				
Self-evaluation	3.04(0.72)	3.75(0.68)	3.50(0.46)	3.72(0.39)
Self-Reaction				
Self-satisfaction	2.97(0.71)	3.81(0.62)	3.42(0.34)	3.71(0.53)
SRL composite score	3.41(0.43)	3.78(0.38)	3.68(0.28)	3.78(0.22)
Critical Analysis	20.00(4.04)	19.38(1.92)	20.42(3.58)	18.83(3.20)

Table 4.2

Cronbach's Alpha for Self-Regulated Learning Measures

Scale	Time 1	Time 3
Self-Motivation Beliefs		
Self-efficacy	.73	.69
Intrinsic goal orientation	.81	.73
Extrinsic goal orientation	.71	.88
Task-related motivational beliefs	.60	.71
Self-Judgment		
Self-evaluation	.82	.70
Self-Reaction		
Self-satisfaction	.80	.76

As indicated in Table 4.2, the Cronbach's alpha for the Self-Motivation Beliefs, Self-Judgment, and Self-Reaction scales were reasonable, the majority being above .70, showing good internal consistency. The exception to this was the Task-Related Motivational Beliefs subscale in Time 1 (.60), in which there was more variability in students' responses. In Time 3, however, the Cronbach's alpha for that subscale increased to .71. In order to ascertain whether each subscale score obtained from Time 1 was linearly related to each subscale score obtained from Time 3, a test-retest reliability method was employed. The results are shown in Table 4.3.

Table 4.3

Test-Retest Reliability for Self-Regulated Learning Measures

Scale	Coefficient	*p*
Self-Motivation Beliefs		
Self-efficacy	.55	.044
Intrinsic goal orientation	.78	.001
Extrinsic goal orientation	.81	.001
Task-related motivational beliefs	.67	.008
Self-Judgment		
Self-evaluation	.45	.109
Self-Reaction		
Self-satisfaction	.28	.327

The test-retest reliability of each subscale in Table 4.3 ranged from .28 to .81, and was particularly low for the self-efficacy, self-evaluation, and self-satisfaction subscales. One possible explanation for the low reliability coefficient for these subscales when measured in Time 1 and in Time 3 is that they measured either participants' beliefs about their capability to successfully carry out the necessary tasks to reach specific goals (Bandura, 1997) or their perceptions or judgments about their performance after accomplishing the tasks. These self-reflections were quite often influenced by task difficulty, participants' emotions and feelings, and the carryover effect (Allen & Yen, 1979), meaning learners' prior experiences related to the tasks at hand; as a result, there was a discrepancy between the test scores obtained in Time 1 and Time 3. Despite this discrepancy in the areas mentioned above, the test-retest reliability of the total scores measured in Time 1 and Time 3 is .72, meaning that there is evidence for the reliability of the self-report instruments used to measure students' self-regulated learning.

The results of the reliability analyses indicated that the internal consistency of the self-regulated learning questionnaire used in this study is substantial. Given this finding, for each student the researcher computed a composite score that consisted of scores from all subscales for Time 1 (pre-test) and another composite score for Time 3 (post-test). The mean and the standard deviation for Time 1 and Time 3 are presented in Table 4.1.

Research Question 1

The first research question, "Is self-regulated learning related to medical students' critical analysis performance?" explored the relationship between self-regulated learning and performance in medical journal clubs. Participants' self-regulated learning was the predictor and their critical analysis skills were seen as performance or outcome. The hypothesis for this research question was that participants' self-regulated learning scores would be positively related to their post-test critical analysis performance.

A 2-step hierarchical regression method was used to assess the hypothesized relationship between participants' self-regulatory skills and their critical appraisal performances. When participants' critical appraisal pre-test scores, the control variable, were entered into the regression equation in Step 1, the resulting R^2 was only .05. When participants' self-regulated learning pre- and post-test scores were also included in the analysis in Step 2, the R^2 increased to .21. The increment in R^2 was .16, $F(3, 10) = .88$, $p = .48$. Thus, neither participants' critical analysis pre-test scores nor their self-regulated learning scores (pre-test or post-test) significantly predicted their critical analysis post-test scores. The summary of the hierarchical regression analysis is presented in Table 4.4.

Table 4.4

Summary of Hierarchical Regression Analysis for Variables Predicting Medical Undergraduate Students' Critical Analysis Performance (N = 14)

Variable	*B*	*SE B*	β
Step 1			
Critical analysis (pre-test)	-0.15	0.19	-0.23
Step 2			
Critical analysis (pre-test)	-0.06	0.26	-0.09
Self-regulated learning (pre-test)	-1.00	2.70	-0.16
Self-regulated learning (post-test)	-2.35	3.00	-0.30

Note. R^2 = .05 for step 1; ΔR^2 = .21 for step 2.

Research Question 2

With a goal of understanding the influence of computer-supported collaborative learning on self-regulated learning skills in medical settings, the second research question was, "Does participation in computer-supported collaborative learning influence self-regulatory processes?" Students in this study were randomly assigned to one of two learning conditions, either a computer-supported collaborative learning environment or an individual learning environment. The learning condition was the predictor, and participants' self-reported post-test self-regulatory skills were viewed as the outcome. The hypothesis for the second research question was that students in a computer-supported collaborative learning condition (the experimental group) would obtain higher scores than would their individual learning condition counterparts (the control group) when measured for self-regulatory skills in the post-test.

To answer the second research question, a 2-step hierarchical regression technique was employed to test if participants' learning conditions significantly predicted their self-regulatory skills. In the first step, participants' self-regulated learning pre-test scores, the control variable, were entered into the regression equation, with a resulting R^2 of .44. In the second step, participants' learning conditions were also included in the analysis, with a resulting R^2 of .51. The addition of this variable in Step 2 resulted in an increment in R^2 of .07, $F(2, 11) = 5.69$, $p < .05$. As is shown in the summary of the analysis in Table 4.5, however, the learning condition had a coefficient that did not differ significantly from zero, $\beta = .29$, $t(11) = 1.26$, $p = .23$, indicating that participants' learning condition was not a significant predictor in the hierarchical regression analysis.

Table 4.5

Summary of Hierarchical Regression Analysis for Variables Predicting Medical Undergraduate Students' Self-Regulated Learning Skills (N = 14)

Variable	*B*	*SE B*	β
Step 1			
Self-regulated learning (pre-test)	.53	.17	.66*
Step 2			
Self-regulated learning (pre-test)	.62	.18	.77**
Condition	.17	.14	.29

Note. $R^2 = .44$ for step 1; $\Delta R^2 = .51$ for step 2 (ps < .05).

*$p < .05$. **$p < .01$.

In order to explore how students self-regulated in the computer-supported collaborative learning environment, the six small group discussions from the experimental group were analyzed. The goal was to determine the types and frequency of self-regulated learning strategies participants demonstrated while engaging in the computer-supported collaborative learning. The findings from the qualitative analysis are presented below.

Self-regulated learning strategies. The 1740 utterances produced by participants were coded in order to determine the degree to which individuals used self-regulatory strategies in their interaction. A total number of 388 utterances (22%) were coded as demonstrations of participants' self-regulated learning strategies, and the categories are as follows: Monitoring, Control, Reflection and Reaction, and Planning. A breakdown of the frequency of self-regulated learning strategies occurring in the group discussions is presented in Table 4.6.

Table 4.6

Frequency of Self-Regulated Learning Strategies Demonstrated in Group Discussions

Frequency	Monitoring	Control	Reflection and reaction	Planning
Number of utterances	177	45	124	42
Percentage of total	45%	12%	32%	11%

As indicated in the table, the self-regulated learning strategy demonstrated the most frequently by participants was Monitoring. The monitoring occurred on several levels, among them the (meta)cognitive level. This consisted primarily of individuals demonstrating their knowledge and understanding of the subject matter at hand (and, more often than not, the lack thereof) while they were reading the articles (e.g., "I had difficulty identifying, some of the questions that were asked in the questionnaire, like, um, 'Did they clearly outline all the variables?' I didn't really know what that meant. . ."). Participants also engaged in motivational monitoring during their interactions, occasionally questioning the purpose of completing the reading tasks (which, nonetheless, they did indeed carry out) (e.g., "I just wish I could think of, I'm not gonna remember any of this stuff, so why am I reading?"). Students also demonstrated behavioural monitoring during the discussions, making observations about their reading approaches as they carried out the tasks (e.g., "…when I highlight, I highlight everything, that, because when I read, I only read what I highlight…").

The second most frequently occurring self-regulatory strategy shown during students' discussions was Reflection and Reaction. Participants frequently reflected upon and reacted to their accomplishments, one example of this being that some pairs occasionally evaluated their own performance while completing the tasks at hand (e.g., "No, That's good. Well said!"). On occasion, learners also attributed their difficulties to specific causes, showing satisfaction regarding their performance on the reading tasks (e.g., "…I had to read a few times the dosages and administration and the, the actual set-up of the, of the study. But, maybe that's just because it's numbers and I wasn't paying attention."). Also important is the fact that participants frequently expressed both positive and negative emotions during the interventions (e.g., "I found that interesting. I didn't know that.", "…it's kind of lost on me…"). Finally, through reflection, on rare occasions students also evaluated their self-regulatory approach and considered alternatives (e.g., "…because I was also answering the questions as I was reading the article, and I think that was kind of a bad.").

The third most commonly occurring self-regulated learning strategy was Control, meaning that only on occasion did students attempt to direct and control their own learning while reading the articles. This took the form of participants sometimes telling themselves how to proceed while they completed the readings (e.g., "…I'm not gonna remember this necessarily, but I'm gonna remember the end result, but to get to the end result, you have to have read this. Because otherwise it doesn't make sense, you know what I mean?..."). It also involved learners occasionally concentrating and screening out both unimportant information in the articles and external events, stating strategies used when completing the reading tasks (e.g., "…something I had to read a few times, well, maybe that's just because it's, I wasn't paying attention well…"), and engaging in help-seeking either through asking questions to partners or searching for information online (e.g., "Wikipedia…").

The self-regulatory strategy that learners demonstrated the least frequently was Planning, meaning that only rarely did individuals engage in planning for their clinical practice through applying what they had learned during the intervention. In tangible terms, this means that they discussed the scope that would be involved when reading around their future patients (e.g., "…if I'm looking up something specific, then yes, I would make a PICO, but if I'm looking up general information, then I'll, I probably am not gonna go on PubMed; I'll probably go on UpToDate…"). They also broached the matter of selecting specific strategies for reading around their patients in their eventual clerkship (e.g., "I don't know very much about it, so I'd like start with, like, textbook level stuff, and like just learn what it is…and then…").

Research Question 3

The objective of this research question was to examine the relationship between computer-supported collaborative learning and learners' use of annotation tools by asking, "Does participation in computer-supported collaborative learning influence the use of annotation tools?" Process data of participants' reading activities were analyzed in order to compare the use of annotation tools across the two groups. These reading activities were carried out using the Adobe Acrobat 9 Professional software, and this software provided 13 annotation tools for participants to use while reading. The number of annotation tools used by participants in the experimental group ranged from 0 to 7 (pre-test) and 1 to 5 (post-test), while the range was from 1 to 4 for both pre-test and post-test in the control group. The number of annotation tools used by the two groups is shown in Table 4.7.

Table 4.7

Number of Annotation Tools Used by Groups

Group	Time 1 *M*(*SD*)	Time 3 *M*(*SD*)
Experimental group[a]	3.25(2.19)	2.00(1.60)
Control group[b]	2.33(1.37)	2.50(1.38)

Note. Annotation tools include the highlight, underline, cross out, cloud, arrow, line, rectangle, oval, pencil, symbol, sticky note, callout, and text box features.

[a]n = 8. [b]n = 6.

A 2 x 2 repeated measure ANOVA with measure time (Time 1, Time 3) as within-subjects factors and group (experimental group, control group) as between-subjects factors revealed no significant main effect of measure time, $F(1, 12) = 2.38$. $p = .149$, no significant main effect of group, $F(1, 12) = 0.06$, $p = .812$, and no significant interaction between group and measure time, $F(1, 12) = 4.06$, $p = .067$.

An examination of the mean number of annotation tools used by learners showed that most students in both groups used only a handful of annotation tools (as indicated in Table 4.7). The mean number of tools used by participants in the experimental group decreased from pre-test ($M = 3.25$) to post-test ($M = 2.00$), while the use of tools by their control group counterparts increased marginally over the same period ($M = 2.33$ for pre-test; $M = 2.50$ for post-test).

Consideration was also given to the frequency with which participants used these annotation tools. In order to obtain a clear picture of the use of the various tools by participants in Time 1 (pre-test) and Time 3 (post-test), the researcher took into account the characteristics of the 13 tools and divided them into three categories: Highlighting tools, Symbol tools, and Note-taking tools. This combining approach was taken because some of the annotation tools were seldom used by participants or not used at all. A frequency breakdown illustrating the use of different categories of annotation tools by the experimental and control groups is presented in Table 4.8.

Table 4.8

Frequency of Types of Annotation Tools Used by Groups

Type	Experimental group[a]		Control group[b]	
	Time 1 *M*(*SD*)	Time 3 *M*(*SD*)	Time 1 *M*(*SD*)	Time 3 *M*(*SD*)
Highlighting tools	35.75(35.68)	40.63(16.41)	45.17(33.43)	43.00(13.87)
Symbol tools	5.25(7.89)	2.38(6.32)	1.17(1.47)	0.67(0.52)
Note-taking tools	2.25(3.88)	1.50(2.98)	3.17(4.31)	0.67(1.03)

Note. Highlighting tools include the highlight, underline, and cross out features. Symbol tools include the cloud, arrow, line, rectangle, oval, pencil, and symbol features. Note-taking tools include the sticky note, callout, and text box features.

[a]n = 8. [b]n = 6.

A 2 x 3 x 2 repeated measure ANOVA with measure time (Time 1, Time 3) and type of tool used (highlighting tools, symbol tools, note-taking tools) as within-subjects factors and group (experimental group, control group) as between-subjects factors showed a significant main effect of type of tool used, $F(2, 12) = 35.77$, $p < .001$, but the predicted main effect of group was not significant, $F(1, 12) = 0.05$, $p = .832$. Also, the predicted interactions between group and type of tool used, $F(2, 12) = 0.35$, $p = .706$, and interaction among group, measure time, and type of tool used, $F(2, 12) = 0.41$, $p = .668$, were not significant. All other main effects and interactions were non-significant and irrelevant to the research question, all $F \leq 0.22$, $p \geq .663$.

Post-hoc analyses using Tukey's HSD indicated that highlighting tools were more frequently used than symbol tools ($p < .01$) and note-taking tools ($p < .01$) in both experimental and control groups. Moreover, there was no significant difference between the use of symbol tools and note-taking tools (p = .68) across the two groups. An examination of the means in Table 4.8, however, indicates that in the experimental group, symbol tools were used slightly more frequently than note-taking tools, while in the control group, note-taking tools were used slightly more often than symbol tools.

Research Question 4

To answer the fourth research question, “Does computer-supported collaborative learning influence individuals’ self-regulated learning in terms of the development of critical analysis?” a simple mediation analysis was performed to examine the hypothesized causal sequence among the three main constructs, namely computer-supported collaborative learning, self-regulated learning, and critical analysis.

In the mediation analysis, the predictor (IV) was participants’ learning conditions, the mediator (M) was the self-regulated learning post-test scores, the criterion (DV) was the critical analysis post-test scores, and the pre-test scores for critical analysis and for self-regulated learning were the covariates. Because the sample size of this research was relatively small, to meet the assumption of normality of the sampling distribution of the total and specific indirect effects, the SPSS version of macro (Preacher & Hayes, 2008) was used to bootstrap the indirect effect of learning condition on critical analysis performance. The macro generated a 95% bias-corrected and accelerated bootstrap confidence interval based on 5000 bootstrap samples (-24.6372 to 0.2065, with a point estimate of -0.4969) for the indirect effect (*ab path*), indicating that participants’ self-regulated learning was not a significant mediator of the relationship between their learning condition and critical analysis. Similarly, the results of the analysis indicated that the paths from learning condition to self-regulated learning (*a path* = 0.1901, p = .2112), and from self-regulated learning to critical analysis controlling for learning condition (*b path* = -2.6144, p = .4640), were not significant. The results are presented in Table 4.9.

Table 4.9

Point Estimates and Standard Errors (SEs) from Simple Mediation Analysis Assessing Hypothesized Causal Sequence among Learning Condition, Self-Regulated Learning and Critical Analysis

Effect	Point estimate	*SE*
Effect of IV on M (*a path*)	0.1901	0.1423
Effect of M on DV (*b path*)	-2.6144	3.4189
Direct effect of IV on DV (*c' path*)	0.3378	1.6696
Indirect effect of IV on DV through M (*ab path*)	-0.4969	1.2673
Total effect of IV on DV (*c path*)	-0.1590	1.5057

Note. IV = learning condition; M = self-regulated learning; DV = critical analysis.

To explore students' involvement in the computer-supported collaborative learning environment, the small group discussions from the experimental group were analyzed. The goal was to determine: (1) the types of co-regulation in which learners engaged, and (2) the types and frequency of critical analysis skills demonstrated by learners. The findings from these qualitative analyses are presented below.

Co-regulation and content processing. To understand what types of regulation learners demonstrated while working collaboratively with their partners, the small group discussions were divided into 99 segments, and were coded into the following categories: Low-level co-regulation, High-level co-regulation, Low-level individual regulation, High-level individual regulation, Difficulties, Reading strategies, and Commentary on article. These categories were taken from the theoretical framework developed by Volet et al. (2009) that examines the relationship between social regulation (co-regulation as a group or individual regulation within group) and level of content processing (high or low). An account of the frequency of the different types of regulation is displayed in Table 4.10.

Table 4.10

Frequency of Types of Regulation Displayed in Group Verbal Interactions

Frequency	Co-regulation		Individual regulation		Others		
	Low	High	Low	High	DIF	RS	COM
Number of segments	33	22	10	15	11	6	2
Percentage of total	34%	22%	10%	15%	11%	6%	2%

Note. DIF = difficulties; RS = reading strategies; COM = commentary on article.

As shown in the table, the type of regulation engaged in the most frequently by participants was low-level co-regulation. An example of this type of regulation is as follows:

Example 1: Group 4, second meeting (00:34 - 00:47)

Anna: Okay, each variable in the study well defined? Yes.
Carmen: Yeah.
Martha: Yeah, I thought so.

Anna: Yes.

Carmen: I put “yes” for everything.

Martha: Yeah, me too.

Carmen: Just for one. . .

Anna: Oh!

Carmen: . . .I put “I don’ know,” because I didn’t read it.

Anna: Yeah. I also put something for I don’t know. Okay. Thr…three, yes, the research design was appropriate. Yes.

Martha: Uh-huh.

As shown in the example, Anna, Carmen and Martha spent a substantial amount of time attempting to understand and clarify information from the articles they read. During this interaction, their turns were relatively short and verbal participation was quite equal; as a result, they did not have the opportunity to co-construct knowledge.

The second most frequently occurring type of regulation engaged in by students was high-level co-regulation. This is exemplified by the following:

Example 2: Group 2, first meeting (08:49 - 11:33)

Polly: Um…do, do, what clinical question can this article help you answer? How and why did you choose that clinical question?

Bill: What can save my patients?

Polly: Yeah, it’s basically, uh, how can you improve the standard regimen. How can you decrease your patient’s, uh, how can you improve your patient’s outcome?

Bill: Yeah, exactly, and, I mean, there’s, there’s a lot of medication that can, uh, potentially, uh, de…uh, improve the symptoms of patients with congestive heart failure, but at the end of the day, you want to know what drug will actually decrease the mortality in these patients, and not just, uh, uh, improve like blood pressure. . .

Polly: Yeah.

Bill: . . .and, uh, like, the volume of the patient, or whatever.

…

As demonstrated in the example above, Polly and Bill made relatively equal verbal contributions as they constructed knowledge together. As they interacted in this manner, they were involved in the reasoning process, linking ideas, and applying information they gleaned from the article to their future clerkship and clinical practice.

The third most commonly occurring type of regulation in participants' collaboration was high-level individual regulation. One example of this is:

Example 3: Group 1, second meeting (44:51 - 46:37)

Karen: Okay, so are we supposed to do it now, or are we supposed to. . .

Thomas: Oh, this was the only other thing that I found interesting was that, the no significant differences section. No significant difference between the two groups in the median length of stay, but I guess these things don't matter because the end is death, you know? Like, no, no difference in stay in the ICU or hospital. Uh, number of patients, single, yeah, so no difference between the control, whatever, between, for new single or multiple organ failure.

Karen: So what's re…just death. They don't know why.

Thomas: Well, yeah. Because you don't stay in hospital longer, the number of new organ failures is the same, uh, no significant difference in days on mechanical ventilation, renal-replacement or the rates of positive blood cultures and red-cell transfusion. You don't see the difference between operative versus non-operative, those with, without diabetes, those with or without severe sepsis…

Karen: What, what does that mean, with or without diabetes? Is, what would the point be? I thought all these patients. . .

Thomas: No, because you can, you give Insulin. Insulin therapy is for a diabetic or non-diabetic, because no matter, in an acutely ill patient, you have this regulation of your glucose, so you have to control it, whether or not you're diabetic, probably more tightly controlled if you're diabetic, or more, yeah, more important to control it. So, you want to, you want to…

As indicated in the example, for the duration of Karen and Thomas' exchange, Thomas typically assumed an instructive role, elaborating upon and explaining ideas from the article to help Karen construct knowledge.

The least frequently occurring type of regulation engaged in by learners was low-level individual regulation. A case in point is:

Example 4: Group 2, second meeting (05:11 - 05:23)

Bill: Okay, so basically they say that the conclusion intensive blood glucose control increases the mortality of patients, versus regular control.
Polly: Yeah.
[Bill and Polly reading quietly]

As shown above, during their discussion, Bill and Polly did not demonstrate the construction of knowledge nor did they show active "meaning making." Instead, Bill read the article word-for-word, and expressed the straightforward, fundamental meaning of information in the article without building upon it in any way.

Along with engaging in the various forms of regulation outlined above, during their discussions participants also demonstrated other forms of discourse as they interacted. On several occasions, participants shared with each other the difficulties they encountered while completing the readings. More specifically, they typically made mention of the challenges they faced when attempting to make sense of the research methods and statistics presented in the articles and when answering the questions in the critical appraisal checklists. A handful of times, participants also shared the strategies they employed when reading the articles. They discussed matters such as the use of annotation tools, the importance of understanding the "big picture" when completing a reading, and paragraph structure. Finally, once each, two group of students provided general commentary on the second article they read, broaching issues such as the degree of challenge presented by each reading.

Critical analysis skills. All of the utterances produced by students in their interactions were coded with the goal of understanding the types and frequency of critical analysis skills shown by participants while engaging in computer-supported collaborative learning. A total of 349 (21%) of 1740 utterances were coded as indications of learners' critical analysis skills, and the categories are as follows: Understanding, Analyzing, Evaluating, and Applying. An account of the occurrence of critical analysis skills demonstrated in group-verbal interactions is presented in Table 4.11.

Table 4.11

Frequency of Critical Analysis Skills Displayed in Group Verbal Interactions

Frequency	Understanding	Analyzing	Evaluating	Applying
Number of utterances	158	106	77	8
Percentage of total	46%	30%	22%	2%

Of the four skills involved in critical analysis, as shown in the table, participants spent the lion's share of their time trying to come to an understanding of the material they had read. In doing so, they created a number of summaries and explanations of the main ideas and results of the studies carried out in the articles (e.g., "…I kind of got a big picture from it, not really too much specific, just, like, uh, what aldosterone does, how spironolactone works in conjunction with ACE inhibitors, and, uh, how it affects the, the specific population that was being studied…"). Students also analyzed the material with which they were working as they assessed and interpreted the evidence presented in the studies (e.g., "…So the observation for death in the intensive control is 1.14. Okay. The median survival time was lower in the intensive… Mmm. Do you want to believe that though, 1.01 to 1.23? 1.02, uh, I didn't notice that at first. That's not a very large [Unintelligible] or not a very good one. It approaches 1."). Moreover, learners sometimes carried out evaluations as they critiqued the strengths and weaknesses of the studies written up in the articles they were reading, focusing on issues such as sample size, randomization, methods, and follow-up (e.g., "I guess it wasn't really bias-free thought because they, they were thinking, patients who they thought would spend 3 days or more in the ICU, so they had to, like, judge whether or not they thought the patients would be…"). Finally, on rare occasion students applied the results of the studies to their own work, citing concrete ways in which they would use information gleaned from the articles to provide better patient care in their future clerkships (e.g., "Well, first, heart failure is really bad, and we need to choose something that we can add to the treatment.").

Research Question 5

This research question, "What is the nature of group dynamics as students engage in self-regulated learning in a computer-supported collaborative learning environment?" explored the interactions within small groups as learners self-regulated in a technology-supported collaborative setting. All of the utterances generated by learners during the discussions were coded (in some cases more than once) with the objective of identifying the nature of the communication used by participants while interacting with each other during the collaborative tasks. A total number of 2320 utterances were coded as evidence of students' communicative activity patterns, and the categories are as follows: Informative, Argumentative, Elicitative, Responsive, Directive, and Off task. A breakdown of the frequency of communicative activities demonstrated in group discussions is presented in Table 4.12.

Table 4.12

Frequency of Communicative Activity Patterns Demonstrated in Group Discussions

Frequency	Informative	Argumentative	Elicitative	Responsive	Directive
Number of utterances	572	551	314	709	96
Percentage of total	25%	24%	13%	31%	4%

Note. 78 utterances (3%) were coded as Off task and were not included in the table.

As indicated in the table above, of the six communicative activity categories, the most frequently occurring among participants was the Responsive, followed by the Informative category. The Argumentative category was the next most commonly occurring communicative activity pattern, while the category that occurred the fourth most frequently was the Elicitative. Finally, the Directive and Off task categories appeared the least frequently in student discourse. An example of these communicative activity patterns as they occurred within the context of one particular group discussion is provided in the section below, the sample coming from the Day 2 discussion of group 4. The sample is made up of both discourse from the group discussion and commentary thereon, each element of the discourse identified as belonging to a particular communicative activity category.

The three group members in question were Anna, Martha, and Carmen. Anna was a 22-year-old graduate of the Health Sciences Program at the CEGEP level, and had no formal training in research methods and statistics. She had no experience conducting research and reading research articles, and had little or no confidence in her ability to assess published articles. Martha was a 24-year-old with a B.Sc. in Kinesiology. She had received training in both research methods and statistics, and had a little experience in conducting research but almost no experience in reading journal articles. Her confidence level as regards assessing published articles was relatively low. Carmen was a 21-year-old who, like Anna, was a graduate of Health Sciences at the CEGEP level. She had no training in research methods, and had only a little training in statistics. She had no experience in conducting research and reading journal articles. As a result, she had little or no confidence in her ability to assess published articles.

At the beginning of the Day 2 collaboration, Anna, Martha, and Carmen decided to read and annotate the assigned article separately, then to work together to complete the Critical Appraisal Checklist and the one-page report related to the article. Having completed the reading, the three group members met at the Apple lab and began to silently fill out the checklist. Their discussion started once Anna, Martha, and Carmen had finished filling out the document in question and proceeded to compare their answers for the various items.

The discussion began with participants taking out their checklists and looking at the first item:

Excerpt 1

Anna: First question: What are the aims of the research? (Elicitative)
Martha: We had to see if tight glus…glucose control is better than conventional. . . (Informative)

Carmen: Indeed! (Responsive)
Martha: . . .uh, in adult patients in the ICU. . . (Informative)
Carmen: Yeah. (Responsive)
Anna: Right. (Responsive)
Martha: . . .at preventing death, because that was the primary outcome, right? (Informative, Elicitative)
Anna: I put "yeah." (Informative)
Carmen: Yeah. (Responsive)
Anna: Yeah. Okay. That's it. (Responsive, Directive)
Carmen: That's exactly it. (Responsive)

Anna asked her teammates what they considered to be the aim of the article they had just finished reading. Martha offered an opinion that both Anna and Carmen agreed with. Exactly the same scenario played out as the group members discussed whether or not the variables in the study were well defined, all three members agreeing in the affirmative.

The trio then turned their attention to the next topic on the checklist, the matter of whether or not the study reported in the article was bias-free:

Excerpt 2

Carmen: I think, I think it was bias-free, but, like, yeah, I didn't really, yeah. Okay, well let's say it's bias-free, because I didn't read it, I didn't see like. . . (Informative, Argumentative)
Martha: I guess it wasn't really bias-free though because they, they were thinking, patients who they thought would spend 3 days or more in the ICU, so they had to, like, judge whether or not they thought the patients would be. . . (Informative, Argumentative)
…
Martha: Or they could just, it just means, like, selection bias. (Argumentative)
Carmen: The choice of population. (Argumentative)
Anna: Oh… (Responsive)
Martha: Yeah, choice of patients. (Responsive)
Anna: Oh! (Responsive)

Martha: Because if they didn't want a patient, they could, they could, think that the patient wouldn't be in there for more than 3 days and kick them out. (Argumentative)

Anna: Okay, okay. So I put "no" then. (Responsive, Informative)

Martha: I guess so. (Responsive)

Anna: Yeah. (Responsive)

Carmen initially stated her opinion that the study was indeed without bias, but Martha quickly countered her assertion. Over the next few minutes, the group discussed the matter as Martha explained her point of view. Carmen and Anna questioned Martha on her perspective as she stated her case, and gradually came to accept her point of view, thereby reaching a consensus.

The group members next examined a series of sample-related questions pertaining to the study. Anna asked the questions and all three students reached an immediate consensus on each of the items. Precisely the same dynamic played out as Anna, Martha, and Carmen discussed the data collection methods used in the study.

The three students then moved on to a discussion of the follow-up by medical professionals of the participants in the study:

Excerpt 3

…

Martha: I don't know how. . . (Argumentative)

Anna: Exactly. (Responsive)

Martha: . . .but I think they did. [Looking for the information in the article] (Argumentative)

Anna: So, exactly, so I don't know the, I know they were followed, they were followed, but then I don't know they were followed the same way, because article doesn't say how. . . (Responsive, Argumentative)

Martha: That's true. (Responsive)

Anna: . . . the, the [Unintelligible] patients… (Argumentative)

Carmen: Do they, well, depends, do they say that equal, there's about equally amount of people who left in each group, or, if it's like, you know what I mean? If, um, like, so many people left in the control group, and then only a little people left in the. . . (Elicitative, Argumentative)

…

Martha: And then they were followed in the same way. (Argumentative)

Anna: They were followed, but I don't know in the same way, because it, it doesn't say how they were followed. (Argumentative)

…

Martha: I think they were. (Informative)

Carmen: Yeah. (Responsive)

Martha: Even if we don't know how, I'm sure they weren't done differently. (Argumentative)

Anna: Okay. I would still c…stay with "I don't know". . . (Responsive, Informative)

Martha: Okay. (Responsive)

Anna: . . .just because it doesn't ex…explicitly, explicitly explain. (Argumentative)

Anna introduced the topic, and it soon came to light that her view of the matter differed from the perspective of Martha and Carmen. The issue was not simply one of whether or not the two groups of patients in the study were both followed up, but whether they were followed up in the same way. They discussed the matter back and forth for several minutes, alternately explaining their points of view and countering each other's arguments. At the end of the exchange, no consensus had been reached.

The three group members then examined the data collection process used in the study and also discussed instrument-related questions pertaining to the research. In all cases, Anna, Carmen, and Martha were in agreement and reached an instant consensus. The same can be said of their discussion of the clarity of the data collection methods and statistical techniques used in the study, all three students agreeing that their limited knowledge of statistics was a handicap as they attempted to interpret the statistics presented in the research. They were similarly in agreement regarding their consideration of the results of the study.

Martha then read the next question on the checklist related to whether or not the researchers drew reasonable implications for theory from their findings:

Excerpt 4

Martha: Draw reasonable implications for theory? I said no. They said, like, maybe Insulin increases cardiovascular. . . (Elicitative, Informative, Argumentative)

Anna: Yeah. (Responsive)

Martha: . . .but we don’t know. Like, I didn’t think that was. . . (Argumentative, Informative)

Carmen: Mm-hmm. (Responsive)

Anna: I thought that was . . . (Informative)

Martha: . . .really a theory. (Informative)

Anna: I thought that was for theory. It’s the implication for a theory. (Informative, Argumentative)

Martha: Implication for the, yeah, I guess. (Responsive)

Anna: Very vague. They’re speculating some. . . (Informative, Argumentative)

Carmen: I put “don’t know.” (Informative)

Martha and Anna disagreed on the matter and discussed it for a short time, each explaining her point of view. At the end of the exchange, all three students reached a consensus on the subject, agreeing with Martha’s perspective.

Anna, Martha, and Carmen then discussed whether the study included practical implications and suggestions for future areas of research, Anna reading the question. Carmen answered in the affirmative, and her two team members quickly echoed her point of view, reaching an immediate consensus in the affirmative. A similar agreement was then reached regarding how well the results answered the research questions, all participants again agreeing in the affirmative.

The three students then set about discussing the strengths and weaknesses of the research:

Excerpt 5

Carmen: I put it's a large study. There were, like, six, six thousand people, so. . . (Informative, Argumentative)

Anna: Okay. (Responsive)

Carmen: . . .so, like a large number of participants. (Argumentative)

Martha: I, I put size as well. (Responsive)

Anna: I c…., I thought the, the methods were clear. (Informative)

Martha: That's true. It was easy to read. Like, it was easy to follow. (Responsive, Informative, Argumentative)

…

Anna: Okay. What other weaknesses or strengths? (Elicitative)

Martha: Um, I said the weakness, that it wasn't confirmed the same way for every patient. (Informative)

Anna: The hypoglycemia? (Elicitative)

Martha: Yeah. (Responsive)

Anna: Okay. (Responsive)

Martha: Um, I also thought that, like, they were only, like it followed them for 90 days, but they were only on the treatment protocol for, like, 4 days, so, I thought that was kind of. . . (Informative, Argumentative)

Carmen: Oh, really? [Unintelligible]… (Elicitative)

Martha: . . .slow. Like, they were only in the ICU under that glucose control for 4 days. . . (Argumentative)

Carmen: Yeah. (Responsive)

Anna: Did it say somewhere? (Elicitative)

Martha: . . .on average. Yeah. (Argumentative, Responsive)

…

Anna: Okay, so how would you improve these weaknesses? Well, we can't really double-blind. We. . . (Elicitative, Informative)

Martha: [Looking for the information in the article] No. (Responsive)

Anna: . . .we can't. Hypoglycemia, they could be confirmed, like, lab for everybody. (Informative, Argumentative)

Martha: Yeah. That's the only thing I put, really. [Continuing to look for the information in the article] That was reasonable. . . (Responsive, Informative, Argumentative)

Carmen: What did you put for the hyp…the…short…hypoglycemia not confirmed in the same way for every patient. Okay. (Elicitative, Informative, Responsive)

Anna: Okay. (Responsive)

The students shared their ideas as to the strengths of the research, Carmen and Anna identifying some of the strengths they had noted; all three teammates agreed with the ideas that were voiced. As they moved on to the weaknesses in the study, the matter of patient follow-up and treatment protocol arose. Martha was instrumental in explaining and clarifying much of the information related to the topic, making the case that this was a weak point in the research. By the end of the exchange, Carmen and Anna came to agree with Martha's perspective on the matter. On a related topic, as the group members discussed the ways in which the weaknesses could be improved upon, they were in complete agreement.

The participants then discussed how the study's findings could be applied to their own practice:

Excerpt 6

Anna: Okay. And how would you use the results of the study in your own practice? (Elicitative)

Martha: Use conventional glucose control… [Laughs] (Informative)

Carmen: Yeah. (Responsive)

Anna: Yeah. That's what I said. Yay! [Laughs] (Responsive)

Martha immediately stated that she would apply the study's primary findings to her own practice in the future. This assumption was immediately confirmed by her two colleagues. Similarly, Anna's assertion that the article was much easier to read than the first one was immediately backed up by Carmen and Martha.

The students then turned their attention to the one-page report, Anna volunteering to type the document for the group:

Excerpt 7

Anna: Having read this article, what did you get out of it? (Elicitative)
Martha: That… (Informative)
Carmen: That, that what we learned, the conclusion there. (Informative)
Martha: Yeah, that, uh, tight glucose control is not recommended for adult patients in the ICU versus conventional glucose control. (Responsive, Informative)
Anna: Uh… (Responsive)
Martha: I think that's it. (Informative)
Carmen: Yeah. That's the main thing I got out of it. (Responsive, Informative)
…
Anna: Okay. Uh, what did, did, did, what did you have difficulty understanding in the article? The statistics! The statistics! (Responsive, Elicitative, Informative)
Martha: Yeah. [Laughs] (Responsive)
Carmen: Yeah, statistics, techniques. . . (Responsive)
…
Martha: I guess the clinical question would be, like, when to start Insulin, sort of, like… (Informative)
Anna: It's, uh, the, well, my clinical question was, does intensive glucose control decrease mortality? (Informative)
Martha: Yeah, that's good. (Responsive, Argumentative)
…
Martha: Well, yeah, like, when, when should you start and stop Insulin? (Responsive, Argumentative)
Anna: Ah. (Responsive)
Martha: Sort of. Like how, you know what I mean? How do you control it, because they, like, started it when glucose went above a number. . .

(Responsive, Elicitative, Argumentative)

Anna: Ah, and stopped. . . (Responsive, Informative)

Martha: . . .and stopped it. You know what I mean? (Responsive, Elicitative)

Anna: Yeah. (Responsive)

When considering what they had gotten out of the article, Martha was the first to offer an opinion on the matter; Anna and Carmen agreed with her answer. On a related note, Anna pointed out the most difficult aspect of the article and was supported wholeheartedly by Carmen and Martha. A second answer provided by Martha likewise met with agreement from her two colleagues. Similarly, when identifying the clinical question that the article could help them answer, Anna and Martha's proposals were agreed upon by all members of the group.

The collaboration concluded with Anna, Martha, and Carmen considering how they will read around their patients once they begin their clerkships:

Excerpt 8

Carmen: When you start your clerkship, how will you read around your patients? (Elicitative)

Anna: I don't know! (Informative)

Carmen: I still don't know. (Informative)

Martha: Yeah, and… (Responsive)

Carmen: We still don't know. (Responsive)

Anna immediately asserted that she could not answer the question. Carmen and Martha strongly agreed with and supported Anna's point of view, likewise stating that they did not know how this would transpire.

Reflections upon Computer-Supported Collaborative Learning Experience

After having participated in computer-supported collaborative learning, students in the experimental group individually completed four questions on the Collaboration Feedback Sheet to reflect on their learning experiences. Participants filled this sheet out twice, at the end of both Day 1 and Day 2 of the training. On Day 1, learners filled out the feedback sheet after they read the article separately (pre-test) and met to write a one-page report on the article. On Day 2, the feedback sheet was completed after participants sat together to read the article (with the option of doing so together or separately), discussed the article, completed the Critical Appraisal Checklist as a team then discussed it, and together wrote a one-page report on the article.

Annotation. The first question on the feedback sheet consisted of two parts. The first part asked students what they had learned about annotation from working with their partners, while the second asked how the collaborative experience would influence the way they annotate while reading journal articles in the future. On Day 1, when responding to the first part of the question, participants' answers were as follows:

Thomas: Did not focus on this
Karen: N/A since we did not discuss our annotation
Bill: We did not talk about it.
Polly: Not discussed
Shawn: Did not discuss
Lisa: N/A

As can be seen in the above, all participants indicated that they did not discuss annotation at all during the initial collaborative experience. They focused instead on writing the one-page report, and stated that they learned nothing about annotation skills from the process.

When asked how the collaborative experience would influence the way they annotate while reading journal articles in the future, students responded as follows:

Thomas: Not much … I would not necessarily choose to work with a partner but would not shy away from the opportunity if it presented itself.

Karen: N/A since we did not discuss annotation

Bill: N/A

Polly: Anotate (Annotate) more carefully. Less massive highligthingt (highlighting).

Shawn: N/A

Lisa: N/A

Clearly, most students reported that the collaborative process would have no impact on their future reading strategies as regards annotation, given that they did not discuss the topic. Polly, however, stated that as a consequence of the collaboration, she would annotate more carefully, specifying that she would highlight less. Thomas offered more general feedback on the process, stating that he would not necessarily work with a partner in the future, but would do so if the opportunity were to arise.

Unlike Day 1, when students reported on Day 2 what they had learned about annotation while working with their respective partners, all participants made reference to the fact that they had discussed annotating. With respect to how much they had learned about the topic at hand from these discussions, their comments were as follows:

Thomas: Not much, used the same annotation as I would have on my own & we mostly annotated separately

Karen: We annotate similarly but I missed some important info by skimming over sections which I normally have difficulty reading.

Bill: I have learned that we both have different opinions about what is the important points to remember and highlight.

Polly: Do not highlight everything

Anna: Not much from what I already knew; we all like to highlight

Martha: Nothing

Carmen: Annotate important ideas

The above comments of Karen, Bill, Polly, and Carmen indicated that they felt they had learned about annotation skills from discussing the matter with their respective partners. Thomas, Martha, and Anna, however, reported that they had not learned anything about annotation from this experience.

As regards the matter of how the collaborative experience would impact the manner in which they annotate while reading journal articles in the future, participants' answers were as follows:

Thomas: Not much, would rather read on my own & then collaborate to solidify the info

Karen: Try to pay more attention & extract info even when I think I will not understand

Bill: I will make sure to focus more on aspects that she believes are important.

Polly: Less highlighting

Anna: I like the software, will definitely use it in the future if it is available

Martha: It won't

Carmen: Not sure

As shown above, an increased number of participants (Karen, Bill, and Polly) reported that they would annotate differently in the future as a result of the collaboration, while another student (Carmen) stated that she was unsure. Only Martha and Thomas indicated that the process would have no real impact on their future use of annotation tools, Thomas adding that he preferred to read individually before collaborating to solidify the information. In answering this question, Anna provided a more general commentary on the usefulness of the software.

Critical analysis. The second question on the feedback sheet also consisted of two parts. The first part asked participants what they had learned about critical analysis from working with their partners, and the second asked how this would impact the strategies they used while engaging in critical appraisal in the future. On Day 1, when responding to the first part of the question, participants' comments were as follows:

Thomas: Not much…her knowledge base was similar to my own. My concerns are similar to hers. My goals for this exercise are also similar.

Karen: That we read the article in a similar way and got a lot of the same things out of the article (which was actually a surprise for me!). This was found out more from discussion since we did not discuss our annotation.

Bill: It will make me focus and put more importance on the inclusion and exclusion criteria.

Polly: Read more carefully, be more precise

Shawn: That it is difficult and has a steep learning curve. It is good to have someone to discuss it with.

Lisa: Always examine the study method first to decide if it's well designed

As can be seen in the above, all but one of the participants (Thomas) indicated that they had slightly added to their knowledge of critical appraisal. Answers ranged from the value of precision in articles and the need to examine the design of the study method to the importance of inclusion and exclusion criteria.

As regards the impact this would have on their critical analysis strategies in the future, students responded as follows:

Thomas: Not influenced

Karen: Give me more confidence that I can read articles!

Bill: I will try to critic (critique) more the litterature (literature) in order to make sure that what was published is correct.

Polly: It will make it so that I will make sure to understand all the including & excluding criteria in a study.

Shawn: Discuss my thoughts with others or form critical appraisal groups

Lisa: Pay more attention to the method section when skimming through abstracts

As shown above, all but one student (again, Thomas) responded that there would indeed be an influence. In identifying the nature of the changes, participants cited issues such as increased confidence in the ability to read articles, the importance of forming critical appraisal groups, and the need to pay attention to the method section when skimming through an abstract.

On Day 2, as had been the case on Day 1, most participants indicated that they had increased their knowledge of critical appraisal, the notable exception once again being Thomas.

Thomas: Not much, we're on a similar level of understanding.

Karen: Not much more than last time… We both still don't know the same types of things.

Bill: I learned that the context in which a study is performed is a key to evaluate the benefit of that study in a more heterogeneous context.

Polly: Take a good look at table 1 & pay attention to quality of study

Anna: Don't know… I thought working in groups helped me extrapolate more relevant conclusions from the articles than when I answered the questions by myself.

Martha: Working with partners helps. People take different valid points from the same article and it's great to compare.

Carmen: Read carefully; read discussion

The above comment of Karen indicated that things had basically stayed the same as they had been on Day 1, while the other participants identified learning important information about context, extrapolating more relevant conclusions, and the general importance of comparing ideas with partners.

As regards how all this would influence their future critical analysis strategies, participants' answers were as follows:

> Thomas: Will not
> Karen: Honestly I don't know, it might not have any influence.
> Bill: I will make sure to always keep in my mind the context in which studies are performed in oder o (order to) evaluate the benefit in a more heterogeneous group.
> Polly: I will pay more attention to these points in the future.
> Anna: Perhaps discuss articles with my peers so I get better understanding of the articles
> Martha: Maybe do a journal club… Some how (somehow) work with peers.
> Carmen: Not sure

Two students, Thomas and Karen, suggested that there would be no impact. Carmen indicated that she was not sure, while the other participants all reported that they would indeed employ different strategies in the future. These changes included discussing articles with peers to better understand them, keeping in mind the contexts of studies, and the value of creating a journal club in order to work with peers.

Technology. The third question on the feedback sheet asked for students' opinions about the role technology played while working with their partners. On Day 1, the responses from all participants were very positive.

> Thomas: Aided in the process…two screens so we could both contribute; Adobe was a great program to use…I was a first time user and understood it quickly.
> Karen: Very good! Convenient, easy to use, environmentally-friendly (Adobe)
> Bill: Very good, allows us to share thoughts and ideas. It gives us some sense of importance since we know that this information is recorded and will be used for good benefit.
> Polly: I prefer paper when studying a text like we did but it was really fun

& interesting using these software.

Shawn: It allowed us to write our thoughts down quickly and efficiently

Lisa: Technology is helpful when properly designed (not too hard to use) and is ecological (no paper!).

As can be seen above, students felt that the technology was easy to use, allowed participants to share thoughts and ideas, was fun and interesting, and that having two screens allowed both dyad members to contribute during the collaboration.

On Day 2, all but two of the participants again expressed their satisfaction with the software.

Thomas: Acrobat reader is a great program.

Karen: Adobe Pro is great for comparing annotations.

Bill: It makes us think louder so that we can discuss important aspects while reading through the article.

Polly: I love technology!

Anna: Very convenient; easy to use tool

Martha: I'd rather have it on paper. The highlighting helps on the screen, but not better than paper.

Carmen: I was still not used to annotating on the computer but getting used to it.

Clearly, participants enjoyed how convenient it was to use Adobe, how Adobe was most useful for comparing annotations, and how it enabled them to discuss important aspects of the article while reading. Martha, however, expressed a preference for hard copies, while Carmen reported that she was unfamiliar with online annotating, but was becoming accustomed to it.

Overall impressions. The last question on the feedback sheet asked participants how the computer-supported collaborative process that they had experienced would influence their future learning (e.g., strategies used while reading, critical appraisal skills). On Day 1, all participants except Thomas indicated the collaborative experience would, in some way, have an impact on their learning in the future.

Thomas: Not influenced

Karen: I don't know exactly, I am comfortable using technology already so it certainly wouldn't be a problem. It would probably make info more accessible since we usually have access to computers but not printers.

Bill: Being able to read an article using a computer and less rely on the need to print it and have a hard copy

Polly: This experience will help me triage the information. I will be exposed to so I can better take care of my patients.

Shawn: I can annotate an article, then email it to a colleague then have a discussion. Simple and effective!

Lisa: If the adequate software is available to use, I would consider reading articles on PC than on paper format.

The comments above showed that as a result of this learning experience, students were inspired in several areas to make changes to their learning approaches in the future. These changes included decisions to rely less on the hard copies of articles, to triage information, and to annotate articles then email them to colleagues to discuss.

When responding to the same question on Day 2, students' comments were as follows:

Thomas: Not much, again, more likely to read & analyze on my own & then discuss the info after ward (afterward).

Karen: It will encourage me to read around my patients if I can highlight & annotate on the PDF.

Bill: I will be more interested in working in a group then (than) alone.

Polly: Better faster access to info that come from different sources but that cover the same subject

Anna: Will use it more then (than) printed paper

Martha: I guess I'll feel more comfortable with reading online, but I will still prefer paper copies.

Carmen: Efficiency of computer-based annotation

As shown above, the majority of students commented on the impact that the entire experience would have on their future learning, citing such issues as how it would enable them to better read around their patients, would give them better and faster access to information, and how working with a group is more interesting than working alone. Thomas, however, restated that his future learning would not be impacted by the intervention. Similarly, Martha reiterated her preference to read the hard copies of articles rather than the online versions.

Chapter 5

Discussion

Teaching undergraduate medical students how to read around their patients is an essential aspect of medical education in the twenty-first century. A crucial step in reaching this objective is to help students develop effective self-regulatory strategies and strong critical analysis skills in a well-designed learning context, such as a computer-supported collaborative learning environment. Possessing these invaluable strategies and skills will enable future physicians to be more discerning as they encounter and evaluate information made available to them through burgeoning technology and the information explosion. Enhancing self-regulation skills in the context of critical analysis performance can enable medical students to make better medical diagnostic decisions and provide better health care using valid, relevant and up-to-date information. Bearing the above in mind, the present study examined whether self-regulated learning influenced critical analysis performance, and the ways in which computer-supported collaborative learning influenced self-regulatory processes.

Empirical evidence has shown that self-regulated learning has a positive effect on students' reading comprehension and achievement (Butler, 1995, 1998b; Housand & Reis, 2008; Pressley et al., 1998; Schunk & Zimmerman, 2007; Smith et al., 2008; Souvignier & Mokhlesgerami, 2006) and, as an extrapolation, on their critical analysis performance, given that reading comprehension necessitates analytical skills. Moreover, empirical findings indicate that computer-supported collaborative learning exerts a positive influence on students' self-regulated learning skills (Azevedo, Winters, et al., 2004; de Jong et al., 2005; Jarvela &

Salovaara, 2004; Lajoie & Lu, 2011; Salovaara, 2005; Salovaara & Jarvela, 2003; Winters & Azevedo, 2005). However, there is a paucity of research on self-regulated learning, critical analysis, and computer-supported collaborative learning in the area of medicine. The present study is the first attempt to examine the relationships among the three key constructs in a medical context; in considering the matter, research findings from various domains were used as a basis to understand the relationships in question. These findings were also used to formulate the study's research questions and to create its hypothesis for the results of this study. Prior to collecting and analyzing the data, it was expected that:

1. Self-regulated learning skills would be positively related to critical analysis performances.

2. Learning in a computer-supported collaborative learning environment would exert a positive influence on self-regulatory skills.

3. Participation in a computer-supported collaborative learning environment would have an effect on learners' use of annotation tools.

4. There was a causal relationship among computer-supported collaborative learning, self-regulated learning, and critical analysis skills.

To test these hypotheses, a two-group experiment was conducted in a naturalistic setting and, using a mixed method design, data were collected through a computer-supported medical journal club activity. The next section provides a detailed discussion of the findings as responses to each of the five research questions. The subsequent sections include the limitations of the current research, suggested directions for future study, a summary of contributions made by the present research through a critical analysis of the findings in terms of their theoretical and practical implications, and a conclusion offering final thoughts.

Findings

Research question 1: Is self-regulated learning related to medical students' critical analysis performance?

The hypothesis for this research question was that students' self-regulated learning skills would be positively related to their performances on critical analysis of medical journal articles. A 2-step hierarchical regression was employed to test the hypothesized relationship. The analysis indicated no significant contribution of critical analysis pre-test or self-reported self-regulated learning pre- and post-test scores to critical analysis post-test performance. However, the percentage of variability in the dependent variable revealed a strong but statistically non-significant effect of self-regulated learning skills on critical analysis post-test performance. After participants' self-reported self-regulated learning pre- and post-test scores were added as a predictor in Step 2, the percentage of variability accounted for (the change in R^2) increased from 5% to 21%, indicating that participants' self-regulated learning was a relatively strong predictor of their critical analysis performance.

A potential explanation for why the strong effect of self-regulated learning on critical analysis failed to achieve statistical significance is the very small sample size in this study. Stemming from the fact that medical students have very demanding schedules, several participants had to withdraw from the study partway through, the consequence being that there were only 14 participants remaining at the end. It was not possible to increase the sample size by redoing the intervention since the course was offered only once a year. The result of this small sample reduced the possibility of detecting significant differences when data were analyzed.

Although the effect was not statistically significant, it was still strong in the indicated direction and provided support for the hypothesis for research question 1 regarding the relationship between self-regulated learning skills and critical analysis performance. The result suggests that having the ability to self-regulate one's own learning is an important component in helping medical undergraduates develop critical analysis skills and become critical thinkers while encountering new medical information. This is in line with the work of previous researchers, who suggest that there exists a positive correlation between learners' self-regulatory skills and their learning performances (i.e., reading comprehension), arguing that students with strong self-regulatory skills outperform low self-regulated learning students in various subject areas (Azevedo, 2005a; Greene, Bolick, & Robertson, 2010; Pressley & Ghatala, 1990; Pressley & Harris, 2006; White & Frederiksen, 2005).

The results of this thesis are encouraging given that they confirm previous research findings on self-regulated learning processes and learning in other domains. Given that this is the first study to explore the complex relationship between self-regulated learning and performance in medical journal clubs, it provides new possibilities for enhancing medical student performance. This investigation has yielded interesting, important results that will serve as a springboard for future research examining self-regulated learning among medical students. More precisely, it lays the groundwork for future self-regulated learning research in medicine investigating when, how, and why high-achieving medical students activate their cognition, motivation, and behaviour towards learning goals.

Research question 2: Does participation in computer-supported collaborative learning influence self-regulatory processes? If so, how?

Reflection on quantitative results. The hypothesis was that, when compared to students learning on their own, students in a computer-supported collaborative learning environment would have significant gains in the self-reported post-test of self-regulatory skills. Technology was used in both groups; one was a computer-supported collaborative learning group and the other group learned individually. A 2-step hierarchical regression was used to test the hypothesized effect and the model was significant. When examining the coefficients table in the analysis, however, a different picture of the matter emerged: the learning condition variable was not significant ($\beta = .29$, $p = .23$), meaning that the learning condition variable did not predict participants' self-reported self-regulated learning post-test scores (the changes in R^2 being 7% due to the addition of learning condition in Step 2). Only the participants' self-reported self-regulated learning pre-test scores were significant predictors of the outcome variable.

The homogeneity of students across the groups may explain why learners in the experimental group did not statistically differ from the control group on their self-reported self-regulated learning scores. Medical students are homogeneously strong academic performers, and, as a consequence, have high self-efficacy as regards their ability to learn (Richardson, Abraham, & Bond, 2012). The students reported limited experience and low confidence in assessing research in the Research Background Questionnaire. In the Self-Regulated Learning

Questionnaire, however, all participants expressed the belief that they possessed the ability to read and comprehend complex texts, engage in critical thinking, and employ effective study tactics, indicating high confidence in their abilities. In the context of this research high confidence may have been unwarranted in conducting the critical analysis task. Over-confidence can sometimes lead to poor performance if confidence and ability do not match (Miller & Geraci, 2011).

It must be stated that self-report surveys are the most common method of measuring self-regulated learning, and were used in the present study because of their long history of usefulness in prior research. Although these surveys are efficient and can provide valuable information about learners' perceptions of how they regulate learning, several researchers have pinpointed the limitations of using self-report data (Dunning, Heath, & Suls, 2005; Perry & Winne, 2006; Tourangeau, Rips, & Rasinski, 2000; Winne, 2004, 2006; Winne & Jamieson-Noel, 2002; Winne, Jamieson-Noel, & Muis, 2002; Winne & Perry, 2000). The key limitation of these surveys is that learners are frequently poor at predicting their performance on self-report measures (Maki, 1998). Winne and Jamieson-Noel (2002), in their investigation of undergraduate students' calibration of self-reports about study tactics and achievement, found that students were slightly positively biased (overconfident) about their achievement and moderately positively biased about (overestimated) their use of study tactics. This matter of students inaccurately assessing their abilities in all likelihood came into play in the current research and may have affected the results.

A final point on the matter of homogeneity in the present study is that all the participants took part on a voluntary basis, meaning that only students who were motivated and interested in learning how to read around patients actually participated in this training. This contention is confirmed in the present research by the fact that participants were uniformly high on levels of self-efficacy, motivation, and interest, and thus it is not surprising that their self-reports of self-regulated learning were also high despite their being inexperienced in the task at hand: reading medical journal articles.

Another possible explanation as to why students in the experimental group did not significantly improve their self-regulated learning skills is the fact that the intervention was too short in duration. As Zimmerman (2000a, 2004) argued, the development of self-regulatory competence is a four-level process (i.e., observation, emulation, self-control, and self-regulation), one that requires time before the final stage is reached. Alexander (1997) made a similar assertion with her Model of Domain Learning (MDL), portraying the nature of developing expertise in academic domains. She focuses on the three components (i.e., knowledge, strategic processing, and interest) that are involved in developing expertise in academic domains and considers their reciprocal relationship at three stages (i.e., acclimation, competence, and proficiency/expertise) in domain learning. According to Alexander (2003), in order to make significant progress toward the expertise stage within the context of a given domain, students need time, opportunity, and support to obtain domain-specific knowledge, to practice cognitive and metacognitive/self-regulatory strategies in relevant contexts, and to develop interest in the subject at hand. Although participants in the current study had all previously passed an introductory course on critical analysis and the articles used in this study were clear and classic examples of appropriate randomized controlled trials, students needed time and experience to help them internalize previously learned knowledge prior to putting such knowledge into practice. This was especially true for the experimental group, given that their task included regulating their own learning as well as co-constructing knowledge and understanding with their peers.

Peer collaboration, according to Kumpulainen & Kaartinen (2003), necessitates a great degree of mutual engagement in joint negotiation in order to establish shared understanding about the task at hand. Participants in the experimental group met only two times during the 3-week pilot course. The short duration of the intervention made it more difficult for students in the experimental group to engage in extensive mutual negotiation and develop a higher level of shared understanding of the topics in question; it was, in turn, difficult for them to significantly improve or develop self-regulatory competence and critical analysis skills. Had the students met more frequently, and had the period been longer, more significant differences between the experimental and control groups may have been evidenced.

Reflection on qualitative findings. Although there were no significant between group differences, the researcher was nonetheless interested in how small groups in the intervention discussed the journal articles and how they self-regulated during the discussion. Qualitative analytic procedures were thus employed to understand what kinds of self-regulated learning skills appeared during verbal discourse.

Modeling in self-regulated learning. Both inductive and deductive procedures were used to analyze the small group discussions of the experimental group in order to understand the types and frequency of self-regulated learning strategies demonstrated by participants as they engaged in computer-supported collaborative learning. Findings showed that 22% of participants' conversations were coded as self-regulated learning, and most of that 22% was made up of Monitoring, followed by Reflection and Reaction, Control, and Planning.

Participants in the experimental group were expected to demonstrate high-levels of self-regulated learning during the discussions since the content of the reading material and the tasks they faced were unfamiliar to them. Interestingly, however, only 22% of participants' utterances were coded as self-regulated learning. This low level of self-regulated learning discourse may be due to the fact that the task was well-organized and thus slightly scaffolded with the Critical Appraisal Checklist, which made it easy for students to read the journals with minimal difficulty. Also useful to students was the one-page report, a document with questions that prompted reflection and a consideration of the practical application of ideas from the readings. In a well-structured intervention such as the one used in this study, students could rely on these external aids to help them accomplish the tasks asked of them and make minimal use of only the most common self-regulatory strategies. Monitoring, therefore, was the most frequently occurring strategy in the students' discussions, indicating that the students paid attention to what they did or did not know as regards the content of the articles they were reading in order to keep track of their progress. Participants also sometimes evaluated their task performance, shared their emotions and satisfaction and, on occasion, reflected on their own self-regulatory approach during the discussions. The other regulatory strategies (i.e., control and planning) occurred relatively infrequently, possibly due to the nature of the tasks. If an ill-structured intervention had been used in this research, it might have prompted participants to engage more extensively in self-regulatory behaviour.

Another explanation as to why participants in the experimental group did not demonstrate self-regulatory behaviour more frequently in their discussions is the homogeneous nature across the pairings. It became apparent from the Research Background Questionnaire that almost all participants in the experimental group were novices with little experience in the domain of critical analysis. It is known that novice learners benefit from receiving explanations and modeling in heterogeneous grouping situations (Swing & Peterson, 1982), whereas the quality of novice students' interaction and learning may be lower in homogeneous groupings (Kyza, Constantinou, & Spanoudis, 2011). Students with low prior knowledge often depend on their partners who have high prior knowledge for cognitive and metacognitive support, and make significant learning gains between pre-test and post-test (Winters & Azevedo, 2005). Given the homogeneity of the novice participants in this study, students did not possess the necessary knowledge of self-regulated learning and critical analysis skills to provide each other with any scaffolding and thereby improve in these areas while reading research articles. Had modeling and scaffolding from peers with advanced knowledge of both self-regulatory and critical analysis skills been available to learners, such as through heterogeneous grouping situations, they may have developed better skills in these areas.

Research question 3: Does participation in computer-supported collaborative learning influence the use of annotation tools?

The hypothesis for research question 3 was that the use of annotation tools by learners in the experimental group would differ significantly from the use of these tools by their counterparts in the control group. ANOVAs were carried out to assess the participants' use of the tools. The results showed the main effect of type of tool used was significant in that highlighting tools were the most frequently used tools in both groups. However, there were no other main effects (group and measure time) and interactions (among group, measure time, and type of tool used). The mean number of tools used by students in the experimental group decreased from pre-test to post-test, while it remained virtually the same in the control group over the same period.

The limited student use of annotation tools in this study is similar to findings in previous research (Narciss et al., 2007; Proske et al., 2007; Winne & Jamieson-Noel, 2002). Narciss, Proske, and Koerndle (Narciss et al., 2007; Proske et al., 2007), for example, examined undergraduate students' use of support tools for self-regulated learning in "Studierplatz," an optional, self-directed, web-based learning environment. The researchers found that students used only a small number of the tools, such as the highlighter and glossary, and spent the majority of their time reading and studying texts presented to them. The note-taking or monitoring tools provided in the web-based learning environment were rarely used by students.

Learners in both groups in the present research used the annotation tools less frequently than the researcher expected and relied on highlighting tools to a greater extent than was anticipated. One possible explanation for this is the participants' lack of experience in conducting research and reading journal articles, and their low level of confidence in assessing various research topics. Since students were reading unfamiliar subject matter in an unfamiliar format (the journal article), they used highlighting tools to help them read the articles and understand the content. Their decision to rely on highlighting tools when encountering new information is not surprising, as according to Caverly, Orlando, and Mullen (2000), highlighting tools usually serve to select and mark important information in the text that readers can incorporate into their summaries or critiques afterwards. Moreover, highlighting behaviours allow readers to concentrate on reading the text at hand and are not as disruptive to the ongoing process of reading as are other strategic behaviours (e.g., note-taking behaviours) (Kobayashi, 2007).

Another possible explanation for why students made minimal use of the annotation tools is their access to the Critical Appraisal Checklist. This generic checklist included all the key elements found in any randomized controlled trial study and thereby helped to structure the reading in a coherent manner without need of further annotation. In their discussions, a number of participants cited the usefulness of the checklist in helping to identify the key points while reading the journal articles.

> "… then make another sentence, saying, like, you know, while filling out the questionnaire, …or the questionnaire called attention to aspects of critical appraisal that we were not otherwise aware of. …"

This utility of the checklist was not apparent to all the students when doing the pre-test, as it was their first time encountering and using it; however, they had become aware of the checklist's practicality by the time of the post-test, making good use of it as a means of orienting them to the most important parts of the article. Due to this new-found ability to easily locate key points in the reading at the time of the post-test, participants simply went immediately to the relevant sections to read and process the content, and did not annotate irrelevant information in the article, thus decreasing their use of annotation tools. With the benefit of the checklist, participants had more confidence in reading journal articles at the end of training course, and this increased confidence in critical analysis led to a decrease in text highlighting behaviour (surface-level strategic processing; Alexander, Murphy, Woods, Duhon, & Parker, 1997).

Participants' reading goals might have influenced their usage of the annotation behaviours. Reading research has demonstrated that reading goals affect how students process a given text and how they annotate (Braten & Samuelstuen, 2004; Kobayashi, 2007; Linderholm & van den Broek, 2002; Lonka, Lindblom-Ylanne, & Maury, 1994). Students' reading goals are often related to the form of outcome measure used to evaluate their learning (Kobayashi, 2007; Lonka et al., 1994). The outcome measure used in this study, the Critical Appraisal Checklist, might have impacted students' selection of annotation strategies. The checklist consists of 19 multiple-choice and seven open-ended questions, and is, by its very nature, a critique-oriented assessment. According to Spivey (1997), a critique is made up of first, objects being criticized, and second, evaluative comments. Critical readers' greater use of highlighting or underlining in the first portion of the annotation process is likely due to their using these strategies for locating and producing the objects of critique. Bearing this in mind, students' use of annotation tools in the present study may reflect this process of generating a critique. It follows that if participants had been asked to read another type of article, or if they had been asked to do a different sort of task related to that article, their annotation behaviours might have been markedly different.

The Collaboration Feedback Sheets of participants in the experimental group reveal that several participants felt that they did not learn a great deal about annotation from working with their partners either because they did not discuss annotation or already had similar ways of doing it. Despite this, some students indicated that they had indeed learned more about one aspect of annotation from the collaborative experience, specifically highlighting skills, and stated that this would change their annotation strategies in the future.

"We annotate similarly but I missed some important info by skimming over sections which I normally have difficulty reading."

"Do not highlight everything"

"Try to pay more attention & extract info even when I think I will not understand"

"I will make sure to focus more on aspects that she believes are important."

"Less highlighting"

Research question 4: Does computer-supported collaborative learning influence individuals' self-regulated learning in terms of the development of critical analysis? If so, how?

Reflection on quantitative results. The hypothesis was that there was indeed a causal sequence between the independent variable, learning condition (either the computer-supported collaborative learning or the individual learning), and the dependent variable, critical analysis performance, through the inclusion of the mediator variable, self-regulated learning skills. The results indicated that there were no statistically significant direct and indirect effects among these three variables. It is not surprising that the direct and indirect effects were not significant, the reasons for the insignificance being very similar to the reasons mentioned when considering research questions 1 and 2: the small sample size, the homogeneity of students across the groups, and the short duration of the intervention.

Research suggests that the quality of learning in peer groups is closely related to the nature of the collaboration and interactions that students engage in while performing academic tasks (King, 1992; Kumpulainen & Kaartinen, 2003; Peterson, Wilkinson, Spinelli, & Swing, 1984; Webb, 1991; Webb, Troper, & Fall, 1995). In order to understand the nature of the verbal interactions of the dyads in the experimental group, the attention will now shift to the results of the qualitative analysis.

Reflection on qualitative findings. Although the mediation analysis revealed no significant relationships between self-regulated learning and critical analysis performance that could be attributed to condition, the researcher was nevertheless interested in the ways in which technology supported the small groups in the intervention as they discussed the journal articles. Qualitative analytic procedures were employed to analyze the verbal discourse of participants in the experimental group to understand their co-regulated learning and critical analysis skills.

Co-regulation and content processing. The small group discussions were coded to understand the types of regulation (co- or individual, low or high) learners demonstrated while working collaboratively with their partners. Findings showed that learners engaged in Low-level co-regulation the most frequently, followed by High-level co-regulation, High-level individual regulation, and Low-level individual regulation.

It comes as no surprise that participants in the experimental group frequently engaged in low-level co-regulation in their interactions since the content of the journal articles was unfamiliar to them. This indicates that the discussions of participants in the experimental group focused extensively on sharing information gleaned from the articles, exchanging ideas, clarifying fundamental facts, and providing definitions. Even though the verbal participation was quite equally distributed between group members, this participation was nonetheless short. As a consequence, students had little opportunity to co-construct knowledge, and, in turn, were not able to develop the target skills. On the positive side, even though the low-level co-regulation exhibited by learners focused primarily on surface-level cognitive/metacognitive processing, it nonetheless helped group members build common ground upon which to accomplish their tasks and work towards a higher level of shared understanding.

Group members sometimes engaged in high-level co-regulation during their discussions. Researchers suggest that high-level co-regulation is the most desirable form of group interactions because it involves high-level cognitive/metacognitive processing and leads to a high-level of learning and understanding (Cohen, 1994; King, 2002; Vauras et al., 2003; Volet et al., 2009). The findings in the current study indicate that participants did indeed engage in reasoning processes and linking ideas, such as summarizing and explaining main ideas and results, and assessing and interpreting evidence in the content of the articles. Learners engaged less frequently in more advanced critical analysis, such as evaluating the strengths and weaknesses of studies and applying the readings to their practice. This finding might reflect the fact that participants did not have enough research and domain knowledge to critique the journal articles and relate results to their own practice.

Participants' individual regulation, whether at a low or high level, usually involved explaining ideas from the articles to each other or reading text word for word. Once again, this indicates an effort to build common ground for understanding.

As a final point of note, only 6% of participants' verbal interactions involved the discussion of reading strategies. The infrequency with which students shared the approaches used when reading the articles meant that there were few opportunities for them to learn from each other in this area and thereby improve their self-regulated learning skills. It is also of interest that 11% of participants' verbal interactions were coded into the Difficulty category. By and large, as learners encountered problems with their tasks, they did not typically consult their partners to overcome these obstacles. Doing so would have provided an opportunity to improve their self-regulatory skill level.

Unlike Volet et al. (2009), the present study did not examine the types of interactions among pairs. If this had been an area of focus, it might have yielded more detailed information about what types of interactions the groups used to accomplish their tasks, and how the differences among groups contributed to the development of students' self-regulatory skills and their learning performance. Moreover, this study did not collect participants' think-aloud protocol, meaning that it was not possible to compare the cognitive and/or self-regulatory processes between the experimental and control groups. Such a comparison would likely have provided valuable insights into the development of self-regulation in different learning conditions.

Modeling in critical analysis. An open-coding procedure was used to analyze all of the verbal interactions to comprehend the types and frequency of critical analysis skills shown by learners while engaging in computer-supported collaborative learning. Results showed that 21% of these discussions were coded as critical analysis. In all probability, the low incidence of critical analysis stems from the types of activities involved in completing the tasks. Collaborating with a partner to type the one-page report, for example, required a great deal of repetition of ideas, clarification of points, and restructuring of sentences. The utterances produced during this type of interaction did not constitute critical analysis.

The most frequently occurring type of critical analysis exhibited by participants was Understanding, followed by Analyzing. Less time was spent evaluating the articles (Evaluating), and learners rarely applied insights from the articles to their future practice (Applying). According to King (2002), the task in which learners are engaged determines the nature of the cognitive processing that takes place. For example, some peer learning tasks, such as those involving review and comprehension, necessitate the recall and repetition of material or basic application of concepts learned, thereby promoting mastery of skills and content. Other peer learning tasks require more complex, higher-level cognitive processing, such as working together to solve ill-structured problems, and building new knowledge with peers. In the present research, the learning tasks of participants in the experimental group consisted of reading and discussing a journal article, comparing the accompanying checklist, and writing a related one-page report. These learning tasks were well-structured, and as such may not have been challenging and complex enough to promote high-level cognitive processing, such as evaluating and applying, among participants. The use of ill-structured, open-ended tasks might have been able to foster higher-level thinking and greater critical analysis skills.

Another explanation for the comparatively high occurrence of the Understanding category is that participants in the experimental group (as well as the control group) did not have prior knowledge and experience in reading medical journal articles and providing patient care. As Moos and Azevedo (2008b) found in their study, students with low prior knowledge employed only a few specific strategies, such as summarizing and note-taking, and did not often practice other active strategies, such as making inferences or elaborating on their knowledge.

To summarize, the qualitative findings of the data analyses related to research question 4 yield interesting insights. The data emerging from the analyses of participants' co-regulation and critical analysis all indicate that individuals in the experimental group spent the majority of their time attempting to build shared understanding of the articles in order to complete the tasks. They devoted less time to evaluating the strengths and weaknesses of the articles and to considering how the information they encountered in the readings could be applied to their practices in order to treat patients. One key explanation for this phenomenon is a lack of knowledge, skills, and experience in research, critical analysis, and the subject matter of each article. Moreover, the well-structured nature of the tasks learners faced and the activities involved in these tasks also contributed to the level of cognitive processing used by participants in the experimental group.

Summary of responses from collaboration feedback sheet. When participants in the experimental group reflected upon what they had learned about critical analysis from working with peers during the training, one common theme that emerged was the usefulness of comparing ideas with partners. Participants also cited having somewhat increased their knowledge of critical appraisal through the intervention. When reflecting upon the impact this would have on their critical analysis strategies in the future, a number of participants cited the importance of creating a journal club to discuss articles with peers. Some participants also stated that when they read journal articles in the future, they would pay close attention to specific sections of those articles. Of note is Thomas, who declared that he had learned nothing about critical analysis from the experience, and that it would therefore have no impact on his critical appraisal skills in the future.

In considering the role played by technology as participants worked with their partners, almost all learners commented that the experience had been most positive. They stated that the technology they used enabled them to carry out their tasks quickly and efficiently.

When reflecting on how participating in this study would influence their future learning, most students responded positively. Participants commented that the software made it easy to read and annotate medical articles as well as to share ideas about the articles with colleagues, and, in the long term, would help them to better read around their patients. Once again, of note is that Thomas declared that the experience would have no impact on his future learning.

Research question 5: What is the nature of group dynamics as students engage in self-regulated learning in a computer-supported collaborative learning environment?

Group dynamics can influence participants' use of self-regulatory strategies for cognition, motivation, and behaviour (Hadwin et al., 2011), and ultimately can determine the effectiveness and efficiency of group decision making and problem solving (Hirokawa & Pace, 1983; Jonassen & Kwon, 2001). Given the importance of group dynamics, it was important to examine the nature of the communication used by participants in the experimental group while interacting with each other during the collaborative tasks. All of the utterances generated during the discussions were therefore coded through the use of inductive analysis. Results showed that Responsive activity was the most frequently occurring type of communication during students' verbal interaction, followed by Informative, Argumentative, Elicitative, Directive, and Off task activity.

In 2005, Saab et al. examined the relationship between collaborative inquiry and communicative activities, finding that Informative and Elicitative activities were correlated to collecting and interpreting data in order to establish common ground. Argumentative, Elicitative, and Responsive activities were correlated to establishing common conclusions. This indicates that all communication patterns involve the goal of building shared understanding of the problems and of the actions required to solve those problems. In the case of the present research, the topic under investigation was different from that of Saab et al.; however, some of their key insights nonetheless apply. Students in the experimental group frequently engaged in Responsive, Informative, Argumentative and Elicitative activity, indicating that they attempted to build shared understanding of the content of the articles they read and tried to reach common conclusions in order to address the questions in their checklists and one-page reports, all of which constituted the primary goal of the collaboration.

The types of communication students engaged in while attempting to reach this goal, however, were relatively superficial and did not require sophisticated self-regulated learning skills. Three key factors may have prevented students from making more extensive use of self-regulatory strategies. First, participants were novice medical students with limited experience in reading journal articles in a critical manner. Furthermore, they had low prior knowledge of the subject matter contained in the articles. Learners' inexperience in critical analysis and their lack of domain and topic knowledge led them to focus primarily on understanding the content of the articles during the reading process. This in turn resulted in students demonstrating only surface-level critical analysis skills (e.g., summarizing) and using only surface-level strategic processing (e.g., highlighting text) in the intervention (Alexander, Dinsmore, Parkinson, & Winters, 2011).

Second, the Critical Appraisal Checklist may have been an unexpected self-regulated learning tool that scaffolded part of the students' tasks. The checklist helped students easily locate answers to the questions about the articles, precluding the group from making suggestions about what they should pursue next. The discourse thus revealed only superficial communications in which students gave each other information and simply agreed or disagreed with each other without debate. Consequently, the types of communicative activities engaged in by students did not reveal sophisticated self-regulated learning.

Finally, the journal club activity was self-directed by nature, in that the teacher did not instruct students in how to critically read the journal articles. As pointed out by Zimmerman (2000a, 2004; see Table 2.2), the first stage in developing self-regulatory competence is observing expert models and acquiring the underlying self-regulation from those models. Since this modeling was lacking in the present study, the groundwork was not there for students to improve their self-regulatory skills.

Limitations

There are a number of limitations involved in the present study that are somewhat problematic and may, in fact, explain the absence of significant results. The first point of note is the small sample size used in the research. Given the fact that medical students have very full schedules, it is not surprising that although two classes of more than 30 students each were given the opportunity to participate in the research, 29 students all told volunteered to join the study. It is similarly not surprising that of those who did indeed volunteer, a number had to withdraw from the research either before or shortly after it began due to demanding schedules and numerous commitments related to their program of study. Not only did this affect sample size, it also affected the make-up of the small groups in which the collaboration took place. In any case, a sample size of fourteen is certainly not catastrophic when conducting a study such as this; however, having a larger number of participants would be desirable to reach more conclusive findings.

Another limitation of the research is that the participants met only three times over the course of the training. As was the case with the relatively small sample size, this problem is likewise rooted in students' busy schedules and numerous obligations related to their studies. It proved most challenging to organize the intervention so that the fourteen students involved were able to meet on three occasions, special arrangements having to be made and last-minute alterations having to be carried out. Bearing this in mind, it would have been next to impossible for students to commit to any more than three days' participation in the research. The inherent problem is that since longer interventions logically result in more substantial improvements in students' performances, a relatively short intervention such as the one carried out in this study is, by its very nature, likely to have a less strong impact. Zimmerman (2000a, 2004) argues, in fact, that the development of self-regulatory competence is a four-level process, consisting of observing expert models, emulating these models, exercising self-control, and, finally, self-regulating one's personal outcome. Clearly, this is a process that requires time before the final stage is reached. This issue of the length of the intervention may therefore go a long way toward explaining why learners did not demonstrate any significant improvement in their self-regulatory and critical analysis skills in the present research, additional meetings being necessary to produce more concrete progress in the target areas.

Another problematic matter related to the study is that self-regulated learning is made up of two properties, an aptitude and an event (Winne & Perry, 2000), and the researcher took into account only the aptitude scores (as measured by self-report questionnaires), and not trace data emerging from the event, when calculating participants' self-regulated learning scores. According to Winne and Perry, an "aptitude" is a quasi-permanent personality trait that may be applied in numerous contexts and tasks, and may be employed to predict future behaviour, while an event is behaviour in a particular context. Using these categories, the forethought and reflection phases of Zimmerman's self-regulated learning model (2000a) fall into aptitude, while the performance phase is an event. In order to understand learners' self-regulatory processes, self-report questionnaires were used in the present research to measure self-regulated learning variables related to forethought and reflection. On the other hand, trace methodology was employed to capture students' performance while accomplishing their tasks. Since these data were fundamentally different and could therefore not be combined, only the self-report scores were used in quantitative analysis, meaning that the picture of students' self-regulatory skills that emerged from the current research was not a complete one.

Directions for Future Research

A number of implications for future research in the field arise from the present study. Bearing these insights in mind will help direct future scholars as they investigate the issues dealt with in this study or explore related topics.

The first such implication has to do with how to combine the various data collected on self-regulated learning so as to form a complete picture of the phenomenon. In order to fully understand this issue, a very brief recapitulation of some key ideas is in order. To begin, the model used in this study is based on the Zimmerman model of self-regulated learning (2000a) and includes Forethought, Performance, and Reflection phases. Winne and Perry (2000) suggest that self-regulated learning has two properties, aptitude and event. Each of the phases in the Zimmerman model corresponds to one of the two properties suggested by Winne and Perry: the Forethought and Reflection phases correspond to aptitude and the Performance phase corresponds to event. The complexity of data analysis and data convergence is that data from the Forethought and Reflection phases of self-regulated learning (in the "aptitude" domain) are measured through the use of Likert Scales, while data from the Performance phase of self-regulated learning (in the "events" domain) are analyzed through coding the qualitative data. It is challenging to converge multiple forms of data to create a comprehensive picture of individuals' self-regulated learning. Most researchers have focused on triangulating the data from the "events" domain, such as trace data and think-aloud protocols, and the "aptitude" domain, such as self-report questionnaires, to examine learners' self-regulated learning skills; however, it is difficult to combine the two ways of measuring self-regulated learning in a meaningful way.

Perhaps some lessons can be taken from early research on reading (see, e.g., Clark et al., 1979; Corno, 1980) where investigators combined test-based measures with measures derived from coded observations in order to reflect different elements of the same construct. The measures they designed were entered into regressions in a theoretically meaningful order; each therefore made contributions to scaled outcomes. If future research can continue in this vein and examine ways to effectively integrate the two measures in question, then the study of self-regulated learning in various contexts, such as the medical setting described here, will be improved.

Second, this study has also highlighted the fact that self-regulation and group co-regulation overlap, self-regulation being nested in co-regulation. As learners collaborate, it is a subjective judgment when attempting to discern whether a given utterance by a student is an instance of self-regulation, meaning that the student is independently reaching insights into the topic at hand, or if the student is engaging in discourse with a peer and acting as a catalyst to generate ideas (or vice-versa). This ambiguity as to the nature of the regulation that is occurring creates a lack of transparency that can lead to somewhat unclear conclusions. It is important for future research to examine how the two forms of regulation can be separated, for example through the establishment of concrete criteria, as this will make data analysis more watertight and will lead to more objective conclusions.

Third, this study has pointed to the fact that whenever possible, researchers should create student groupings that are heterogeneous in terms of prior knowledge when implementing an intervention. Taking this approach, it is likely that peer modeling will occur and peer feedback will be provided within a given group, and this interaction will increase the probability that students' self-regulated learning and critical analysis skills will be enhanced. This principle not only holds true when working with learners who possess dramatically different skill levels, but also with a group of novices (as was the case in the present study). Even amongst the latter group, small differences in skill level or prior knowledge can come to the fore and result in useful peer modeling and feedback.

Fourth, the participants involved in the present research were novice medical students with limited prior knowledge of critical analysis and the sample size was small. Should the intervention be carried out with a more advanced learner population and a larger sample, the correlation between self-regulated learning and critical analysis might differ from the one that emerged from the present study. Future researchers should bear in mind this caveat when replicating the intervention carried out by the researcher, and should find ways of accomplishing this goal. A potential means of doing this would be to persuade the Faculty of Medicine to make participation in computer-supported collaborative journal clubs a standard part of the curriculum. Alternately, researchers could approach individual course instructors in the Faculty and have them agree to make it mandatory for students to participate in these journal clubs and to run the study across several sections. Since data provided on the Collaboration Feedback Sheet indicated that students found the computer-supported collaborative journal club activity useful in enhancing their development of self-regulatory skills and critical analysis, making these clubs mandatory would greatly benefit all students.

Fifth, the Critical Appraisal Checklist was intended to be a measurement of students' critical analysis in this study. Unexpectedly, however, the checklist was used by students as a learning tool in that it helped structure their search for information in their assignments. The resultant dual function of the checklist may have compromised the intended purpose in the present research, which was to see if collaborative technology tools led to better critical analysis and self-regulated learning. Future studies will need to ensure that measurement of critical analysis be unguided by a checklist that could be used during the learning process.

Finally, by ascertaining that the intervention did not lead to improvements in self-regulated learning and critical analysis skills, the present research has, by process of elimination, shed light on the elements that are required in order to effectively use technological tools in teaching to obtain better outcomes. The research findings provide us with valuable insights regarding future directions that may be taken by investigators as they examine the constructs under study in a computer-supported collaborative learning environment.

(1) Researchers must bear in mind that students require more time to improve in the skill areas under investigation, specifically self-regulated learning and critical analysis. An intervention consisting of three sessions, as was the case in this study, is not long enough to lay the groundwork for learners to experience concrete progress in the target areas. More time and opportunities are required for students to learn from each other and internalize the ideas, strategies, and approaches they encounter.

(2) Future research must take into account that specific instruction, modeling, and feedback are required to act as a springboard for medical students to develop both improved critical analysis and self-regulated learning skills. In the present study, the medical instructor's debriefings included instruction on how to "read around your patients" in a general sense, but touched only peripherally on the matter of critical analysis. Students' comments indicated that the intervention led them to certain insights regarding what to focus on when reading a medical journal article, such as which sections of the article to read in detail and what factors to keep in mind when reading. Their comments indicated that the training

did not, however, lead participants to any insights regarding actual critical analysis skills that could be used when reading these articles. If specific instruction, modeling, and feedback on how to critically read journal articles are provided to students, students will develop a foundation upon which to build their knowledge of critical analysis. In turn, as learners improve their critical analysis skills, they will over time internalize these skills and become better self-regulated readers in the future.

(3) As future studies in self-regulated learning and critical analysis are carried out, researchers must be aware of the fact that more advanced, convenient, user-friendly software is needed in interventions such as the present one. The software used in this study is not specifically designed for examining self-regulated learning, critical analysis, and collaboration. A number of researchers in recent years have been developing new software, such as nStudy (Beaudoin & Winne, 2009; Winne, Hadwin, & Beaudoin, 2009; Winne & Nesbit, 2009), created to enhance students' self-regulatory skills and to provide opportunities for learners to work in either an individual or collaborative environment. This technology has not yet reached its full potential of applicability, however. More appropriate software will have to be developed in the future to better foster improved self-regulated learning and critical analysis skills among all learners, including medical students.

Summary of Contributions to Scholarship

The present study has made a number of important contributions to scholarship. First, it is unique for the simple reason that it has examined the three central constructs, namely self-regulated learning, critical analysis, and computer-supported collaborative learning, as they relate to each other, an investigation that has not been carried out by other researchers in a medical or any other context. Through an examination of these dynamics, the current work is therefore unique and has made a significant contribution to academia.

On a related note, the current study also stands out in that it provides a valuable comparative analysis of the three models of self-regulated learning that are at the core of the work. The summary and comparison provided in this dissertation will serve as a springboard for future scholars doing research in medical and other settings, and will allow them to distinguish among the models and decide which best suits their studies, or to synthesize elements of each model and create a unique research approach.

The present research is also unique in that it includes a number of task-specific questionnaires created by the researcher that are related to two core constructs of the study, namely self-regulation and critical analysis. These surveys can be used or adapted by other researchers carrying out investigations that involve these constructs in a medical or any other setting, and should prove most useful in eliciting key information from participants and shedding valuable light on the topic being studied.

Finally, and perhaps most importantly, the present work contributes to scholarship in that it provides a better understanding of what practices are required to improve learners' self-regulated learning and critical analysis skills in computer-supported collaborative journal clubs. First, a lengthy training period is required to help students develop better skills in the target areas. Second, journal clubs must be well structured, particularly when participants are novices, in order to ensure that learners benefit from the training. Third, modeling and feedback should be provided in journal clubs to facilitate the development of self-regulation and critical analysis. Lastly, software designed specifically to foster the development of self-regulated learning and critical analysis skills would be most beneficial in helping students improve in these crucial areas.

Conclusion

A review of some of the key findings of this study is now in order. Due primarily to the small sample size in this study, not surprisingly, none of the results related to the research questions was significant. As has been established, despite this lack of significance, participants' self-regulated learning nonetheless appeared to be a strong predictor of their critical analysis performance. Also of interest were the findings of the qualitative data analysis, as they led to numerous insights into the ways in which undergraduate medical students' self-regulated learning and critical analysis interrelated in a computer-supported collaborative learning environment.

Although many of the results were thus somewhat unexpected, carrying out this study has been an important exercise simply because the subject matter is so crucial. In a globalized world, with pandemics a very real danger, with exponentially growing knowledge, and with an aging population, it is imperative to have well-qualified medical professionals capable of creative, independent, insightful observation. Being able to self-regulate one's learning and engage in critical analysis are essential skills in this process. It is important for physicians to not only develop these skills as part of their medical training, but to be lifelong learners and carry them through to their practice once they are fully-qualified professionals. In a world in which technology is becoming increasingly widespread, and in a world in which colleagues in various parts of the world can collaborate professionally, it is also essential that doctors develop the requisite technical and collaborative skills. The present research is not a blueprint for how to train medical professionals to reach these stated lofty goals. The research does, however, provide guidance in how computer-supported collaborative learning environments can be used to shed light on the development of self-regulated learning and critical analysis, providing a solid foundation for future research.

References

Akhund, S., & Kadir, M. M. (2006). Do community medicine residency trainees learn through journal club? An experience from a developing country. *BMC Medical Education, 6*, 43-50.

Alexander, P. A. (1997). Mapping the multidimensional nature of domain learning: The interplay of cognitive, motivational, and strategic forces. In M. L. Maehr & P. R. Pintrich (Eds.), *Advances in motivation and achievement: Vol. 10.* (pp. 213-250). Greenwich, CT: JAI Press.

Alexander, P. A. (2003). The development of expertise: The journey from acclimation to proficiency. *Educational Researcher, 32*(8), 10-14.

Alexander, P. A., Dinsmore, D. L., Parkinson, M. M., & Winters, F. I. (2011). Self-regulated learning in academic domains. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 393-407). New York: Routledge.

Alexander, P. A., & Judy, J. E. (1988). The interaction of domain-specific and strategic knowledge in academic performance. *Review of Educational Research, 58*(4), 375-404.

Alexander, P. A., Murphy, P. K., Woods, B. S., Duhon, K. E., & Parker, D. (1997). College instruction and concomitant changes in students' knowledge, interest, and strategy use: A study of domain learning. *Contemporary Educational Psychology, 22*(2), 125-146.

Alguire, P. C. (1998). A review of journal clubs in postgraduate medical education. *Journal of General Internal Medicine, 13*(5), 347-353.

Allen, M. J., & Yen, W. M. (1979). *Introduction to measurement theory*.

Monterey, CA: Brooks/Cole Publishing Company.

Ames. C. (1992). Classroom: Goals, structures, and student motivation. *Journal of Educational Psychology, 84*(3)*,* 261-271.

Artino, A. R., & Stephens, J. M. (2006). Learning online: Motivated to self-regulate? *Academic Exchange Quarterly, 10*(4), 176-182.

Azevedo, R. (2005a). Computer environments as metacognitive tools for enhancing learning. *Educational Psychologist, 40*(4), 193-197.

Azevedo, R. (2005b). Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning. *Educational Psychologist, 40*(4), 199-209.

Azevedo, R., & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? *Journal of Educational Psychology, 96*(3), 523-535.

Azevedo, R., Cromley, J. G., Winters, F. I., Moos, D. C., & Greene, J. A. (2005). Adaptive human scaffolding facilitates adolescents' self-regulated learning with hypermedia. *Instructional Science, 33*(5-6), 381-412.

Azevedo, R., Greene, J. A., & Moos, D. C. (2007). The effect of a human agent's external regulation upon college students' hypermedia learning. *Metacognition and Learning, 2*(2-3), 67-87.

Azevedo, R., Guthrie, J. T., & Seibert, D. (2004). The role of self-regulated learning in fostering students' conceptual understanding of complex systems with hypermedia. *Journal of Educational Computing Research, 30*(1&2), 87-111.

Azevedo, R., Winters, F. I., & Moos, D. C. (2004). Can students collaboratively use hypermedia to learn science? The dynamics of self- and other-regulatory processes in an ecology classroom. *Journal of Educational Computing Research, 31*(3), 215-245.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W. H. Freeman and Company.

Barab, S. A., & Duffy, T. M. (2000). From practice fields to communities of practice. In D. H. Jonassen & S. M. Land (Eds.), *Theoretical foundations of learning Environments* (pp. 25-55). Mahwah, NJ: Lawrence Erlbaum Associates.

Barron, B. J. S., Swartz, D. L., Vye, N. J., Moore, A., Petrosino, A., Zech, L., et al. (1998). Doing with understanding: Lessons from research on problem- and project-based learning. *The Journal of the Learning Sciences*, *7*(3&4), 271-311.

Barrows, H. S. (1985). *How to design a problem-based curriculum for the preclinical years*. New York: Springer.

Barrows, H. S. (1994). *Practice-based learning: Problem-based learning applied to medical education*. Springfield, IL: Southern Illinois University School of Medicine.

Barrows, H. S. (2000). *Problem-based learning applied to medical education*. Springfield, IL: Southern Illinois University School of Medicine.

Barrows, H. S., & Pickell, G. C. (1991). *Developing clinical problem-solving skills: A guide to more effective diagnosis and treatment* (1st ed.). New York:

W. W. Norton & Company.

Barrows H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An approach to medical education*. New York: Springer.

Beaudoin, L. P. & Winne, P. H. (2009). *nStudy: An Internet tool to support learning, collaboration and researching learning strategies*. Paper presented at the 2009 Canadian e-Learning Conference, Vancouver, BC, Canada.

Bereiter, C., & Scardamalia, M. (1987). *The psychology of written composition*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Bielaczyc, K., Pirolli, P. L., & Brown, A. L. (1994). Collaborative explanations and metacognition: Identifying successful learning activities in the acquisition of cognitive skills. In A. Ram & K. Eiselt (Eds.), *Proceedings of the sixteenth annual conference of the Cognitive Science Society* (pp. 39-44). Hillsdale, NJ: Lawrence Erlbaum Associates.

Blumberg, P. (2000). Evaluating the evidence that problem-based learners are self-directed learners: A review of the literature. In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp.199-226). Mahwah, NJ: Lawrence Erlbaum Associates.

Boekaerts, M. (1997). Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers, and students. *Learning and Instruction, 7*(2), 161-186.

Boekaerts, M. (2002). The On-Line Motivation Questionnaire: A self-report instrument to assess students' context sensitivity. In P. R. Pintrich & M. L. Maehr (Eds), *Advances in motivation and achievement: Vol. 12. New directions in measures and methods* (pp. 77-120). Oxford, England: Elsevier

Science Ltd.

Boekaerts, M., & Corno, L. (2005). Self-regulation in the classroom: A perspective on assessment and intervention. *Applied Psychology: An International Review, 54*(2), 199-231.

Boekaerts, M., & Niemivirta, M. (2000). Self-regulated learning: Finding a balance between learning goals and ego-protective goals. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 417-450). San Diego, CA: Academic Press.

Boekaerts, M., Pintrich, P. R., & Zeidner, M. (Eds.). (2000). *Handbook of self-regulation*. San Diego, CA: Academic Press.

Borkowski, J. G., & Muthukrishna, N. (1992). Moving metacognition into the classroom: "Working models" and effective strategy teaching. In M. Pressley, K. R. Harris, & J. T. Guthrie (Eds.), *Promoting academic competence and literacy in school* (pp. 477-501). Toronto, Canada: Academic.

Bradley, P., Oterholt, C., Nordheim, L., & Bjorndal, A. (2005). Medical students' and tutors' experiences of directed and self-directed learning programs in evidence-based medicine: A qualitative evaluation accompanying a randomized controlled trial. *Evaluation Review, 29*(2), 149-177.

Braten, I., & Samuelstuen, M. S. (2004). Does the influence of reading purpose on reports of strategic text processing depend on students' topic knowledge? *Journal of Educational Psychology, 96*(2), 324-336.

Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65-116). Hillsdale, NJ:

Lawrence Erlbaum Associates.

Brown, A. L., & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-270). Cambridge, MA: The MIT Press.

Brown, A. L., & Campione, J. C. (1996). Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. In L. Schauble & R. Glaser (Eds.), *Innovations in learning: New environments for education* (pp. 289-325). Mahwah, NJ: Lawrence Erlbaum Associates.

Brown, A. L., & Palincsar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 393-451). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Brydges, R., & Butler, D. (2012). A reflective analysis of medical education research on self-regulation in learning and practice. *Medical Education, 46*(1), 71-79.

Butler, D. L. (1995). Promoting strategic learning by postsecondary students with learning disabilities. *Journal of Learning Disabilities*, *28*(3), 170-190.

Butler, D. L. (1998a). Metacognition and learning disabilities. In B. Y. L. Wong (Ed.), *Learning about learning disabilities* (2nd ed., pp. 277-307). Toronto, Canada: Academic.

Butler, D. L. (1998b). A strategic content learning approach to promoting self-regulated learning by students with learning disabilities. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 160-183). New York: The Guilford Press.

Butler, D. L. (2002). Qualitative approaches to investigating self-regulated learning: Contributions and challenges. *Educational Psychologist, 37*(1), 59-63.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*(3), 245-281.

Caverly, D. C., Orlando, V. P., & Mullen, J.-A. L. (2000). Textbook study reading. In R. F. Flippo & D. C. Caverly (Eds.), *Handbook of college reading and study strategy research* (pp. 105-147). Mahwah, NJ: Lawrence Erlbaum.

Chapman, J. W., & Tunmer, W. E. (1995). Development of young children's reading self-concepts: An examination of emerging subcomponents and their relationship with reading achievement. *Journal of Educational Psychology, 87*(1), 154-167.

Chi, M. T. H. (1997). Quantifying qualitative analyses of verbal data: A practical guide. *Journal of the Learning Sciences, 6*(3), 271-315.

Clark, C. M., Gage, N. L., Marx, R. W., Peterson, P. L., Stayrook, N. G., & Winne, P. H. (1979). A factorial experiment on teacher structuring, soliciting, and reacting. *Journal of Educational Psychology, 71*(4), 534-552.

Cleary, T. J., & Zimmerman, B. J. (2004). Self-regulation empowerment program: A school-based program to enhance self-regulated and self-motivated cycles of student learning. *Psychology in the Schools, 41*(5), 537-550.

Cohen, A., & Scardamalia, M. (1998). Discourse about ideas: Monitoring and regulation in face-to-face and computer-mediated environments. *Interactive Learning Environments*, *6*(1-2), 93-113.

Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research, 64(*1), 1-35.

Collins, A., & Brown, J. S. (1988). The computer as a tool for learning through reflection. In H. Mandl & A. Lesgold (Eds.), *Learning issues for intelligent tutoring systems* (pp.1-18). New York: Springer-Verlag.

Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator, 6*(11), 38-46.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum Associates.

Coomarasamy, A., Taylor, R., & Khan, K. S. (2003). A systematic review of postgraduate teaching in evidence-based medicine and critical appraisal. *Medical Teacher, 25*(1), 77-81.

Corno, L. (1980). Individual and class level effects of parent-assisted instruction in classroom memory support strategies. *Journal of Educational Psychology, 72*(3), 278-292.

Corno, L. (2001). Volitional aspects of self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2nd ed., pp. 191-225). Mahwah, NJ: Lawrence Erlbaum Associates.

Corno, L., & Mandinach, E. B. (1983). The role of cognitive engagement in classroom learning and motivation. *Educational Psychologist, 18*(2), 88-108.

Creswell, J. W. (2005). *Educational research: Planning, conducting and evaluating quantitative and qualitative approaches to research* (2nd ed.). Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

de Jong, F., Kolloffel, B., van der Meijden, H., Staarman, J. K., & Janssen, J. (2005). Regulative processes in individual, 3D and computer supported cooperative learning contexts. *Computers in Human Behavior, 21*(4), 645-670.

Dolmans, D. H. J. M., & Schmidt, H. G. (2000). What directs self-directed learning in a problem-based curriculum? In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp.251-262). Mahwah, NJ: Lawrence Erlbaum Associates.

Dunbar, K. (1995). How scientists really reason: Scientific reasoning in real-world laboratories. In R. J. Sternberg & J. Davidson (Eds.), *The nature of insight* (pp. 365-395). Cambridge, MA: The MIT Press.

Dunning, D., Heath, C., & Suls, J. M. (2005). Flawed self-assessment: Implications for health, education, and the workplace [Special issue]. *Psychological Science in the Public Interest, 5*(3), 69-106.

Ebbert, J. O., Montori, V. M., & Schultz, H. J. (2001) The journal club in postgraduate medical education: A systematic review. *Medical Teacher, 23*(5), 455-461.

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *The Journal of the Learning Sciences, 8*(3&4), 391-450.

Edwards, R., White, M., Gray, J., & Fischbacher, C. (2001). Use of a journal club and letter-writing exercise to teach critical appraisal to medical undergraduates. *Medical Education, 35*(7), 691-694.

Elliot, A. J., & McGregor, H. A. (2001). A 2 × 2 achievement goal framework. *Journal of Personality and Social Psychology, 80*(3), 501-519.

Elliot, A. J., & Harackiewicz, J. M. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology, 70*(3), 461-475.

Engestrom, Y., & Cole, M. (1997). Situated cognition in search of an agenda. In D. Kirshner & J. A. Whitson (Eds.), *Situated cognition: Social, semiotic, and psychological perspectives* (pp. 301-309). Mahwah, NJ: Lawrence Erlbaum Associates.

Englert, C. S., Raphael, T. E., Anderson, L. M., Anthony, H. M., & Stevens, D. D. (1991). Making strategies and self-talk visible: Writing instruction in regular and special education classrooms. *American Educational Research Journal*, *28*(2), 337-372.

Eom, W., & Reiser, R. A. (2000). The effects of self-regulation and instructional control on performance and motivation in computer-based instruction. *International Journal of Instructional Media, 27*(3), 247-260.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data* (Rev. ed.). Cambridge, MA: The MIT Press.

Ertmer, P. A., Newby, T. J., & MacDougall, M. (1996). Students' responses and approaches to case-based instruction: The role of reflective self-regulation. *American Educational Research Journal, 33*(3), 719-752.

Evensen, D. H. (2000). Observing self-directed learners in a problem-based learning context: Two case studies. In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp. 263-298). Mahwah, NJ: Lawrence Erlbaum Associates.

Evensen, D. H., & Hmelo, C. E. (2000). *Problem-based learning: A research perspective on learning interactions*. Mahwah, NJ: Lawrence Erlbaum Associates.

Facione, P. A. (1990). Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction (The Delphi Rep. No. ED 315 423). Millbrae, CA: The California Academic Press.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), *The nature of intelligence* (pp. 231-235). Hillsdale, NJ: Lawrence Erlbaum Associates.

Flem, A., Moen, T., & Gudmundsdottir, G. (2004). Towards inclusive schools: A study of inclusive education in practice. *European Journal of Special Needs Education, 19*(1), 85-98.

Forester, J. P., Cole, M. S., Thomas, P. P., & McWhorter, D. L. (2007). Introducing critical appraisal of biomedical literature to first-year medical students in histology. *JIAMSE: Journal of the International Association of Medical Science Educators, 13*(1), 21-29.

Fritsche, L., Greenhalgh, T., Falck-Ytter, Y., Neumayer, H-H., & Kunz, R. (2002). Do short courses in evidence based medicine improve knowledge and skills? Validation of Berlin questionnaire and before and after study of courses in evidence based medicine. *BMJ: British Medical Journal, 325*(7376), 1338-1341.

Graesser, A. C., McNamara, D. S., & VanLehn, K. (2005). Scaffolding deep comprehension strategies through Point&Query, AutoTutor and iSTRAT. *Educational Psychologist, 40*(4), 225-234.

Graham, S., & Harris, K. R. (1989a). Components analysis of cognitive strategy instruction: Effects on learning disabled students' compositions and self-efficacy. *Journal of Educational Psychology, 81*(3), 353-361.

Graham, S., & Harris, K. R. (1989b). Improving learning disabled students' skills at composing essays: self-instructional strategy training. *Exceptional Children, 56*(3), 201-214.

Green, M. L. (1999). Graduate medical education training in clinical epidemiology, critical appraisal, and evidence-based medicine: A critical review of curricula. *Academic Medicine, 74*(6), 686-694.

Greene, J. A., & Azevedo, R. (2007a). Adolescents' use of self-regulatory processes and their relation to qualitative mental model shifts while using hypermedia. *Journal of Educational Computing Research*, *36*(2), 125-148.

Greene, J. A., & Azevedo, R. (2007b). A theoretical review of Winne and Hadwin's model of self-regulated learning: New perspectives and directions. *Review of Educational Research, 77*(3), 334-372.

Greene, J. A., Bolick, C. M., & Robertson, J. (2010). Fostering historical knowledge and thinking skills using hypermedia learning environments: The role of self-regulated learning. *Computer & Education, 54*(1), 230-243.

Greene, J. A., Moos, D. C., Azevedo, R., & Winters, F. I. (2008). Exploring differences between gifted and grade-level students' use of self-regulatory learning processes with hypermedia. *Computers & Education, 50*(3), 1069-1083.

Greenhalgh, T. (2001). Computer assisted learning in undergraduate medical education. *BMJ: British Medical Journal, 322*(7277), 40-44.

Guyatt, G. H., & Busse, J. W. (2006). The philosophy of evidence-based medicine. In V. M. Montori (Ed.), *Evidence-based endocrinology* (pp. 25-33), Totowa, NJ: Humana Press.

Guyatt, G. H., Cook, D., & Haynes, B. (2004). Evidence-based medicine has come a long way. *BMJ: British Medical Journal, 329*(7473), 990-991.

Hadwin, A. F., Jarvela, S., & Miller, M. (2011). Self-regulated, co-regulated, and socially shared regulation of learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 65-84). New York: Routledge.

Hadwin, A., & Oshige, M. (2011). Self-regulation, coregulation, and socially shared regulation: Exploring perspectives of social in self-regulated learning theory. *Teachers College Record, 113*(2), 240-264.

Hadwin, A. F., Wozney, L., & Pontin, O. (2005). Scaffolding the appropriation of self-regulatory activity: A socio-cultural analysis of changes in teacher-student discourse about a graduate research portfolio. *Instructional Science, 33*(5-6), 413-450.

Hakkarainen, K., Jarvela, S., Lipponen, L., & Lehtinen, E. (1998). Culture of collaboration in computer-supported learning: A Finnish perspective. *Journal of Interactive Learning Research, 9*(3/4), 271-288.

Hakkarainen, K., Lipponen, L., & Jarvela, S. (2002). Epistemology of inquiry and computer-supported collaborative learning. In T. Koschmann, R. Hall, & N. Miyake (Eds.), *CSCL 2: Carrying forward the conversation* (pp. 129-156). Mahwah, NJ: Lawrence Erlbaum associates.

Hakkarainen, K., Palonen, T., Paavola, S., & Lehtinen, E. (2004). *Communities of networked Expertise: Professional and educational perspective*. Oxford, UK: Elsevier.

Halpern, D. F. (1998). Teaching critical thinking for transfer across domains: Dispositions, skills, structure training, and metacognitive monitoring. *American Psychologist, 53*(4), 449-455.

Harris, K. R., & Graham, S. (1992). *Helping young writers master the craft: Strategy instruction and self-regulation in the writing process*. Cambridge, MA: Brookline Books.

Harris, K. R., & Graham, S. (1996). *Making the writing process work: Strategies for composition and self-regulation*. Cambridge, MA: Brookline Books.

Hatala, R., & Guyatt, G. (2002). Evaluating the teaching of evidence-based medicine. *JAMA: The Journal of the American Medical Association, 288*(9), 1110-1112.

Hatano, G., & Inagaki, K. (1991). Sharing cognition through collective comprehension activity. In L. B. Resnick, J. M. Levine & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 331-348). Washington, DC: American Psychological Association.

Hatano, G., & Inagaki, K. (1993). Desituating cognition through the construction of conceptual knowledge. In P. Light & G. Butterworth (Eds.), *Context and cognition: Ways of learning and knowing* (pp. 115-133). Hillsdale, NJ:

Lawrence Erlbaum Associates.

Hewitt, J. (2002). From a focus on tasks to a focus on understanding: The cultural transformation of a Toronto classroom. In T. Koschmann, R. Hall, & N. Miyake (Eds.), *CSCL 2: Carrying forward the conversation* (pp. 11-42). Mahwah, NJ: Lawrence Erlbaum associates.

Hirokawa, R. Y., & Pace, R. (1983). A descriptive investigation of the possible communication-based reasons for effective and ineffective group decision making. *Communication Monographs, 50*(4), 363-379.

Hmelo, C. E., & Lin, X. (2000). Becoming self-directed learners: Strategy development in problem-based learning. In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp. 227-250). Mahwah, NJ: Lawrence Erlbaum Associates.

Hofer, B. K., Yu, S. L., & Pintrich, P. R. (1998). Teaching college students to be self-regulated learners. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 57-85). New York: The Guilford Press.

Housand, A., & Reis, S. M. (2008). Self-regulated learning in reading: Gifted pedagogy and instructional setting. *Journal of Advanced Academics, 20*(1), 108-136.

Hulleman, C. S., Schrager, S. M., Bodmann, S. M., & Harackiewicz, J. M. (2010). A meta-analytic review of achievement goal measures: Different labels for the same constructs or different constructs with similar labels? *Psychological Bulletin, 136*(3), 422-449.

Hutchins, E. (1991). The social organization of distributed cognition. In L. B.

Resnick, J. M. Levine & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 283-307). Washington, DC: American Psychological Association.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: The MIT Press.

Iiskala, T., Vauras, M., & Lehtinen, E. (2004). Socially-shared metacognition in peer learning? *Hellenic Journal of Psychology, 1*(2), 147-178.

Iiskala, T., Vauras, M., Lehtinen, E., & Salonen, P. (2011). Socially shared metacognition of dyads of pupils in collaborative mathematical problem-solving processes. *Learning and Instruction, 21*(3), 379-393.

Jarvela, S. (1996). New models of teacher-student interaction: A critical review. *European Journal of Psychology of Education, 11*(3), 249-268.

Jarvela, S., & Salovaara, H. (2004). The interplay of motivational goals and cognitive strategies in a new pedagogical culture: A context-oriented and qualitative approach. *European Psychologist, 9*(4), 232-244.

Johnson, B. & Christensen, L. B. (2004). *Educational research: Quantitative, qualitative, and mixed approaches* (2nd ed.). Boston, London: Allyn and Bacon.

Jonassen, D. H., & Kwon, H. II (2001). Communication patterns in computer mediated versus face-to-face group problem solving. *Educational Technology Research and Development, 49*(1), 35-51.

Joo, Y.-J., Bong, M., & Choi, H.-J. (2000). Self-efficacy for self-regulated learning, academic self-efficacy, and Internet self-efficacy in web-based instruction. *Educational Technology Research and Development, 48*(2), 5-17.

Karasavvidis, I., Pieters, J. M., & Plomp, T. (2000). Investigating how secondary school students learn to solve correlational problems: Quantitative and qualitative discourse approaches to the development of self-regulation. *Learning and Instruction, 10*(3), 267-292.

Kellum, J. A., Rieker, J. P., Power, M., & Powner, D. J. (2000). Teaching critical appraisal during critical care fellowship training: A foundation for evidence-based critical care medicine. *Critical Care Medicine, 28*(8), 3067-3070.

Khan, K. S., & Gee, H. (1999). A new approach to teaching and learning in journal club. *Medical Teacher, 21*(3), 289-293.

King, A. (1992). Facilitating elaborative learning through guided student-generated questioning. *Educational Psychologist, 27*(1), 111-126.

King, A. (2002). Structuring peer interaction to promote high-level cognitive processing. *Theory into Practice, 41*(1), 33-39.

Kitcher, P. (1989). Explanatory unification and the causal structure of the world. In P. Kitcher & W. C. Salmon (Eds.), *Scientific explanation: Vol. 13. Minnesota studies in the philosophy of science* (pp. 410-505). Minneapolis: The University of Minnesota Press.

Kitcher, P. (1993). *The advancement of science: Science without legend, objectivity without illusions*. New York: Oxford University Press.

Kobayashi, K. (2007). The influence of critical reading orientation on external strategy use during expository text reading. *Educational Psychology, 27*(3), 363-375.

Koschmann, T. (Ed.). (1996). *CSCL: Theory and practice of an emerging* *paradigm*. Mahwah, NJ: Lawrence Erlbaum Associates.

Koschmann, T., Hall, R., & Miyake, N. (2002). *CSCL 2: Carrying forward the conversation*. Mahwah, NJ: Lawrence Erlbaum Associates.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behavior, 19*(3), 335-353.

Krueger, P. M. (2006). Teaching critical appraisal: A pilot randomized controlled outcomes trial in undergraduate osteopathic medical education. *JAOA: The Journal of the American Osteopathic Association, 106*(11), 658-662.

Ku, K. Y. L., & Ho, I. T. (2010). Metacognitive strategies that enhance critical thinking. *Metacognition and Learning, 5*(3), 251-267.

Kumpulainen, K., & Kaartinen, S. (2003). The interpersonal dynamics of collaborative reasoning in peer interactive dyads, *The Journal of Experimental Education, 71*(4), 333-370.

Kuppersmith, R. B., Stewart, M. G., Ohlms, L. A., & Coker, N. J. (1997). Use of an Internet-based journal club. *Otolaryngology - Head and Neck Surgery, 116*(4), 497-498.

Kyza, E. A., Constantinou, C. P., & Spanoudis, G. (2011). Sixth graders' co-construction of explanations of a disturbance in an ecosystem: Exploring relationships between grouping, reflective scaffolding, and evidence-based explanations, *International Journal of Science Education, 33*(18), 2489-2525.

Lajoie, S. P. (2009). Developing professional expertise with a cognitive apprenticeship model: Examples from avionics and medicine. In K. A. Ericsson (Ed.), *Development of professional expertise: Toward measurement of expert performance and design of optimal learning environments* (pp.61-83). New York: Cambridge University Press.

Lajoie, S. P., & Azevedo, R. (2006). Teaching and learning in technology-rich environments. In P. Alexander & P. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 803-821). Mahwah, NJ: Lawrence Erlbaum Associates.

Lajoie, S. P., Garcia, B. C., Berdugo, G. C., Marquez, L., Espindola, S., & Nakamura, C. (2006). The creation of virtual and face-to-face learning communities: An international collaboration experience. *Journal of Educational Computing Research, 35*(2), 163-180.

Lajoie, S. P., & Lesgold, A. (1989). Apprenticeship training in the workplace: A computer-coached practice environment as a new form of apprenticeship. *Machine-Mediated Learning, 3*(1)*,* 7-28.

Lajoie, S. P., & Lu, J. (2011). Supporting collaboration with technology: Does shared cognition lead to co-regulation in medicine? *Metacognition and Learning.*

Lamon, M., Secules, T., Petrosino, A. J., Hackett, R., Bransford, J. D., & Goldman, S. R. (1996). Schools for thought: Overview of the project and lessons learned from one of the sites. In L. Schauble & R. Glaser (Eds.), *Innovations in learning: New environments for education* (pp. 243-288). Mahwah, NJ: Lawrence Erlbaum Associates.

Last, J. M. (Ed.). (2001). *A dictionary of epidemiology* (4th ed.). New York:

Oxford University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.

Lehtinen, E. (2003). Computer-supported collaborative learning: An approach to powerful learning environments. In E. De Corte, L. Verschaffel, N. Entwistle, & J. van Merrieboer (Eds.), *Powerful learning environments: Unravelling basic components and dimensions* (pp. 35-53). Oxford, UK: Pergamon.

Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M., & Muukkonen, H. (2000). Computer supported collaborative learning: a review. In H. van der Meijden, P. R. J. Simons, & F. de Jong (Eds.), *Computer supported learning networks in primary and secondary education, Project 2017* (pp. 1-46). Nijmegen, The Netherlands: University of Nijmegen.

Lehtinen, E., & Repo, S. (1996). Activity, social interaction, and reflective abstraction: Learning advanced mathematical concepts in a computer environment. In S. Vosniadou, E. De Corte, R. Glaser & H. Mandl (Eds.), *International perspectives on the design of technology-supported learning environments* (105-128). Mahwah, NJ: Lawrence Erlbaum Associates.

Lesgold, A. (1998). Multiple representations and their implications for learning. In M. W. van Someren, P. Reimann, H. P. A. Boshuizen & T. de Jong (Eds.), *Learning with multiple representations* (pp. 307-319). Amsterdam: Pergamon.

Lester, F. K., Garofalo, J., & Kroll, D. L. (1989). *The role of metacognition in mathematical problem solving: A study of two grade seven classes*. (Final report, NSF project MDR 85-50346). Bloomington: Indiana University, Mathematics Education Development Center.

Letterie, G. S., & Morgenstern, L. S. (2000). The journal club. Teaching critical evaluation of clinical literature in an evidence-based environment. *The Journal of Reproductive Medicine, 45*(4), 299-304.

Linn, M. C., Bell, P., & Hsi, S. (1998). Using the Internet to enhance student understanding of science: The knowledge integration environment. *Interactive Learning Environments*, *6*(1-2), 4-38.

Linderholm, T., & van den Broek, P. (2002). The effects of reading purpose and working memory capacity on the processing of expository text. *Journal of Educational Psychology, 94*(4), 778-784.

Linnenbrink, E. A., & Pintrich, P. R. (2002). Achievement goal theory and affect: An asymmetrical bidirectional model. *Educational Psychologist, 37*(2), 69-78.

Linnenbrink, E. A., & Pintrich, P. R. (2004). Role of affect in cognitive processing in academic contexts. In D. Y. Dai & R. J. Sternberg (Eds.), *Motivation, emotion, and cognition: Integrative perspectives on intellectual functioning and development* (pp. 57-87). Mahwah, NJ: Lawrence Erlbaum Associates.

Linzer, M., Brown, J. T., Frazier, L. M., DeLong, E. R., & Sieigel, W. C. (1988). Impact of a medical journal club on house-staff reading habits, knowledge and critical appraisal skills: A randomized control trail. *Journal of the American Medical Association, 260*(17), 2537–2541.

Lipnevich, A. A., & Smith, J. K. (2007, April). *Russian and American perspectives on self-regulated learning*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Lipponen, L., Hakkarainen, K., & Paavola, S. (2004). Practices and orientations of CSCL. In J.-W. Strijbos, P. A. Kirschner, & R. L. Martens (Eds.), *What we know about CSCL: And implementing it in higher education* (pp. 31-50). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Lonka, K., Lindblom-Ylanne, S., & Maury, S. (1994). The effect of study strategies on learning from text. *Learning and Instruction, 4*(3), 253-271.

Lu, J., & Lajoie, S. P. (2008). Supporting medical decision making with argumentation tools. *Contemporary Educational Psychology, 33*(3), 425-442.

MacGregor, S. K. (1999). Hypermedia navigation profiles: Cognitive characteristics and information processing strategies. *Journal of Educational Computing Research, 20*(2), 189-206.

MacRae, H. M., Regehr, G., McKenzie M., Henteleff, H., Taylor, M., Barkun, J., et al. (2004). Teaching practicing surgeons critical appraisal skills with an Internet-based journal club: A randomized, controlled trial. *Surgery, 136*(3), 641-646.

Magno, C. (2010). The role of metacognitive skills in developing critical thinking. *Metacognition and Learning, 5*(2), 137-156.

Maki, R. (1998). Test predictions over text material. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp.117-144). Mahwah, NJ: Lawrence Erlbaum Associates.

Markert, R. J. (1989). A research methods and statistics journal club for residents. *Academic Medicine, 64*(4), 223-224.

Marttunen, M., & Laurinen, L. (2001). Learning of argumentation skills in networked and face-to-face environments. *Instructional Science, 29*(2), 127-153.

McCaslin, M. (2009). Co-regulation of student motivation and emergent identity. *Educational Psychologist, 44*(2), 137-146.

McCaslin, M., & Burross, H. L. (2011). Research on individual differences within a sociocultural perspective: Co-regulation and adaptive learning. *Teachers College Record, 113*(2), 325-349.

McCaslin, M., Good, T. L., Nichols, S., Zhang, J., Wiley, C. R. H., Bozack, A. R., et al. (2006). Comprehensive school reform: An observational study of teaching in Grades 3 to 5. *The Elementary School Journal, 106*(4), 313-331.

McCaslin, M., & Hickey, D. T. (2001). Educational psychology, social constructivism, and educational practice: A case of emergent identity. *Educational Psychologist, 36*(2), 133-140.

McManus, T. F. (2000). Individualizing instruction in a web-based hypermedia learning environment: Nonlinearity, advance organizers, and self-regulated learners. *Journal of Interactive Learning Research, 11*(3), 219-251.

Mead, G. H. (1977). *On social psychology: Selected papers*. Edited by A. Strauss. Chicago: The University of Chicago Press.

Meyer, D. K., & Turner, J. C. (2002). Using instructional discourse analysis to study the scaffolding of student self-regulation. *Educational Psychologist, 37*(1), 17-25.

Meyer, K. A. (2003). Face-to-face versus threaded discussions: The role of time and higher-order thinking. *The Journal of Asynchronous Learning Networks,* *7*(3), 55-65.

Miller, T. M., & Geraci, L. (2011). Unskilled but aware: Reinterpreting overconfidence in low-performing students. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*(2), 502-506.

Moberg-Wolff, E. A., & Kosasih, J. B. (1995). Journal clubs: Prevalence, format and efficacy in PM & R. *American Journal of Physical Medicine & Rehabilitation, 74*(3), 224-229.

Moharari, R. S., Rahimi, E., Najafi, A., Khashayar, P., Khajavi, M. R., & Meysamie, A. P. (2009). Teaching critical appraisal and statistics in anesthesia journal club. *QJM: An International Journal of Medicine, 102*(2), 139-141.

Moos, D. C., & Azevedo, R. (2006). The role of goal structure in undergraduates' use of self-regulatory processes in two hypermedia learning tasks. *Journal of Educational Multimedia and Hypermedia, 15*(1), 49-86.

Moos, D. C., & Azevedo, R. (2008a). Monitoring, planning, and self-efficacy during learning with hypermedia: The impact of conceptual scaffolds. *Computers in Human Behavior, 24*(4), 1686-1706.

Moos, D. C., & Azevedo, R. (2008b). Self-regulated learning with hypermedia: The role of prior domain knowledge. *Contemporary Educational Psychology, 33*(2), 270-298.

Mulhall, A. (1997). Nursing research: Our world not theirs? *Journal of Advanced Nursing, 25*(5), 969-976.

Narciss, S., Proske, A., & Koerndle, H. (2007). Promoting self-regulated learning in web-based learning environments. *Computers in Human Behavior, 23*(3), 1126-1144.

Nesbit, J. C., Winne, P. H., Jamieson-Noel, D., Code, J., Zhou, M., MacAllister, K., et al. (2006). Using cognitive tools in gStudy to investigate how study activities covary with achievement goals. *Journal of Educational Computing Research, 35*(4), 339-358.

Newman, R. (1994). Academic help-seeking: A strategy of self-regulated learning. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 283-301). Hillsdale, NJ: Lawrence Erlbaum Associates.

Norman, D. A. (1993). *Things that make us smart: Defending human attributes in the age of the machine*. New York: Addison-Wesley.

Norman, G. R. (l988). Problem-solving skills, solving problems and problem-based learning. *Medical Education, 22*(4), 279-286.

Norman, G. R., & Schmidt, H. G. (1992). The psychological basis of problem-based learning: A review of the evidence. *Academic Medicine, 67*(9), 557-565.

Norman, G. R., & Shannon, S. I. (1998). Effectiveness of instruction in critical appraisal (evidence-based medicine) skills: A critical appraisal. *CMAJ: Canadian Medical Association Journal, 158*(2), 177-181.

Nussbaum, E. M., Hartley, K., Sinatra, G. M., Reynolds, R. E., & Bendixen, L. D. (2002, April). *Enhancing the quality of on-line discussions*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Palincsar, A. S., & Brown, A. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, *1*(2), 117-175.

Paris, S. G., & Byrnes, J. P. (1989). The constructivist approach to self-regulation and learning in the classroom. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theory, research, and practice* (pp. 168-200). New York: Springer-Verlag.

Paris, S. G., Cross, D. R., & Lipson, M. Y. (1984). Informed strategies for learning: A program to improve children's reading awareness and comprehension. *Journal of Educational Psychology*, *76*(6), 1239-1252.

Paris, S. G., & Paris, A. H. (2001). Classroom applications of research on self-regulated learning. *Educational Psychologist, 36*(2), 89-101.

Parkes, J., Hyde, C., Deeks, J., & Milne, R. (2001). Teaching critical appraisal skills in health care settings. *Cochrane Database of Systematic Reviews, 3*, 1-16.

Patrick, H., & Middleton, M. J. (2002). Turning the kaleidoscope: What we see when self-regulated learning is viewed with a qualitative lens. *Educational Psychologist, 37*(1), 27-39.

Paul, R., & Elder, L. (2008). *The miniature guide to critical thinking: Concepts and tools* (4th ed.). Dillon Beach, CA: The Foundation for Critical Thinking.

Paul, R., & Elder, L. (2009). *The miniature guide to critical thinking: Concepts and tools* (5th ed.). Dillon Beach, CA: The Foundation for Critical Thinking.

Pea, R. D. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 47-87). Cambridge, UK: Cambridge University Press.

Pea, R. D. (1994). Seeing what we build together: Distributed multimedia learning environments for transformative communications. *The Journal of the Learning Sciences, 3*(3), 285-299.

Pea, R. D., Tinker, R., Linn, M., Means, B., Bransford, J., Roschelle, J., et al. (1999). Toward a learning technologies knowledge network. *Educational Technology Research and Development, 47*(2), 19-38.

Perkins, D. N. (1993). Person-plus: A distributed view of thinking and learning. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 88-110). Cambridge, UK: Cambridge University Press.

Perkins, D. N., & Simmons, R. (1988). Patterns of misunderstanding: An integrative model for science, math, and programming. *Review of Educational Research, 58*(3), 303-326.

Perry, N. E., & Winne, P. H. (2006) Learning from Learning Kits: gStudy traces of students' self-regulated engagements with computerized content. *Educational Psychology Review, 18*(3), 211-228.

Peterson, P. L., Wilkinson, L. C., Spinelli, F., & Swing, S. R. (1984). Merging the process-product and sociolinguistic paradigms: Research on small group processes. In P. L. Peterson, L. C. Wilkinson, & M. T. Hallinan (Eds.), *The social context of instruction: Group organization and group processes* (pp. 126-152). New York: Academic Press.

Phitayakorn, R., Gelula, M. H., & Malangoni, M. A. (2007). Surgical journal clubs: A bridge connecting experiential learning theory to clinical practice. *Journal of the American College of Surgeons, 204*(1), 158-163.

Pintrich, P. R. (2000a). Multiple goals, multiple pathways: The role of goal orientation in learning and achievement. *Journal of Educational Psychology, 92*(3), 544-555.

Pintrich, P. R. (2000b). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 451-502). San Diego, CA: Academic Press.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology, 95*(4), 667-686.

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review, 16*(4), 385-407.

Pintrich, P. R., Anderman, E. M., & Klobucar, C. (1994). Intraindividual differences in motivation and cognition in students with and without learning disabilities. *Journal of Learning Disabilities, 27*(6), 360-370.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*(1), 33-40.

Pintrich, P. R., Roeser, R. W., & De Groot, E. A. M. (1994). Classroom and individual differences in early adolescents' motivation and self-regulated learning. *The Journal of Early Adolescence, 14*(2), 139-161.

Pintrich, P. R., & Schrauben, B. (1992). Students' motivational beliefs and their cognitive engagement in classroom academic tasks. In D. H. Schunk & J. L. Meece (Eds.), Student perceptions in the classroom (pp.149-183). Hillsdale, NJ: Lawrence Erlbaum Associates.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. Ann Arbor: University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement, 53*, 801-813.

Pintrich, P. R., Wolters, C. A., & Baxter, G. P. (2000). Assessing metacognition and self-regulated learning. In G. J. Schraw & J. C. Impara (Eds.), *Issues in the measurement of metacognition* (pp. 43-97). Lincoln, NE: Buros Institute of Mental Measurements, University of Nebraska-Lincoln.

Pintrich, P. R., & Zusho, A. (2002). The development of academic self-regulation: the role of cognitive and motivational factors. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 249-284). San Diego, CA: Academic Press.

Plastow, N. A., & Boyes, C. (2006). Unidisciplinary continuing professional development in a multidisciplinary world: Experiences from practice. *Work Based Learning in Primary Care, 4*(4), 322-344.

Pokay, P., & Blumenfeld, P. C. (1990). Predicting achievement early and late in the semester: The role of motivation and use of learning strategies. *Journal of Educational Psychology, 82*(1), 41-50.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models.

Behavior Research Methods, 40(3), 879-891.

Pressley, M., Almasi, J., Schuder, T., Bergman, J., Hite, S., El-Dinary, P. B., et al. (1994). Transactional instruction of comprehension strategies: The Montgomery County, Maryland, SAIL program. *Reading and Writing Quarterly: Overcoming Learning Difficulties*, *10*(1), 5-19.

Pressley, M., EI-Dinary, P. B., Wharton-McDonald, R., & Brown, R. (1998). Transactional instruction of comprehension strategies in the elementary grades. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 42-56). New York: The Guilford Press.

Pressley, M., & Ghatala, E. S. (1990). Self-regulated learning: Monitoring learning from text. *Educational Psychologist, 25*(1), 19-33.

Pressley, M., & Harris, K. R. (2006). Cognitive strategies instruction: From basic research to classroom instruction. In P. Alexander & P. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 264-286). Mahwah, NJ: Lawrence Erlbaum.

Proske, A., Narciss, S., & Korndle, H. (2007). Interactivity and learners' achievement in web-based learning. *Journal of Interactive Learning Research, 18*(4), 511-531.

Puustinen, M., & Pulkkinen, L. (2001). Models of self-regulated learning: A review. *Scandinavian Journal of Educational Research, 45*(3), 269-286.

Quintana, C., Zhang, M., & Krajcik, J. (2005). A framework for supporting metacognitive aspects of online inquiry through software-based scaffolding. *Educational Psychologist, 40*(4), 235-244.

Rahikainen, M., Jarvela, S., & Salovaara, H. (2000). Motivational processes in CSILE-based learning. In B. Fishman & S. O'Connor-Divelbiss (Eds.), *Proceedings of the Fourth International Conference of the Learning Sciences* (pp. 50-51). Mahwah, NJ: Lawrence Erlbaum Associates.

Resnick, L. B. (1991). Shared cognition: Thinking as social practice. In L. B. Resnick, J. M. Levine & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 1-20). Washington, DC: American Psychological Association.

Resnick, L. B., Saljo, R., Pontecorvo, C., & Burge, B. (1997). *Discourse, tools, and reasoning: Essays on situated cognition.* Berlin: Springer-Verlag.

Resta, P., & Laferriere, T. (2007). Technology in support of collaborative learning. *Educational Psychology Review, 19*(1), 65-83.

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: A systematic review and meta-analysis. *Psychological Bulletin, 138*(2), 353-387.

Roschelle, J. (1992). Learning by collaborating: Convergent conceptual change. *Journal of the Learning Sciences, 2*(3), 235-276.

Roschelle, J., & Pea, R. (1999). Trajectories from today's WWW to a powerful educational infrastructure. *Educational Researcher, 28*(5), 22-25.

Rosenberg, W., & Donald, A. (1995). Evidence based medicine: An approach to clinical problem solving. *BMJ: British Medical Journal, 310*(6987), 1122-1126.

Saab, N., van Joolingen, W. R., & van Hout-Wolters, B. H. (2005). Communication in collaborative discovery learning. *British Journal of*

Educational Psychology, 75(4), 603-621.

Sackett, D. L., & Parkes, J. (1998). Teaching critical appraisal: No quick fixes. *CMAJ: Canadian Medical Association Journal, 158*(2), 203-204.

Sackett, D. L., Rosenberg, W. M. C., Muir Gray, J. A., Haynes, R. B., & Richardson, W. S. (1996). Evidence based medicine: What it is and what it isn't. *BMJ: British Medical Journal, 312*(7023), 71-72.

Salomon, G. (1993). No distribution without individuals' cognition: A dynamic interactional view. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 111-138). Cambridge, UK: Cambridge University Press.

Salomon, G., Perkins, D. N., & Globerson, T. (1991). Partners in cognition: Extending human intelligence with intelligent technologies. *Educational Researcher*, *20*(3), 2-9.

Salovaara, H. (2005). An exploration of students' strategy use in inquiry-based computer-supported collaborative learning. *Journal of Computer Assisted Learning, 21*(1), 39-52.

Salovaara, H., & Jarvela, S. (2003). Students' strategic actions in computer-supported collaborative learning. *Learning Environments research, 6*(3), 267-284.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *The Journal of the Learning Sciences, 3*(3), 265-283.

Schoenfeld, A. H. (1985). *Mathematical problem solving.* Orlando, FL: Academic Press.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334-370). New York: Macmillan.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology, 82*(3), 498-504.

Schumm, J. S., & Post, S. A. (1996). *Executive learning: Successful strategies for college reading and studying.* Englewood Cliffs, NJ: Prentice Hall.

Schunk, D. H. (1994). Self-regulation of self-efficacy and attributions in academic settings. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 75-99). Hillsdale, NJ: Lawrence Erlbaum Associates.

Schunk, D. H. (1996). Goal and self-evaluative influences during children's cognitive skill learning. *American Educational Research Journal, 33*(2), 359-382.

Schunk, D. H. (2001). Social cognitive theory and self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2nd ed., pp. 125-151). Mahwah, NJ: Lawrence Erlbaum Associates.

Schunk, D. H. (2005a). Commentary on self-regulation in school contexts. *Learning and Instruction, 15*(2), 173-177.

Schunk, D. H. (2005b). Self-regulated learning: The educational legacy of Paul R. Pintrich. *Educational Psychologist, 40*(2), 85-94.

Schunk, D. H., & Ertmer, P. A. (1999). Self-regulatory processes during computer skill acquisition: Goal and self-evaluative influences. *Journal of Educational Psychology, 91*(2), 251-260.

Schunk, D. H., & Ertmer, P. A. (2000). Self-regulation and academic learning: Self-efficacy enhancing interventions. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 631-649). San Diego, CA: Academic Press.

Schunk, D. H., & Swartz, C. W. (1993). Goals and progress feedback: Effects on self-efficacy and writing achievement. *Contemporary Educational Psychology, 18*(3), 337-354.

Schunk, D. H., & Zimmerman, B. J. (1997). Social origins of self-regulatory competence. *Educational Psychologist, 32*(4), 195-208.

Schunk, D. H., & Zimmerman, B. J. (Eds.). (1998). *Self-regulated learning: From teaching to self-reflective practice*. New York: The Guilford Press.

Schunk, D. H., & Zimmerman, B. J. (2007). Influencing children's self-efficacy and self-regulation of reading and writing through modeling. *Reading & Writing Quarterly, 23*(1), 7-25.

Schunk, D. H., & Zimmerman, B. J. (Eds.). (2008). *Motivation and self-regulated learning: Theory, research, and applications*. New York: Lawrence Erlbaum Associates.

Scriven, M., & Paul, R. (1987). *Defining critical thinking*. Retrieved November 5, 2008, from http://www.criticalthinking.org/aboutCT/define_critical_thinking.cfm

Seymour, B., Kinn, S., & Sutherland, N. (2003). Valuing both critical and creative thinking in clinical practice: Narrowing the research-practice gap? *Journal of*

Advanced Nursing, 42(3), 288-296.

Shapiro, A., & Niederhauser, D. (2004). Learning from hypertext: Research issues and findings. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology* (2nd ed., pp. 605-620). Mahwah, NJ: Lawrence Erlbaum Associates.

Sidorov, J. (1995). How are internal medicine residency journal clubs organized, and what makes them successful? *Archives of Internal Medicine, 155*(11), 1193-1197.

Smith, L. E., Borkowski, J. G., & Whitman, T. L. (2008). From reading readiness to reading competence: The role of self-regulation in at-risk children. *Scientific Studies of Reading, 12*(2), 131-152.

Snow, R. E., Corno, L., & Jackson, D. III (1996). Individual differences in affective and conative functions. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology*, (pp. 243-310). New York: Simon & Shuster Macmillan.

Souvignier, E., & Mokhlesgerami, J. (2006). Using self-regulation as a framework for implementing strategy instruction to foster reading comprehension. *Learning and Instruction, 16*(1), 57-71.

Spivey, N. N. (1997). *The constructive metaphor: Reading, writing, and the making of meaning*. New York: Academic Press.

Stacey, R., & Spencer, J. (2000). Assessing the evidence in qualitative medical education research. *Medical Education, 34*(7), 498-500.

Stahl, E., Pieschl, S., & Bromme, R. (2006). Task complexity, epistemological beliefs and metacognitive calibration: An exploratory study. *Journal of*

Educational Computing Research, 35(4), 319-338.

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: The MIT Press.

Stahl, G., Koschmann, T., & Suthers, D. D. (2006). Computer-supported collaborative learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 409-426). New York: Cambridge University Press.

Stone, L. D., & Gutierrez, K. D. (2007). Problem articulation and the processes of assistance: An activity theoretic view of mediation in game play. *International Journal of Educational Research, 46*(1-2), 43-56.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Thousand Oaks, CA: Sage.

Sweller, J. (2006). The worked example effect and human cognition. *Learning and Instruction, 16*(2), 165-169.

Sweller, J., & Sweller, S. (2006). Natural information processing systems. *Evolutionary Psychology, 4*, 434-458.

Swing, S. R., & Peterson, P. L. (1982). The relationship of student ability and small-group interaction to student achievement. *American Educational Research Journal, 19*(2), 259-274.

Taylor, R., Reeves, B., Ewings, P., Binns, S., Keast, J., & Mears, R. (2000). A systematic review of the effectiveness of critical appraisal skills training for clinicians. *Medical Education, 34*(2), 120-125.

Taylor, R. S., Reeves, B. C., Ewings, P. E., & Taylor, R. J. (2004). Critical appraisal skills training for health care professionals: A randomized controlled trial. *BMC Medical Education, 4*(1), 30-39.

Tourangeau, R., Rips, L. J., & Rasinski, K. (2000). *The psychology of survey response*. Cambridge, UK: Cambridge University Press.

van Boxtel, C. (2000). *Collaborative concept learning: Collaborative learning tasks, student interaction, and the learning of physics concepts*. Unpublished Doctoral thesis, Utrecht University, Utrecht, the Netherlands.

VanderStoep, S. W., & Pintrich, P. R. (2003). *Learning to learn: The skill and will of college success*. Upper Saddle River, NJ: Prentice Hall.

Vauras, M., Iiskala, T., Kajamies, A., Kinnunen, R., & Lehtinen, E. (2003). Shared-regulation and motivation of collaborating peers: A case analysis. *Psychologia: An International Journal of Psychological Sciences, 46*(1), 19-37.

Verschaffel, L., De Corte, E., Lasure, S., van Vaerenbergh, G., Bogaerts, H., & Ratinckx, E. (1999). Learning to solve mathematical application problems: A design experiment with fifth graders. *Mathematical Thinking and Learning, 1*(3), 195-229.

Volet, S., Summers, M., & Thurman, J. (2009). High-level co-regulation in collaborative learning: How does it emerge and how is it sustained? *Learning and Instruction 19*(2), 128-143.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Webb, N. M. (1991). Task-related verbal interaction and mathematics learning in small groups. *Journal for Research in Mathematics Education, 22*(5), 366-389.

Webb, N. M., Troper, J. D., & Fall, R. (1995). Constructive activity and learning in collaborative small groups. *Journal of Educational Psychology, 87*(3), 406-423.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.

Wenger, E. (2000) Communities of practice: The key to knowledge strategy. In E. L. Lesser, M. A. Fontaine & J. A. Slusher (Eds.), *Knowledge and communities* (pp. 3-20). Boston, MA: Butterworth-Heinemann.

Wertsch, J. V., & Stone, C. A. (1985). The concept of internalization in Vygotsky's account of the genesis of higher mental functions. In J. V. Wertsch (Ed.), *Culture, communication, and cognition: Vygotskian perspectives* (pp. 162-179). New York: Cambridge University Press.

Whipp, J. L., & Chiarelli, S. (2004). Self-regulation in a web-based course: A case study. *Educational Technology Research and Development, 52*(4), 5-22.

White, B., & Frederiksen, J. (2005). A theoretical framework and approach for fostering metacognitive development. *Educational Psychologist, 40*(4), 211-223.

Whitebread, D., Bingham, S., Grau, V., Pasternak, D. P., & Sangster, C. (2007). Development of metacognition and self-regulated learning in young children: Role of collaborative and peer-assisted learning. *Journal of Cognitive Education and Psychology, 6*(3), 433-455.

Williams, P. E., & Hellman, C. M. (2004). Differences in self-regulation for online learning between first- and second-generation college students. *Research in Higher Education, 45*(1), 71-82.

Winne, P. H. (1995). Inherent details in self-regulated learning. *Educational Psychologist, 30*(4), 173-187.

Winne, P. H. (1996). A metacognitive view of individual differences in self-regulated learning. *Learning and Individual Differences, 8*(4), 327-353.

Winne, P. H. (1997). Experimenting to bootstrap self-regulated learning. *Journal of Educational Psychology, 89*(3), 397-410.

Winne, P. H. (2001). Self-regulated learning viewed from models of information processing. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2nd ed., pp. 153-189). Mahwah, NJ: Lawrence Erlbaum Associates.

Winne, P. H. (2004). Students' calibration of knowledge and learning processes: Implications for designing powerful software learning environments. *International Journal of Educational Research, 41*(6), 466-488.

Winne, P. H. (2006). How software technologies can improve research on learning and bolster school reform. *Educational Psychologist, 41*(1), 5-17.

Winne, P. H. (2011). A cognitive and metacognitive analysis of self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 15-32). New York: Routledge.

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277-304). Mahwah, NJ: Lawrence Erlbaum Associates.

Winne, P. H., & Hadwin, A. F. (2008). The weave of motivation and self-regulated learning. In D. H. Schunk & B. J. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and applications* (pp. 297-314). New York: Lawrence Erlbaum Associates.

Winne, P. H., Hadwin, A. F., & Beaudoin, L. (2009). nStudy: A web application for researching and promoting self-regulated learning (Version 0.8) [Computer program]. Burnaby, BC, Canada: Simon Fraser University.

Winne, P. H., & Jamieson-Noel, D. (2002). Exploring students' calibration of self reports about study tactics and achievement. *Contemporary Educational Psychology, 27*(4), 551-572.

Winne, P. H., & Jamieson-Noel, D. (2003). Self-regulating studying by objectives for learning: Students' reports compared to a model. *Contemporary Educational Psychology, 28*(3), 259-276.

Winne, P. H., Jamieson-Noel, D., & Muis, K. (2002). Methodological issues and advances in researching tactics, strategies, and self-regulated learning. In P. R. Pintrich & M. L. Maehr (Eds.), *Advances in motivation and achievement: Vol. 12. New directions in measures and methods* (pp. 121-155). Oxford, England: Elsevier Science Ltd.

Winne, P. H., & Nesbit, J. C. (2009). Supporting self-regulated learning with cognitive tools. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of metacognition in education* (pp. 259-277). New York: Routledge.

Winne, P. H., Hadwin, A. F., Nesbit, J. C., Kumar, V., & Beaudoin, L. (2005). gStudy: A toolkit for developing computer-supported tutorials and researching learning strategies and instruction (Version 2.0) [Computer program]. Burnaby, BC, Canada: Simon Fraser University.

Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 531-566). San Diego, CA: Academic Press.

Winne, P. H., & Stockley, D. B. (1998). Computing technologies as sites for developing self-regulated learning. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 106-136). New York: The Guilford Press.

Winsler, A., Diaz, R. M., Atencio, D. J., McCarthy, E. M., & Chabay, L. A. (2000). Verbal self-regulation over time in preschool children at risk for attention and behavior problems. *Journal of Child Psychology and Psychiatry, 41*(7), 875-886.

Winsler, A., Diaz, R. M., McCarthy, E. M., Atencio, D. J., & Chabay, L. A. (1999). Mother-child interaction, private speech, and task performance in preschool children with behavior problems. *Journal of Child Psychology and Psychiatry, 40*(6), 891-904.

Winters, F. I., & Azevedo, R. (2005). High-school students' regulation of learning during computer-based science inquiry. *Journal of Educational Computing Research, 33*(2), 189-217.

Winters, F. I., Greene, J. A., & Costich, C. M. (2008). Self-regulation of learning within computer-based learning environments: A critical analysis. *Educational Psychology Review, 20*(4), 429-444.

Wolff, N. (2001). Randomised trials of socially complex interventions: Promise or peril? *Journal of Health Services Research and Policy, 6*(2), 123-126.

Wolters, C. A., & Rosenthal, H. (2000). The relation between students' motivational beliefs and their use of motivational regulation strategies. *International Journal of Educational Research, 33*(7-8), 801-820.

Wolters, C. A., Yu, S. L., & Pintrich, P. R. (1996). The relation between goal orientation and students' motivational beliefs and self-regulated learning. *Learning and Individual Differences, 8*(3), 211-238.

Yin, R. K. (2003). *Case study research: Design and methods.* Thousand Oaks, CA: Sage.

Young, J. D. (1996). The effect of self-regulated learning strategies on performance in learner controlled computer-based instruction. *Educational Technology Research and Development, 44*(2), 17-27.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology, 81*(3), 329-339.

Zimmerman, B. J. (1990a). Self-regulated learning and academic achievement: An overview. *Educational Psychology, 25*(1), 3-17.

Zimmerman, B. J. (1990b). Self-regulating academic learning and achievement: The emergence of a social cognitive perspective. *Educational Psychology Review, 2*(2), 173-201.

Zimmerman, B. J. (1994). Dimensions of academic self-regulation: A conceptual framework for education. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 5-21). Hillsdale, NJ: Lawrence Erlbaum Associates.

Zimmerman, B. J. (1995). Self-regulation involves more than metacognition: A social cognitive perspective. *Educational Psychologist, 30*(4), 217-221.

Zimmerman, B. J. (1998a). Academic studying and the development of personal skill: A self-regulatory perspective. *Educational Psychologist, 33*(2-3), 73-86.

Zimmerman, B. J. (1998b). Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instructional models. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 1-19). New York: The Guilford Press.

Zimmerman, B. J. (2000a). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13-39). San Diego, CA: Academic Press.

Zimmerman, B. J. (2000b). Self-efficacy: The essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82-91.

Zimmerman, B. J. (2001). Theories of self-regulated learning and academic achievement: An overview and analysis. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2nd ed., pp. 1-37). Mahwah, NJ: Lawrence Erlbaum Associates.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice, 41*(2), 64-70.

Zimmerman, B. J. (2004). Sociocultural influence and students' development of academic self-regulation: A social-cognitive perspective. In D. M. McInerney & S. Van Etten (Eds.), *Research on sociocultural influences on motivation and learning: Vol. 4. Big theories revisited* (pp. 139-164). Greenwich, CT: Information Age Publishing.

Zimmerman, B. J. (2008a). Goal setting: A key proactive source of academic self-regulation. In D. H. Schunk & B. J. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and applications* (pp. 267-295). New York: Lawrence Erlbaum Associates.

Zimmerman, B. J. (2008b). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal, 45*(1), 166-183.

Zimmerman, B. J., & Bandura, A. (1994). Impact of self-regulatory influences on writing course attainment. *American Educational Research Journal*, *31*(4), 845-862.

Zimmerman, B. J., & Martinez-Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal, 23*(4), 614-628.

Zimmerman, B. J., & Martinez-Pons, M. (1988). Construct validation of a strategy model of student self-regulated learning. *Journal of Educational Psychology, 80*(3), 284-290.

Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology, 82*(1), 51-59.

Zimmerman, B. J., & Paulsen, A. S. (1995). Self-monitoring during collegiate studying: An invaluable tool for academic self-regulation. In P. R. Pintrich (Ed.), *Understanding self-regulated learning: New directions in college teaching and learning* (No. 63, pp. 13-27). San Francisco, CA: Jossey-Bass.

Zimmerman, B. J., & Schunk, D. H. (2011). Self-regulated learning and performance: An introduction and an overview. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 1-12). New York: Routledge.

APPENDICES

Appendix A: Self-Regulated Learning - Forethought Questionnaire

Name: **Date:**

Please answer a few questions about how you view the task you are about to start. Read every statement and circle the number that best describes your thoughts.

If a statement is **very true** of you, circle **5**.
If a statement is **not at all true** of you, circle **1**.
If a statement is more or less true of you, circle the number between **2** and **4** that best describes you.

The task you will be asked to perform is to read a medical research article online and analyze it critically.

1. I am certain that I can understand the entire article although it might be very complex.

1	2	3	4	5
Not at all true		Somewhat true		Very true

2. I personally enjoy reading medical journal articles.

1	2	3	4	5
Not at all true		Somewhat true		Very true

3. It is very important for me to try to understand the content of a medical journal article, regardless of the level of difficulty.

1	2	3	4	5
Not at all true		Somewhat true		Very true

4. I consider the critical reading of medical journal articles very useful.

1	2	3	4	5
Not at all true		Somewhat true		Very true

5. Showing others that I have the ability to read critically is very important to me.

1	2	3	4	5
Not at all true		Somewhat true		Very true

6. I will be able to improve my critical appraisal skills if I make a strong effort.

1	2	3	4	5
Not at all true		Somewhat true		Very true

7. It is very important for me to identify the strengths and weaknesses of the research, even if this process is challenging.

1	2	3	4	5
Not at all true		Somewhat true		Very true

8. I am confident in my ability to identify the strengths and weaknesses of the research.

1	2	3	4	5
Not at all true		Somewhat true		Very true

9. Improving my critical appraisal skills will better enable me to read around my patients.

1	2	3	4	5
Not at all true		Somewhat true		Very true

10. I want to perform the task well because it is very important to me to demonstrate my critical analysis skills to my peers.

1	2	3	4	5
Not at all true		Somewhat true		Very true

11. The task I am going to perform is very interesting to me.

1	2	3	4	5
Not at all true		Somewhat true		Very true

12. The most satisfying thing for me is to learn something new from the article to improve my practice.

1	2	3	4	5
Not at all true		Somewhat true		Very true

13. I believe I will be able to use the information gleaned from the article in my practice.

1	2	3	4	5
Not at all true		Somewhat true		Very true

14. I believe that I can apply the results of the article to my practice if they are pertinent.

1	2	3	4	5
Not at all true		Somewhat true		Very true

15. Getting a good evaluation from an instructor is the most satisfying thing for me.

1	2	3	4	5
Not at all true		Somewhat true		Very true

16. I am very interested in improving critical analysis skills.

1	2	3	4	5
Not at all true		Somewhat true		Very true

17. The most important thing for me when reading around my patient is to learn how to read medical research critically.

1	2	3	4	5
Not at all true		Somewhat true		Very true

18. If possible, I would like to get a better evaluation than my peers.

1	2	3	4	5
Not at all true		Somewhat true		Very true

19. Improving my critical appraisal skills will make me a better physician.

1	2	3	4	5
Not at all true		Somewhat true		Very true

20. I am confident in my ability to read the medical journal article critically.

1	2	3	4	5
Not at all true		Somewhat true		Very true

21. I believe I will be able to use the skills I learn from the task in other situations.

1	2	3	4	5
Not at all true		Somewhat true		Very true

22. Do you have a goal for this task? If so, what is it? (If you have more than one, please list them all.)

23. What strategies will you use to help you accomplish the task?

24. How do you feel right now, just before starting the task?

O Confident	O Good	O Excited	O Relaxed
O Worried	O Pessimistic	O Nervous	O Inconvenienced

Thank you for your interest! Please begin the task.

Appendix B: Self-Regulated Learning - Reflection Questionnaire

Name: **Date:**

0. How do you feel now that you have completed the task?

O Relieved	O Calm	O Satisfied	O Confident	O Pleased
O Concerned	O Nervous	O Disappointed	O Worried	O Frustrated

Now that you have finished reading the article, here is another series of questions. Please circle the number that best describes your thoughts.

If a statement is **very true** of you, circle **5**.
If a statement is **not at all true** of you, circle **1**.
If a statement is more or less true of you, circle the number between **2** and **4** that best describes you.

1. I am very pleased with how I read the article critically.

1	2	3	4	5
Not at all true		Somewhat true		Very true

2. Based on what is expected of students at my level, I performed the task very well.

1	2	3	4	5
Not at all true		Somewhat true		Very true

3. I am very satisfied with my ability to identify the strengths and weaknesses of the article.

1	2	3	4	5
Not at all true		Somewhat true		Very true

4. Regarding the goal(s) I set for myself, I accomplished the task very well.

1	2	3	4	5
Not at all true		Somewhat true		Very true

5. I think that the task I just performed is very useful to my practice.

1	2	3	4	5
Not at all true		Somewhat true		Very true

6. Compared to students at my level, I performed the task well.

1	2	3	4	5
Not at all true		Somewhat true		Very true

7. I am very satisfied with my performance.

1	2	3	4	5
Not at all true		Somewhat true		Very true

Answer either question 8 or question 9
Answer question 8 if you think you did well on the task.
Answer question 9 if you think you did not do well on the task.

8. I think I did well on this task …

	Not at all true		Somewhat true		Very true
a. because I am good at this type of task	1	2	3	4	5
b. because I was lucky	1	2	3	4	5
c. because I made a strong effort	1	2	3	4	5
d. because I found it an easy task	1	2	3	4	5

9. I think I did not do well on this task …

	Not at all true		Somewhat true		Very true
a. because I am not good at this type of task	1	2	3	4	5
b. because I had bad luck	1	2	3	4	5
c. because I didn't make a strong effort	1	2	3	4	5
d. because I found it a difficult task	1	2	3	4	5

10. Did you reach the goal(s) you had set before starting the task? Please explain your answer.

11. What strategies did you use to help you accomplish the task?

12. Based on this experience, the next time you read a medical article, is there anything you will improve/change in order to perform the task better?

Thank you for your time!

Appendix C: Critical Appraisal Checklist

Name: **Date:**

Aims:

1. What are the aims of the research?

2. Was each of the variables in the study clearly defined?

O Yes O No O Don't know O N/A

3. Was the research design the most appropriate to address the aims of the study?

O Yes O No O Don't know O N/A

Methods:

4. Was the choice of population bias-free?

O Yes O No O Don't know O N/A

5. Was the sample representative of an identifiable population?

O Yes O No O Don't know O N/A

6. Was the number of participants in the study justified?

O Yes O No O Don't know O NA

7. Were participants randomized into groups?

O Yes O No O Don't know O N/A

8. Were the groups (intervention and control) well-matched (e.g. age, sex)?

O Yes O No O Don't know O N/A

9. Were the data collection methods appropriate?

O Yes O No O Don't know O N/A

10. Were the participants in both the intervention and control groups followed up in the same way?

O Yes O No O Don't know O N/A

11. Were data collected in the same way in both the intervention and control groups?

O Yes O No O Don't know O N/A

12. Was each of the instruments used to collect data sufficiently valid for its intended purpose?

O Yes O No O Don't know O N/A

13. Was each of the instruments used to collect data sufficiently reliable for its intended purpose?

O Yes O No O Don't know O N/A

14. Were the intervention and data collection methods explained clearly so that other researchers could replicate the study?

O Yes O No O Don't know O N/A

15. Were the statistical techniques used appropriate?

O Yes O No O Don't know O N/A

Results:

16. Briefly describe the main results:

17. Did the researcher(s) take account of potential confounding factors in the analysis?

O Yes O No O Don't know O N/A

Conclusion / Discussion:

18. Were the researchers' conclusions supported by the data?

O Yes O No O Don't know O N/A

19. Did the researchers draw reasonable implications for theory from their findings?

O Yes O No O Don't know O N/A

20. Did the researchers draw reasonable implications for practice from their findings?

O Yes O No O Don't know O N/A

21. Were suggestions provided for further areas to research?

O Yes O No O Don't know O N/A

In your opinion:

1. How well do the results answer the research questions?

2. Did you identify any strengths and weaknesses in this research?

Strengths:

Weaknesses:

3. If there are weaknesses in the study, what actions would you take to improve the research?

4. How could you use the results of this study in your own practice?

5. Other Comments

Appendix D: Pre-Test Answer Key

Aims:

1. What are the aims of the research?

To test the hypothesis that 25 mg. of spironolactone daily added to diuretics and an ACE inhibitor in patients with NYHA class 3 or 4 systolic heart failure will significantly reduce their risk of death from all causes as compared with placebo.

2. Was each of the variables in the study clearly defined?

X Yes O No O Don't know O N/A

3. Was the research design the most appropriate to address the aims of the study?

X Yes O No O Don't know O N/A

Methods:

4. Was the choice of population bias-free?

O Yes X No O Don't know O N/A

5. Was the sample representative of an identifiable population?

X Yes O No O Don't know O N/A

6. Was the number of participants in the study justified?

X Yes O No O Don't know O NA

7. Were participants randomized into groups?

X Yes O No O Don't know O N/A

8. Were the groups (intervention and control) well-matched (e.g. age, sex)?

X Yes O No O Don't know O N/A

9. Were the data collection methods appropriate?

X Yes O No O Don't know O N/A

10. Were the participants in both the intervention and control groups followed up in the same way?

X Yes O No O Don't know O N/A

11. Were data collected in the same way in both the intervention and control groups?

X Yes O No O Don't know O N/A

12. Was each of the instruments used to collect data sufficiently valid for its intended purpose?

    X Yes O No O Don’t know O N/A

13. Was each of the instruments used to collect data sufficiently reliable for its intended purpose?

    X Yes O No O Don’t know O N/A

14. Were the intervention and data collection methods explained clearly so that other researchers could replicate the study?

    X Yes O No O Don’t know O N/A

15. Were the statistical techniques used appropriate?

    X Yes O No O Don’t know O N/A

Results:

16. Briefly describe the main results:

White patients in the mid-60’s-70’s age range with an ejection fraction of less than 35% and who are unable to carry on all of their daily activities because of symptoms related to heart failure despite moderate doses of an ACE inhibitor, a loop diuretic and close follow-up in a university setting will, if given 25 mg of spironolactone daily, live significantly longer and can live their lives significantly better compared to those randomly allocated to treatment with placebo and with infrequent, minor or easily detectable and correctable side-effects. The number of patients in this population who must be treated with 25 mg of spironolactone in order to save one life is 12.5 (= the NNT or number needed to treat).

17. Did the researcher(s) take account of potential confounding factors in the analysis?

    X Yes O No O Don’t know O N/A

Conclusion / Discussion:

18. Were the researchers’ conclusions supported by the data?

    X Yes O No O Don’t know O N/A

19. Did the researchers draw reasonable implications for theory from their findings?

    X Yes O No O Don’t know O N/A

20. Did the researchers draw reasonable implications for practice from their findings?

X Yes O No O Don't know O N/A

21. Were suggestions provided for further areas to research?

X Yes O No O Don't know O N/A

In your opinion:

1. How well do the results answer the research questions?

They do so very well: In my opinion this paper is an exemplar of how a good RCT should be designed, conducted, analyzed and reported.

2. Did you identify any strengths and weaknesses in this research?

Strengths:

1. Very powerful study with a large number of patients that are representative of Caucasian patients with severe heart failure
2. Spironolactone is readily available, cheap and its side effects are predictable and familiar to most physicians
3. It used very objective end-points (risk of death) rather than surrogate outcome measures
4. It also focused on quality of life (as assessed by NYHA class change): Spironolactone made patients live longer and made their longer lives worth living according to this study.
5. It balanced other factors (e.g. the % of patients using digitalis) between control and experimental groups that might have led to a spurious improvement in quality of life.

Weaknesses:

1. This study cannot be directly applied to patients over the age of 75. By far the greatest burden of heart failure is seen in patients over the age of 75 and the population in this study were younger than 75.
2. This study cannot readily be extrapolated to non-caucasian patients as 86-87% of the patients in this study were Caucasian.
3. Only 10% of the patients in this study were receiving beta-blockers which are known to decrease mortality in patients with systolic heart failure.

3. If there are weaknesses in the study, what actions would you take to improve the research?

Further studies need to be done in other age groups (greater than 75) and in non-caucasian populations and in more community settings. In addition the effect of spironolactone needs to be tested in patients with heart failure who are already taking an ACE inhibitor, loop diuretic AND a betablocker.

4. How could you use the results of this study in your own practice?

This study contributed another tool to the hierarchy of treatments one can offer to patients suffering from severe symptomatic systolic heart failure: I will add spironolactone to treatment with an ACE inhibitor, a loop diuretic, and a beta-blocker for my patients who match those in this study.

5. Other Comments

This paper shows how one decides what place a new treatment has among all other proven and available treatments for a common, treatable and dangerous chronic disease.

Appendix E: Post-Test Answer Key

Aims:

1. What are the aims of the research?

This study aimed to show that dabigatran is as effective as warfarin in the treatment of patients who have received a course of conventional perenteral anticoagulation for the treatment of acute venous thromboembolism. The authors argue that dabigatran has important advantages over warfarin because unlike warfarin it does not require frequent monitoring of its anticoagulation effect and it has less drug interactions than warfarin.

2. Was each of the variables in the study clearly defined?

O Yes X No O Don't know O N/A

3. Was the research design the most appropriate to address the aims of the study?

X Yes O No O Don't know O N/A

Methods:

4. Was the choice of population bias-free?

O Yes O No X Don't know O N/A

5. Was the sample representative of an identifiable population?

O Yes O No X Don't know O N/A

6. Was the number of participants in the study justified?

X Yes O No O Don't know O NA

7. Were participants randomized into groups?

X Yes O No O Don't know O N/A

8. Were the groups (intervention and control) well-matched (e.g. age, sex)?

O Yes O No X Don't know O N/A

9. Were the data collection methods appropriate?

X Yes O No O Don't know O N/A

10. Were the participants in both the intervention and control groups followed up in the same way?

X Yes O No O Don't know O N/A

11. Were data collected in the same way in both the intervention and control groups?

X Yes O No O Don't know O N/A

12. Was each of the instruments used to collect data sufficiently valid for its intended purpose?

X Yes O No O Don't know O N/A

13. Was each of the instruments used to collect data sufficiently reliable for its intended purpose?

X Yes O No O Don't know O N/A

14. Were the intervention and data collection methods explained clearly so that other researchers could replicate the study?

O Yes X No O Don't know O N/A

15. Were the statistical techniques used appropriate?

X Yes O No O Don't know O N/A

Results:

16. Briefly describe the main results:

In mainly white patients with very little known cancer and mysterious acute venous thromboembolism, treatment with 6 months of dabigatran following 5-9 days of parenteral anticoagulation was no less effective than mysterious treatment with warfarin for 6 months.

17. Did the researcher(s) take account of potential confounding factors in the analysis?

X Yes O No O Don't know O N/A

Conclusion / Discussion:

18. Were the researchers' conclusions supported by the data?

X Yes O No O Don't know O N/A

19. Did the researchers draw reasonable implications for theory from their findings?

X Yes O No O Don't know O N/A

20. Did the researchers draw reasonable implications for practice from their findings?

X Yes O No O Don't know O N/A

21. Were suggestions provided for further areas to research?

X Yes O No O Don't know O N/A

In your opinion:

1. How well do the results answer the research questions?

If one ignores certain study weaknesses (see below) under the conditions of this study the authors showed that dabigatran is no less effective than warfarin.

2. Did you identify any strengths and weaknesses in this research?

Strengths:

1. They did a good power calculation, critical for studies of this type where you are trying to show that a new drug is no worse than another in preventing events with a low chance of occurrence.
2. I like the double dummy way of blinding caregivers to the treatment that patients received
3. The outcome measures were objective and valid.

Weaknesses:

1. The authors did not provide an adequate description of how they adjusted the warfarin dose according to patients' INR: And indeed the INR's obtained in this study were within therapeutic range only 60% of the time. The literature shows that using a computerized or other warfarin dosing algorithm will lead to 75% of INR's in the therapeutic range. So basically the authors were comparing the study drug to crummy warfarin dosing. However there was no difference in the event rates with the study drug as compared with warfarin despite the substandard anticoagulation effect (as measured by INR) achieved with warfarin. And having 60% of INR's in therapeutic range is what can be achieved in normal practice without the use of algorithms.
2. There were a lot of important patient variables that were not clearly mentioned as balanced between groups: What does "for whom 6 months of anticoagulant therapy WAS CONSIDERED to be an appropriate treatment" mean? What exactly were the indications for 6 months of anticoagulation?
    - Patients who have a reversible/transient reason for thromboembolism (e.g. leg fracture, plane travel, surgery) do not need 6 months of anticoagulation cause they have very low recurrence rates – we have no idea whether the distribution of patients between the control and treatment groups balanced this important variable. If by chance there were more of these kinds of patients in the study drug group that could make an inferior new drug look as good as the old drug it is being compared with.
    - Patients with the anticardiolipin antibody syndrome need to be

anticoagulated to a higher INR level than that achieved in this study and many would argue lifelong: If there were more anticardiolipin patients in the warfarin group this would make dabigatran look like it is at least as good as warfarin when it is not.

3. There were too few patients with cancer or who were non-caucasian in this study to know if the same results would apply to these patients.
4. The authors claim that the new drug would be more convenient to take since it does not require laboratory monitoring. They did not, however, mention that the new drug must be taken TWICE per day whereas warfarin is taken only once per day. Patients will comply much better with once versus twice daily dosage of any medication. In addition they made no mention of the cost of the new drug whereas warfarin is cheap. In addition, warfarin is easy to reverse when taken in an overdose – there was no mention of how to treat (or if one CAN treat) an overdose of the new study drug. We have no idea what medications patients in this study were taking in addition to the study drugs: The authors claim that the new drug has less drug interactions is a theoretic one that has yet to be proved.
5. This study was run by a drug company with a scientific conflict of interest – it is to the company's advantage to prove that their new drug product is as effective as and more convenient than older established therapy. We are reassured that members of the steering committee vouch for the accuracy and completeness of the data. However we are not told what if any relationship there may between steering committee members and the company: Do any of the steering committee members get fees, research funds salaries or other perks from the company?

3. If there are weaknesses in the study, what actions would you take to improve the research?

   The authors should have reported in their paper the missing patient information identified (in numbers 1 to 5) above. This study needs to be redone in populations with cancer and in non-whites.

4. How could you use the results of this study in your own practice?

   If this new drug is affordable, it will make outpatient anticoagulation more convenient because it does not require laboratory monitoring – if it is more expensive, the cost of the new drug might be counterbalanced with saving on the considerable cost of drug monitoring. I would need to see that this drug has been used in patients taking multiple medications and who have multiple acute and chronic illnesses (the internal medicine population) before I would abandon the use of warfarin for the new drug.

5. Other Comments

   So this is a very promising new drug that may be ready for general use in the near future.

Appendix F: Rubric for Evaluating Open-Ended Questions on Critical Appraisal Checklist

Question	Pre-test	Post-test	Total Points
What are the aims of the research?	Key terms (in bold type) from the following answer are required (0.5 points each, for a total of 2 points) 25 mg. of ***spironolactone*** daily added to ***diuretics and an ACE inhibitor*** / ***standard treatment*** patients with ***NYHA class 3 or 4 systolic heart failure / severe heart failure reduce risk of death*** from all causes	Key terms (in bold type) from the following answer are required (0.5 points each, for a total of 2 points) ***Dabigatran and warfarin*** are **equally effective** for patients who have received a course of ***conventional perenteral anticoagulation*** for the treatment of ***acute venous thromboembolism***	2
Briefly describe the main results.	The 4 following answers are required (0.5 points each, for a total of 2 points) 1. white patients in the mid-60's-70's age range 2. with an ejection fraction of less than 35% and who are unable to carry on all of their daily activities because of symptoms related to heart failure 3. given 25 mg of spironolactone daily with moderate doses of an ACE inhibitor, a loop diuretic 4. live significantly longer and can live their lives significantly better with infrequent, minor or easily detectable and correctable side-effects	The 4 following answers are required (0.5 points each, for a total of 2 points) 1. white patients 2. with very little known cancer and mysterious acute venous thromboembolism 3. treatment with 6 months of dabigatran following 5-9 days of parenteral anticoagulation 4. was no less effective than mysterious treatment with warfarin for 6 months	2

Appendix E *(continued).*

Question	Pre-test	Post-test	Total Points
How well do the results answer the research questions?	One of the following answers is required (2 points) Very well / Well	One of the following answers is required (2 points) Well / Pretty well / Fairly well	2
Did you identify any strengths in this research?	Both answers from answer key (see Appendix C) are required (1 point each, for a total of 2 points)	Both answers from answer key (see Appendix D) are required (1 point each, for a total of 2 points)	2
Did you identify any weaknesses in this research?	Both answers from answer key (see Appendix C) are required (1 point each, for a total of 2 points)	Both answers from answer key (Appendix D) are required (1 point each, for a total of 2 points)	2
If there are weaknesses in the study, what actions would you take to improve the research?	One of the following answers is required (2 points) 1. Further studies need to be done in other age groups (greater than age 75) and in non-Caucasian populations and in more community settings. 2. The effect of spironolactone needs to be tested in patients with heart failure who are already taking an ACE inhibitor, loop diuretic AND a betablocker.	One of the following answers is required (2 points) 1. The authors should have reported in their paper the missing patient information identified (in numbers 1 to 5) above. 2. This study needs to be redone in populations with cancer and in non-whites.	2

Appendix E *(continued)*.

Question	Pre-test	Post-test	Total Points
How could you use the results of this study in your own practice?	Each part of the following answer (in bold type) is required (1 point each, for a total of 2 points) Prescribe **spironolactone** with an **ACE inhibitor**, a **loop diuretic**, and a **beta-blocker** for my **patients who match those in this study**	One of the following answers is required (2 points) 1. Price – affordable / expensive 2. Need to see that this drug has been used in patients taking multiple medications and who have multiple acute and chronic illnesses (the internal medicine population) before I would abandon the use of warfarin for the new drug	2

Note. A flexible approach was use when correcting these tests.

Appendix G: Collaboration Feedback Sheet

Name: Date:

1a. What have you learned about annotation skills from working with your partner?

1b. How will this influence the way you annotate while reading journal articles in the future?

2a. From working with your partner, what have you learned about critical analysis?

2b. How will this influence the strategies you use when engaging in critical analysis in the future?

3a. What is your opinion of the role played by technology in the collaborative process?

3b. What was the overall impact of this on your learning (the strategies you used while reading, critical analysis skills, …)?

Thank you for your participation!

Appendix H: Information and Consent Document

Research Title
Examining the Role of Self-Regulated Learning in the Context of Enhancing Critical Analysis in a Computer-Supported Collaborative Medical Journal Club Activity

Researchers
This study is being conducted by Yuan-Jin Hong, Ph.D. Candidate, Department of Educational and Counselling Psychology, McGill University, under the supervision of Dr. Susanne P. Lajoie, Professor, Department of Educational and Counselling Psychology, McGill University, and Dr. Kevin Waschke, Assistant Professor of Medicine, Department of Medicine, McGill University.

Introduction
You are being invited to participate in a research project being carried out at the McGill University Health Centre (MUHC). This research study builds upon the pre-existing research conducted by Dr. Susanne Lajoie regarding the cognitive tools which foster self-regulated learning among medical students. Approximately 20 undergraduate medical students at the MUHC will be participating in this study.

Purpose of the Study
The proposed research explores the relationship between computer-supported collaborative learning and the development of critical analysis and self-regulation in medical students. More specifically, this study investigates how undergraduate medical students develop their “Read around Your Patient” skills and how computer collaborative tools can enhance their ability to systematically use medical literature to provide better patient care. This study is being conducted as part of a Ph.D. thesis in the Department of Educational and Counselling Psychology at McGill University’s Faculty of Education.

Procedures
As an undergraduate medical student participating in this study, you will be randomly assigned to either the experimental group or the control group.

As part of the research, you will be introduced to a software that supports self-regulated learning in the context of individual or collaborative learning, and will read and annotate articles using this software. A screen capture software may be used to chart your activity while completing reading tasks.

Over the course of the research, you will complete several questionnaires: 1) ***Research Background Questionnaire***; 2) ***Self-Regulated Learning Forethought Questionnaire***; 3) ***Critical Analysis Checklist***; 4) ***Self-Regulated Learning Reflection Questionnaire***; and 5) ***Collaboration Feedback Sheet***.

At particular stages of this research study, you may be expected to work with a partner (and will be asked to find him/her on your own), and may be asked to participate in a ***focus group interview*** to allow you to share reflections on your learning. During these stages of the research, your participation will be audio/video taped.

Your participation in the present study will involve meeting 3 times during the term, each meeting lasting 3 hours.

Potential Risks
This study involves no known or foreseeable risks or discomforts of any kind. Your critical analyses will not be used for assessment purposes but rather as learning experiences in analyzing medical research.

Potential Benefits
As a participant in this study, you may not benefit personally from your involvement, but you may contribute new information that may benefit others.

Financial Compensation
You will not be compensated for your participation in this study.

Confidentiality
Your identity will be concealed by using a participant code (in lieu of your name) on computer output, questionnaires, and transcribed data. Your name will not appear on any of these materials. Only the investigator will keep a record of your name and have access to the master list of linked information. Likewise, audio and video recordings will be analyzed only by the researcher, and solely for data transcription and coding purposes.

All data, including the master list of names and code numbers, audio/videotapes, electronic files, and consent forms, will be stored in a locked filing cabinet in the researcher's laboratory at McGill University, and will be accessible only to the investigator, his co-investigator/supervisor, and his research assistant (also working under the supervision of Dr. Lajoie). All these data will be stored there until the completion of the study, and will be destroyed after the study is finished.

Anonymity will be guaranteed throughout the entire research process and when the results are made public. If mention is made of the individuals participating in this study, pseudonyms will be employed in lieu of participants' real names.

Representatives of the MUHC Research Ethics Board (REB) may inspect the data collected in order to verify the quality and integrity of the research.

Voluntary Participation and Withdrawal
Your participation in this study is absolutely voluntary, and refusal to participate will involve no penalty. Participation or non-participation will in no way affect your academic standing or performance ranking. Moreover, you can withdraw from the study at any point without penalty.

Persons to Contact
Please contact us, the researchers, at any point during the research process should you have any concerns or questions.

Dr. Susanne P. Lajoie
Professor, Department of Educational and Counselling Psychology, McGill University
Phone: (514) 398-4242
E-mail: susanne.lajoie@mcgill.ca

Yuan-Jin Hong
Ph.D. Candidate, Department of Educational and Counselling Psychology, McGill University
Phone: (514) 398-4914
E-mail: yuan-jin.hong@mail.mcgill.ca

You may also contact the project consultant/coordinator at the MUHC should you have any concerns.

Dr. Kevin Waschke
Assistant Professor of Medicine, Department of Medicine, McGill University
Phone: (514) 934-8308 ext. 43899
E-mail: kevin.waschke@mcgill.ca

If you have any questions about your rights as a research subject participating in a study at the McGill University Health Centre (MUHC), you may contact the Ombudsman at:

Montreal General and Montreal Neurological Hospital	(514) 934-8306
The Montreal Children’s Hospital	(514) 934-1934, local 22223
Royal Victoria Hospital and Montreal Chest Institute	(514) 934-1934, local 35655

Consent Form

For the sake of anonymity, this document will be kept in a confidential location on McGill University premises, accessible only to the investigators, and will be used to confirm that informed consent for the data has been provided.

Please read the statements below and indicate your response. When you are done, please print your name and sign in the space provided.

1. I have been informed about the nature of this study and what my participation involves. I have had the opportunity to ask questions and all of my questions have been answered to my satisfaction.
2. I understand that my identity will not be disclosed, and that coding will be used with all data to ensure anonymity.
3. I understand that I am free to withdraw from this research study with no penalty at any time and for any reason.
4. I understand that all the data gathered will be used for research purposes only, and may be published and /or presented in an academic setting.
5. I freely consent and voluntarily agree to participate in this study.
6. I have been given a copy of this "Information and Consent Document" for my records.

____ Yes, I wish to participate

____ No, I do not wish to participate

Name (PLEASE PRINT): ____

Signature: ___________________________________ Date: __________________

E-mail: ____

Thank you for your time and interest!

Best regards,

Yuan-Jin Hong, Ph.D. Candidate

____ Date: __________________

Department of Educational and Counselling Psychology

McGill University

Appendix I: Research Background Questionnaire

Personal Information

Name:
Gender: M F
Age:
Did you complete the Med-P year? Yes No
Please list the degrees you have completed, including your major(s):

Research Background

1. Have you received any formal education or training in any of the following?

Research methods	Yes	No
Epidemiology	Yes	No
Statistics	Yes	No

2. How much experience do you have in conducting research?

O No experience at all O Almost no experience at all O A little experience O Moderate experience O A great deal of experience

3. How much experience do you have in reading research articles?

O No experience at all O Almost no experience at all O A little experience O Moderate experience O A great deal of experience

4. What is your level of confidence in assessing each of the following aspects of a published article?

Please tick the box that best represents your level of confidence.	**Very Low**	**Low**	**Medium**	**High**	**Very High**
a) Study design					
b) Bias					
c) Sample size					
d) Generalisability					
e) Statistical tests/principles					
f) General worth of an article					

Experience with Annotation Software

1. How much experience do you have in using annotation software (e.g., Adobe Acrobat Professional, Foxit, Skim, etc.) while reading PDF articles on the computer?

O No experience at all O Almost no experience at all O A little experience O Moderate experience O A great deal of experience

Appendix J: Illustrations of Co-Regulation Coding Scheme

Low-Level Individual Regulation

Excerpt 1: Group 1, second meeting

KAREN: When do you want to write one page report?
THOMAS: Let's do it. Severe hypoglycemia was more na-na-na. But, so, they comment on hypoglycemia, but then they say no long-term sequelae of severe hypoglycemia were reported. Though that doesn't mean that long-term sequelae aren't happening.
KAREN: Where's that? Oh.
THOMAS: They, like, stress that, like hypoglycemia in the tight control, then no long-term sequelae that came, from, so that was weird.

Most of the cases which were coded as low-level individual regulation are made up of a single student's near word-for-word readings of articles or other writings. Low-level individual regulation episodes were so classified because participants did not demonstrate the construction of knowledge nor did they show the active making of meaning. Instead, each case was characterized by a participant expressing the straightforward, fundamental meaning of information in an article without building upon it in any way. When an individual student made clear the meaning of a fundamental term, which might include paraphrasing a dictionary definition, this too was interpreted as low-level individual regulation. Once again, the making of meaning did not figure at all prominently in these episodes.

Low-Level Co-Regulation

Excerpt 2: Group 4, second meeting

ANNA: Was the sample representative of an, an identifiable population?
MARTHA: I think so.
ANNA: I think so too. . .
CARMEN: Yeah.
ANNA: . . .like…a…acutely ill patients.
MARTHA: Yeah.
CARMEN: Yeah.
ANNA: Was the number of participants in the study justified?
MARTHA: I think so.
CARMEN: Yeah.
MARTHA: They talked about it.
CARMEN: They had a whole table explaining everything.
MARTHA: Yeah. [Nodding head]
ANNA: Yeah. Were participants randomized in groups? Yes.

CARMEN: Mm-hmm.
MARTHA: Yes.
ANNA: Were the groups well matched? Yes.
MARTHA: Yes.
CARMEN: Mm-hmm.

Contrary to most cases of low-level individual regulation, word-for-word reading is not a prominent characteristic of the majority of cases demonstrating low-level co-regulation. In the second excerpt, participants did not co-construct knowledge; instead, they engaged more in an attempt to make clear pre-existing information from the article they read and clearly referred to over the course of the discussion. The case is also marked by there being a number of individuals who contributed to the dialogue; it features short turns, regular changes of speaker, and quite equal levels of verbal participation among group members.

High-Level Individual Regulation

Excerpt 3: Group 1, second meeting

KAREN: What does an odds ratio mean? Like, what would the reaction be? Not that it wouldn't be clear.
THOMAS: Well, no, of course it wouldn't be. Uh, I just think of it as the like, the, like for here, on an odds ratio 1.14, means that you're 1.14 times more likely to die on the intensive care compared to the conventional control group.
KAREN: Okay. Okay.
THOMAS: It's like an odds ratio, a decimal is weird, but like an odds ratio of three, you know, is easier. You're three times more likely to die if you're intensive controlled on glucose than if you're conventionally controlled. But what, what's weird with odds ratio is when you drop below one, you have to think of percentages, so if you're like, if the odds ratio is 0.7, then you're 30% less likely to die. Do you know what I mean?
KAREN: There's some nugget of memory in my brain.
THOMAS: I found that a little weird…, because 1.14 doesn't mean you're 14% more likely, of 0.7, means like a third less likely…
KAREN: Clear. I see what you're saying. Okay.
THOMAS: I don't exactly know why. Maybe you should ask that. It seems like a good question.
KAREN: Okay.

Excerpt 3 features an example of high-level individual regulation. The duration of Thomas's turns is such that the regulation was indeed coded as being individual in nature. Also marking it as individual regulation is Thomas' instructive role as a source of knowledge for his colleague, this permitting Thomas to chart the course for the construction of his own knowledge. Of note is the fact that the verbal responses to Thomas's utterances did indeed play a role in regulating Karen's learning. Thomas' contributions were also coded as high-level, this in part because he tried to elaborate on facts from the article to explain ideas to his partner. Another reason this exchange also exemplifies high-level individual regulation is that Thomas clearly constructed knowledge for his partner and did not simple make factual statements (by saying, for example, "…just think of it as the…").

High-Level Co-Regulation

Excerpt 4: Group 2, first meeting

POLLY: Um…do, do, what clinical question can this article help you answer? How and why did you choose that clinical question?

BILL: What can save my patients?

POLLY: Yeah, it's basically, uh, how can you improve the standard regimen. How can you decrease your patient's, uh, how can you improve your patient's outcome?

BILL: Yeah, exactly, and, I mean, there's, there's a lot of medication that can, uh, potentially, uh, de…uh, improve the symptoms of patients with congestive heart failure, but at the end of the day, you want to know what drug will actually decrease the mortality in these patients, and not just, uh, uh, improve like blood pressure. . .

POLLY: Yeah.

BILL: . . .and, uh, like, the volume of the patient, or whatever.

Excerpt 4 typifies high-level co-regulation, the type of regulation which is widely felt to be the most useful for students' learning. In this excerpt, the two participants both made weighty verbal contributions to knowledge construction, and both participated in the process of reasoning. The episode is co-regulation at a high-level in that participants linked ideas and applied previous learning to a new situation. Indeed, they attempted to connect and apply the content of the article which they had read to their future clerkship and clinical practice.

Appendix K: Coding Scheme for Self-Regulated Learning

Category	Subcategory and description	Example
Monitoring		
	(Meta)cognition monitoring Demonstrating what one knows and does not know	"Look, I don't see the point in reading the statistical analysis, because, like, I'm not, I don't even know what it means."
	Motivation monitoring Expressing motivation during reading task	"I just wish I could think of, I'm not gonna remember any of this stuff, so why am I reading?"
	Behaviour monitoring Observing one's behavior during task	"I don't, I don't want to get overwhelmed, so I just kind of like don't pay attention to certain things."
Control		
	Controlling cognitive strategies Telling oneself how to proceed during a reading task	"…because it's usually at the beginning of a paragraph and the end of a paragraph, the most important things."
	Attention focus Concentrating and screening out external events	"…something I had to read a few times, well, maybe that's just because it's, I wasn't paying attention well…"
	Controlling task strategies Stating strategies used when completing a reading task	"…if I highlight something, and it's just out of the blue, I won't understand the context, whereas if I highlight, highlight the paragraph, that, like, makes sense to me, I just read the paragraph and then I understand it."
	Help-seeking behaviour Asking questions to partner or searching for information online	"What's a, a parallel-group?" "Let's look up what the Internet has to say about that."

Appendix K *(continued)*.

Category	Subcategory and description	Example
Reflection and reaction		
	Task evaluation Self-evaluating a pair's own performance	"Okay, that's good though; that's fine. Okay, I think we're doing well."
	Causal attribution Attributing phenomena to specific causes	"…I had to read a few times the dosages and administration and the, the actual set-up of the, of the study. But, maybe that's just because it's numbers and I wasn't paying attention."
	Perceptions of satisfaction Showing satisfaction or dissatisfaction regarding one's performance with one's partner	"I'm satisfied with us."
	Negative self-efficacy Expressing lack of confidence in one's ability to perform a task	"I'm so bad at this. That's why I'm here."
	Affect Expressing positive or negative emotions	"I found that interesting. I didn't know that." "…it's kind of lost on me…"
	Self-regulatory strategies adaptation Evaluating one's self-regulatory approach and considering alternatives	"…because I was also answering the questions as I was reading the article, and I think that was kind of a bad."
Planning		
	Goal setting Deciding on the scope involved when reading around one's patient	"I would start with broad things, then I would look for guidelines, because I want to know what I'm dealing with before dealing with guidelines."
	Strategy planning Selecting specific strategies to	"Make a PICO; use a database, like PubMed or

Appendix K *(continued)*.

Category	Subcategory and description	Example
	read around one's patients	something…"

Appendix L: Coding Scheme for Critical Analysis Skills

Category	Description	Example
Understanding	Summarizing main ideas and results of studies	"…just, like, uh, what aldosterone does, how spironolactone works in conjunction with ACE inhibitors, and, uh, how it affects the, the specific population that was being studied."
	Explaining main ideas and results of studies	"…it sounds like what they're saying is…people that were assigned to the intensive control, they did have lower glucose levels, because that was the point, to achieve lower glucose levels and receive more Insulin,…"
Analyzing	Assessing evidence in studies	"But, the, the most important thing here for me was 6,100 patients, 98% follow-up. That was good."
	Interpreting evidence in studies	"Oh, these are the other differences; cardiovascular deaths were more common in the tight control. Deaths were more common."
Evaluating	Critiquing strengths of studies	"Large patient population, good randomization, excellent follow-up."
	Critiquing weaknesses of studies	"…the weakness…is that they provided a strict glucose control algorithm, but the rest of the patient care was left in the hands of the physician…"
Applying	Relating results of studies to one's work, and adjusting one's professional approach accordingly	"And I was like, at least I would mention to a male patient gynecomastia and breast pain."

Appendix M: Coding Scheme for Communicative Activities

Category	Description	Example
1. Informative	Speaker provides information	
1.1 Statement	Participant gives personal feedback, answers, examples or commentaries, and summarizes content or ideas	"It's the, as I remember, it's like, a clinical assessment score to see how well the patient is doing."
2. Argumentative	Utterances may contain the following words	
2.1 Reason	"because"	"…I guess I would go on, like, PubMed to find one of these problems, because they give you the guidelines…"
2.2 Condition	"if"	"…if it hadn't been mentioned in the questionnaire, I wouldn't even have thought of those things."
2.3 Consequence	"then, thus, so"	"I don't want to get overwhelmed, so I just kind of like don't pay attention to certain things."
2.4 Continuation	"and, then, so"	"And then the fact that patients were evenly matched, so randomization worked."
2.5 Countering	"but", "no + explanation"	"…but the thing is, like, it was very important that ACE inhibitors were involved…"
2.6 Elaborating / Expanding	Participant produces a verbalization further explaining a previous statement	"…means that you're 1.14 times more likely to die on the intensive care compared to the conventional control group."
2.7 Evaluation	Participant gives an opinion or judgment related to the task	"That's good. Well said!"

Appendix M *(continued)*.

Category	Description	Example
3. Elicitative	Speaker asks for addressee's opinion	
3.1 Question	Participant checks / asks for information	
3.1.1 Verification	Participant checks ideas and opinions, or asks one to repeat oneself	"Will you actually do a PICO?"
3.1.2 Open	Participant asks for new information	"What's a foreground question?"
3.2 Proposal	Participant proposes a common action	"How about, maybe we can start…"
4. Responsive	Speaker reacts to an earlier utterance	
4.1 Acceptance	Participant gives neutral support	"Okay", "Mm-hmm", "Uh-huh"
4.2 Negation	Participant objects without explanation	"No"
4.3 Confirmation	Participant shows explicit support	"Yeah", "That is true", "I think so", "Sure"
4.4 Repeating	Participant repeats the previous utterance	MARTHA: "Um, it's in the discussion…" ANNA: "Yeah, it's in the discussion. Here!"
5. Directive	Speaker gives an instruction or makes a suggestion	
5.1 Suggestion	Participant makes a suggestion	"You can write Karen says this, or you can just write like Karen colon."
5.2 Order	Participant gives an order	"Could you just write full words, please?"
6. Off task	Utterances irrelevant to the task	