

THE INFLUENCE OF SELF-REGULATED LEARNING AND PRIOR KNOWLEDGE
ON KNOWLEDGE ACQUISITION IN COMPUTER-BASED LEARNING
ENVIRONMENTS

A Dissertation
Submitted to
the Temple University Graduate Board
in Partial Fulfillment
of the Requirements for the Degree
DOCTOR OF PHILOSOPHY

by

Matthew Bernacki

May, 2010

Examining Committee Members:

James P. Byrnes, Advisory Chair, Associate Dean

Jennifer Cromley, Educational Psychology

Julie Booth, Educational Psychology

Joseph Ducette, Educational Psychology

Diane Ketelhut, Curriculum, Instruction and Technology in Education

©

by

Matthew L. Bernacki

2010

All Rights Reserved

ABSTRACT

Title: The influence of self-regulated learning and prior knowledge on knowledge acquisition in computer-based learning environments

Candidate's Name: Matthew L Bernacki

Degree: Doctor of Philosophy

Temple University, 2010

Doctoral Advisory Committee Chair: James P. Byrnes, Ph. D

This study examined how learners construct textbase and situation model knowledge in hypertext computer-based learning environments (CBLEs) and documented the influence of specific self-regulated learning (SRL) tactics, prior knowledge, and characteristics of the learner on posttest knowledge scores from exposure to a hypertext. A sample of 160 undergraduate education majors completed measures of prior knowledge, goal orientation, intrinsic motivation, self-efficacy to self-regulate learning, and a demographic survey. They were trained in the use of nStudy, a learning environment designed to facilitate self-regulated learning from web-based media including hypertext and to trace learners' actions while they learned online. Learners completed a 20-minute study session learning about Attention Deficit Hyperactivity Disorder and a posttest to assess changes in knowledge scores. Results indicate that employment of individual SRL tactics including tendency to highlight was found to be associated with increased posttest knowledge scores across learners. Goal orientation and prior knowledge also significantly predicted posttest knowledge scores in regression models. These findings can be used to inform the design and use of hypertext in order to

individualize computer-based instruction and maximize knowledge acquisition for students, based upon their individual characteristics.

ACKNOWLEDGMENTS

I have many people to thank for their assistance in completing this dissertation. I'd first like to express my thanks to Jim Byrnes, whose advisement from day one through the defense and beyond was prompt, helpful, patient when necessary, and always encouraging. To Jennifer Cromley and Julie Booth who, as a Dissertation Advisory Committee, challenged me to constantly rethink my theoretical basis for my beliefs about learning and my methods I use to investigate research questions. I am grateful also for their expertise both statistical and professional, and their involvement as a hands-on committee. Thanks also go to Drs. Ketelhut and Ducette for agreeing to be act as Examining Committee, and for providing their time, energy, expertise and feedback.

My study could not have been completed without the graciousness of Phil Winne, and Luc Beaudoin who allowed me to use their software and connected me to the nStudy project staff. Bi Ling Chen, Liam Doherty, Ming Ming Zhou and most especially Rylan Egan walked me through the stickiest of design and analysis problems with expertise, interest and patience. Thanks also to Tressa Aulenbach, Brad Litchfield, Rachel Meyer and Mark Snyder who graciously offered to allow me to work with their students. Lastly, this project might still be buried in paperwork and strangled in red tape without the assistance of Richard Thom, Linda Pryor, Geri Ball and Alice Jackson.

Most special thanks to my wife Jeanne, who spent many days enduring a husband who cloistered himself in libraries, computer labs, advisors offices and, at times, the corner of the dining room. Thanks for seeing me through this. I love you. Finally to my son Jonah, who kept his crying to a dull roar and his smiles constant. You provided the best possible diversion when I needed a break.

TABLE OF CONTENTS

	Page
ABSTRACT	iv
ACKNOWLEDGEMENTS	vi
LIST OF TABLES	
LIST OF FIGURES	x
CHAPTER	
1 INTRODUCTION	1
2 LITERATURE REVIEW	9
3 METHOD	84
4 RESULTS	109
5 DISCUSSION	148
REFERENCES	162
APPENDICES	
A KNOWLEDGE SCALE	176
B DEMOGRAPHIC QUESTIONNAIRE	182
C ACHIEVEMENT GOALS QUESTIONNAIRE - REVISED	183
D INTRINSIC MOTIVATION INVENTORY	184
E ADAPTED SELF-EFFICACY FOR SELF-REGULATED LEARNING SCALE	185
F OFFLINE SRL ITEMS FROM THE MSLQ	186
G NODE STRUCTURE	187
H CHILDREN WITH ATTENTION-DEFICIT HYPERACTIVITY DISORDER	188
I LEARNING GOALS NODE	193
J CHECKLIST NODE	194

LIST OF TABLES

Tables	Page
1. Descriptive statistics for demographic variables	86
2. Descriptive Statistics of Pretest and Posttest on Knowledge Measures	89
3. Item Statistics for the Knowledge Measure ($N = 50$)	91
4. Expanded table of SRL classes to include indicators of behavior in nStudy corresponding to classes of SRL as defined by Zimmerman and Martinez-Pons (1986)	100
5. Kappa statistics used to determine inter rater reliability for situation model knowledge items	103
6. Schedule for Data Collection Sessions	106
7. Descriptive Statistics for Self-efficacy for SRL, Achievement Goal Orientation and Intrinsic Motivation Scales ($N = 160$).....	111
8. Descriptive Statistics for Knowledge Scales ($N = 160$).....	113
9. Correlation Matrix of Pretest Posttest and Knowledge Scores	115
10. Correlation Matrix of Transformed Knowledge Scores	116
11. Descriptive Statistics for MSLQ items	118

12. Descriptive Statistics of Count of Online Behaviors	119
13. Descriptive Statistics of Amount and Percentage of Time Spent in CBLE by Page ($N=160$).	123
14. Descriptive Statistics for Frequencies of SRL Tactics Employed in the Learning Task ($N = 160$).....	126
15. Summary of Regression Models predicting Posttest Knowledge Scores	130
16. Correlation Matrix of Traced SRL Tactics Predicting Posttest Knowledge Scores	135
17. Mean Mastery and Performance Orientation Scores and Corresponding Highlights Made.....	138
18. Correlation of Achievement Goal Orientations with Note Taking and Highlighting and with Knowledge Scores ($N = 160$))	141
19. Mean Mastery and Performance Orientation Scores and Corresponding Highlights Made.....	144

LIST OF FIGURES

Figures	Page
1. The nStudy browser	98
2. Equations used to calculate confidence interval for Kappa statistic.....	104
3. Equation to calculate SRLtactics score.....	127

CHAPTER 1: INTRODUCTION

The Changing Context of the Learning Environment

In the field of education, there exists a growing movement that seeks to recast learning as a process that increasingly occurs in computer-based environments (Sawyer, 2006). New theories are beginning to emerge that explain the skill sets that a learner must possess in order to construct meaning and gain knowledge in such environments. In the current study, I document the increasing need for learners to possess skills that allow for self-regulated learning (SRL) to occur (Winne & Hadwin, 1998; Zimmerman, 2000) and make a case that prior knowledge and SRL strategy use will influence the experience of students learning in computer-based learning environments (CBLEs). In addition to the literacy skills needed to construct knowledge from a reading passage (Kintsch, 1998), certain self-regulated learning strategies may increase a student's ability to learn in a hypertext that presents a non-linear reading experience which result in increased flexibility of access to information and learner control.

This study examined how learners construct knowledge in computer-based environments and documented the influence of specific SRL tactics, prior knowledge, and characteristics of both the learner and the learning environment on knowledge gained from exposure to a hypertext. Individual SRL tactics, including tendency to highlight and monitor understanding were found to increase knowledge scores across learners. Such findings can be used to personalize the design of CBLEs in order to individualize computer-based instruction and increase the likelihood that students will acquire the knowledge presented.

Transition from Printed to Electronic Media via Computers, the Internet, and CBLEs

The importance of understanding how students learn in CBLEs is predicated on the idea that students will increasingly conduct learning tasks on computers and that this phenomenon will require students to acquire knowledge from software or the Internet. Such a trend is indeed occurring, and can be demonstrated by student-to-computer ratios, frequency of computer and Internet use in classrooms, and the prevalence of distance learning programs.

Describing the ongoing transformation of K-12 education, the National Academy of Sciences (Pea, Wulf, Elliot & Darling, 2003) has targeted a one-to-one student to computer ratio as a critical factor that will allow for successful implementation of technology in learning environments. Pea and colleagues (2003) suggest that an equal ratio is integral for each student to successfully develop information technology skills, and that this is a prerequisite for the full integration of information technology into the classroom learning environment. Until recently, the idea of obtaining a one-to-one student to computer ratio could have been considered impractical, given the costs of providing such resources to individual students. In fact, initiatives which provide students with laptops for educational purposes have obtained success. In Maine, where middle school students across the state were provided with laptops during the school year, writing performances of students using laptops were significantly higher than student performances before the program's initiation (Silvernail & Gritter, 2007). Further, those students who used their laptops in all phases of their writing process experienced significant gains above peers who used their laptops less often for writing. Similarly, the

Freedom to Learn initiative in Michigan schools provided students in selected districts with laptops and (Lowther, Strahl, Inan, & Bates, 2007). Using school-level data, Freedom to Learn schools tended to outperform their matched comparison schools in math, English and writing. This evidence suggest that initiatives which provide students opportunities to use computers for their schoolwork lead to increased achievement, and should be supported more broadly.

As of 2005, the student to computer ration in K-12 classrooms in the U.S. was 4:1 (Setzer & Lewis, 2005), which is an improvement over the 12.1 to 1 ratio which was reported just five years prior. Such a trend suggests that we are nearing the critical ratio identified by the National Academy of Sciences, and are approaching a milestone in students' opportunity to learn using technology.

Corporate support for one to one initiatives and recent innovations that drive down the cost of laptops suggest that cost should no longer be considered a barrier to integrating technology into the curriculum of U.S. public schools. In 2005, the Massachusetts Institute of Technology unveiled a durable laptop that could be produced for the cost of \$199 per student (One Laptop Per Child, 2009). While originally developed as a tool to bring Internet capabilities to children in developing countries, this technology demonstrates that affordable, durable technology can become commonplace in learning environments. In the U.S., corporations including Acer, Apple, Dell, Intel, HP, Lenovo, Microsoft, Sony and Toshiba all have programs supporting 1:1 programs which can provide lower cost laptops to school districts for classroom use (K-12 Blueprint, 2010).

Sawyer (2006) suggests that, as computers become ubiquitous to learning environments, textbooks will increasingly be read online, streamlining the educational process and limiting costs to school districts. If this is the case, it makes sense to look more specifically at the characteristics of CBLEs that may become prevalent in schools and increasingly replace textbooks and other forms of instruction. It is of great import, then, to study how students' comprehension of text is influenced by presentation in a hypertext environment, and whether providing tools can support greater comprehension.

In higher education, the trend towards online learning and CBLE use has been well documented. According to the NCES (Waits & Lewis, 2003), twenty-nine of higher education institutions that offer distance education courses relied primarily on CD-ROM based instruction in 2000-2001, and an additional thirty-nine percent of schools surveyed planned to increase such utilization (Waits & Lewis, 2003). The Sloan Consortium (2006) reported there were 3.2 million postsecondary students in the United States who took at least one online course; this represents a 25% increase over the previous year. In 2008, there were approximately 4 million college students currently enrolled in fully online courses (Sloan Consortium, 2006).

If CBLEs such as online courses and textbooks continue to compose a larger portion of students' learning resources, theorists must begin to consider the ramifications of the ubiquity of CBLEs in the learning process. These trends will continue in higher education, and with the K-12 student-to-computer ratio increasingly approaching one to one, increases in the use of computer-based texts for learning can be expected.

Differences Between Learning Environments

As the characteristics of instructional materials change, it is possible that the cognitive demands of the learning environment will be different in computer-based settings than in traditional settings where course materials are primarily printed textbooks. Students who have would previously read a chapter in a textbook from start to finish would sequentially encounter all the material for which they are responsible. While the design of CBLEs vary, students using online versions of textbooks generally can navigate segments of text in a linear format, but must often navigate through the larger environment in a non-linearly fashion. This has been tentatively shown to influence knowledge acquisition (Zumbach, 2006). That is, in CBLEs, students may need to navigate from one page of information to another in an order of their choosing, rather than flipping pages bound within a text. The path students take through texts may influence the quality of their textbase knowledge acquisition as well (Salmerón, Cañas, Kintsch, & Fajardo, 2005; Salmerón, Kintsch & Cañas, 2006).

The opportunities students have to use tools also differ between CBLEs and printed text with respect to both navigation of text and annotation of its content. When using a paper textbook, students can use a chapter outline, table of contents or index to navigate the text and find the topic they are seeking. In a CBLE, they may have these options, and the tools may include hyperlinks which allow users to navigate directly to content. Additionally, users may be provided with advance organizers or concept maps which support navigation. Provision of these types of tools in CBLEs has been shown to influence the amount of knowledge students acquire (Potelle & Rouet, 2002).

In print media, learners may organize their studying by taking notes in margins, on a separate page, or by highlighting relevant passages. Depending on the CBLE, the environment may or may not support such processes with analogous annotation tools. If students normally use paper-based study strategies, opportunities to use parallel computer-based study strategies will likely influence both their learning processes and their performance. While CBLEs vary in the degrees to which they support annotation, nStudy, which is used in this study, supports highlighting and note taking of hypertext. These differences between print-based and computer-based learning environments suggest that CBLEs are at least modestly different from traditional learning environments, and that students may perform differently in a CBLE. Given the increase in exposure to CBLEs in the K-12 and higher educational settings, it is imperative, then, to explore how students learn in these new environments.

This paper outlines the role that self-regulated learning might play in the knowledge acquisition process when individuals learn in computer-based learning environments. The discussion of learning in CBLEs is here embedded in a conventional model of comprehension (the construction-integration theory; Kintsch, 1998) that documents the process by which students attempt to learn from the content of a textual passage. While the study focuses on knowledge acquisition as an outcome, self-regulated learning behaviors are examined to determine if they influence either the process of studying a text passage, or the ability to gain knowledge from studying text in a CBLE.

I begin by defining knowledge acquisition using Kintsch's (1998) Construction Integration Model. I next review theories of self-regulated learning (Boekaerts &

Niemivirta, 2000; 1997; Winne & Hadwin, 1998; Zimmerman, 2000), their conception of SRL as a component model or process model, and the requisite online and offline assessment techniques that have been used to measure SRL strategy use. Self-regulated learning is then examined as a tendency intrinsic to a learner, as an outcome of the learning process, and as a cyclically recurring process that influences the process of knowledge acquisition. These conceptions of SRL are then applied to knowledge acquisition in hypertext assisted learning environments (Shapiro & Neiderhauser, 2004) and a study is described that was intended to examine the role of self-regulation in the learning process when students learn from hypertext. This study topic was chosen based upon review of empirical research examining individual characteristics of the learner (including SRL tendency) and contextual factors of the learning environment that influence knowledge construction and with a goal of using embedded methods of tracing student learning behaviors. Specifically, the following four research questions were proposed:

1. How does employing multiple SRL tactics influence knowledge acquisition?
2. How do students gain more knowledge when they use specific tactics to study a reading passage?
3. How does their level of prior knowledge influence learners' knowledge acquisition process when studying hypertext?
4. How does goal orientation influence the use of SRL behaviors? And does this result in different amounts of knowledge gained?

If these research questions can be sufficiently answered, findings would allow educators to consider students' personal characteristics and make adjustments to their motivation or preparedness before a computer-based learning task is presented. Alternately, they could adjust the CBLE to accommodate the learner's characteristics by enabling the learner to

utilize design features that might scaffold their learning process and result in a higher likelihood of acquiring knowledge.

As CBLEs become an increasingly common vehicle for instruction, it is imperative for educators to understand the potential impact of different aspects of the design of the learning environment, the characteristics of the learner, and the fit between the two. Empirical studies document the role that self-regulation plays in educational contexts, and specifically, when computer-based instruction is employed. These studies provide a context for this study that examined whether college students using CBLEs would acquire knowledge in different amounts and through different processes depending upon their self-regulatory ability, prior knowledge and individual characteristics.

CHAPTER 2: LITERATURE REVIEW

The goal of this study was to examine the associations among learner characteristics, learner behaviors and knowledge acquisition. I am particularly interested in the relationship between learners' goal orientation, the use of self-regulated learning (SRL) strategies, the level of prior knowledge, and knowledge acquisition from hypertext, a form of computer-based learning environment (CBLE). The foundations for my hypotheses about SRL strategy use are theories of self-regulated learning and a theory of text processing (Kintsch, 1998) used to define knowledge acquisition. Therefore, the literature review is organized as follows. In the first section, I define knowledge acquisition using Kintsch's Construction-Integration Model for comprehension of text. Next, I describe several prominent models of SRL and discuss the possible options for measuring SRL. After this theoretical discussion, I review a series of empirical studies that examine the impact that different learner characteristics and CBLE design features have on the process of knowledge acquisition. Once this literature has been reviewed, I describe a study I conducted that was intended to further develop our collective understanding of the impact that CBLE design has on knowledge acquisition for learners with different individual characteristics.

Theory of Text Processing

Kintsch's (1998) Construction-Integration Model (C-I) describes reading comprehension as a cyclical process of constructing and integrating the propositions that appear in a passage into a *textbase* that readers elaborate upon using prior knowledge and experience to form a *situation model*. This model describes the process by which a reader

activates prior knowledge and information derived from text to come to comprehend in a new and/or more meaningful way. According to Kintsch, learners perform a combination of mental processes in which they derive meaning from text that can be described as occurring from the top-down and from the bottom-up.

Kintsch describes text processing activity as a top-down process in that the reader has a schema into which he or she attempts to fit the content of the passage. The reader activates prior knowledge and supplements understanding with the newly acquired information. This process drives the reader's ability to make inferences. Additionally, C-I is a bottom-up process in that reading is based on an associative process where meaning is constructed from the connections of letters into words, words into meaningful phrases, and so on, until inferences or imagery can be built and knowledge can be acquired and retained.

The process of construction and integration begins when the reader constructs all possible meanings for a given word, and then integrates those meanings in light of other words' meanings and the degree to which they make sense in context. For instance, a reader may read the words "cross" and "intersection." Each word has multiple definitions that, upon identifying the word, the reader will recall. When seen together, meanings of cross as an adjective (angry or upset) or as a noun (a wooden cross) are ignored and the word cross is understood as a verb in the context that one crosses an intersection of two roads. To describe this process, Kintsch (1998) characterizes construction rules as "weak and dumb" (p. 95) in that original definitions are tentative until they can be strengthened or eliminated based on the context in which the words occur. Once phrases are

constructed and their meanings are clarified, the phrases are then oriented to one another as either directly, indirectly or subordinately related so that meaning can be attributed. These meaningful portions of text are then stored in the working memory through associations and may be recalled when future phrases or sentences are read that relate to their content.

In the C-I Model, text representations are built sequentially. Text is processed word-by-word, sentence-by-sentence, and then integrated with what has already been read or is known. The process is cyclical so that new construction is followed by integration and the cycle repeats. At the end of each sentence, the pieces are dropped from the working memory and the larger more meaningful unit is retained. Those pieces may be recalled later if a future sentence requires them.

As readers progress through a text, the memory of previous sentences is repeatedly reinforced or they fall from the working memory. As meaning is made, the learner can then connect individual meanings together with one another or to prior knowledge to construct inferences. This is done to recast prior knowledge in light of new information, or to form a “macroproposition” that summarizes meaning from the new text. Kintsch (1998) describes working memory as the spotlight that highlights a sentence for processing.

To describe the unitary concept that is comprehension, Kintsch breaks down reading comprehension into elements called the textbase and the situation model. The textbase is described as the “elements and relations that are directly derived from the text itself” (Kintsch, 1998, p. 103). The textbase includes a propositional structure that

includes the meaning of words and phrases, and a surface structure, such as a rhyme scheme or literary style. Comprehension of the textbase is improved through the C-I process as the reader establishes stronger links between nodes, either from prior knowledge or from experiences within the reading task.

A higher order element of reading comprehension is the situation model. Kintsch describes the situation model as “a construction that integrates the textbase and relevant aspects of the comprehender’s knowledge” (Kintsch, 1998, p.107). To develop comprehension at the level of the situation model, the learner must have an understanding of rules for language and a larger understanding of how this passage might apply to their prior knowledge of how the world, or a specific phenomenon works. When the reader engages in the C-I process, he or she builds situation model comprehension by identifying causal linkages between nodes of text and can create elaborative inferences based on individual text pieces, the tone of the text, or the feelings of the speaker.

For an example of textbase and situation model knowledge, let us consider the example of a reading passage that Kintsch (1998) calls the overtake scenario where one car passes another. An example of text that describes this might say “The blue car sped past the red car.” Readers would perform construction and integration and come to the textbase comprehension that a blue car moved in front of a red car. To develop a situation model understanding of this sentence, readers may connect this scenario to past experiences where cars have been seen to pass one another and readers then make an inference about what is going on in the text, dependent upon the imagery or the verbal or propositional representations they recall of previous overtake situations.

The key elements of the C-I model include the ability to conduct propositional representation, to process words and sentences in a cyclical fashion, and to make distinctions between the microstructure and the macrostructure of the text. By conducting this process, readers are able to comprehend the individual propositions within a text and to assign an overarching meaning to the passage as connections are made between the passage and readers' prior knowledge.

Kintsch's Construction-Integration Model can be used to define knowledge acquisition in that the learner, having been exposed to a new text passage, will increase his or her understanding of a phenomenon based on comprehension of the new text. Prior knowledge may be improved based on this new knowledge, or comprehension of a new topic may occur in the absence of prior knowledge. Therefore, the difference between knowledge after reading versus before reading becomes the dependent variable in the proposed study.

Kintsch's theory of construction and integration as a means of developing comprehension of written text is dependent upon a series of metacognitive activities. These activities include the activation of prior knowledge, drawing inferences, rehearsing information for retention purposes among others. While all learners are capable of conducting such mental actions, learners employ these tactics to varying degrees, which educational psychologists (Pintrich, 2000, Winne & Hadwin, 1998, Zimmerman, 2000) have described as a learners' degree of self-regulation when learning. It can be argued, then, that the degree to which a learner tends to conduct metacognitive activities, or to self-regulate learning, directly influences the level of textbase and situation model

comprehension. If this is accurate, a learner's self-regulatory behavior should predict knowledge gain from hypertext, and it should be possible to isolate specific metacognitive actions as potential indicators of SRL, and predictors of knowledge gain. The following section summarizes theories of self-regulated learning (SRL) and details how SRL behaviors have been operationalized and measured.

Models of Self-Regulated Learning

Self-regulated learning is one of the many self-regulation constructs described in the *Handbook of Self-Regulation* (Boekaerts, Pintrich, & Zeidner, 2000). Additional constructs include self-control and self-management, among others. As an overarching construct, self-regulation is defined differently depending upon the theoretical assumptions of the author, which has led to a diffuse distribution of self-regulation publications across a variety of journals. Definitions of self-regulation vary and are strongly held, to the point that two different handbooks of self-regulation are published (Baumeister & Vohs, 2004; Boekaerts, Pintrich, & Zeidner, 2000). Baumeister and Vohs' volume focuses on the self-regulation of physical and affective dimensions, whereas the volume edited by Boekaerts, Pintrich and Zeidner (2000) focuses primarily on social, cognitive and behavioral dimensions of self-regulation. A seminal model for the discussion of self-regulation as a cognitive and behavioral process was conceived by Albert Bandura (1986), who described self-regulation as a social and cognitive process involving personal, behavioral and environmental processes that must be regulated by the individual as he or she pursues a goal.

Paul Pintrich (2000) described self-regulated learning (SRL) as an “application of general models of regulation and self-regulation to issues of learning, in particular, academic learning that takes place in school or classroom contexts” (p. 451). SRL is conceptualized alternately as a trait-like ability one possesses (Boekaerts & Niemivirta, 2000) or as a process through which one continually expresses the ability to self-regulate (Winne & Hadwin, 1998; Zimmerman, 2000).

Boekaerts' Model of Adaptable Learning

Monique Boekaerts (Boekaerts & Niemivirta, 2000) depicts the self-regulation process as being driven by the appraisals of the learner, which dictate whether or not one takes on a learning task, and the route one takes to successful goal attainment. She posits that individuals make decisions to take on tasks based upon their perception of the learning situation and their metacognitive beliefs that the situation represents a task they can accomplish. This is then moderated by motivational factors. If learners develop positive appraisals, they advance to a goal process that involves goal setting and action. If their appraisals are negative, learners choose instead to not complete a task and protect their ego, resources, and well-being.

When positive appraisals occur, the learner advances to the goal process and considers the learning context by identifying the context, interpreting features of the context and appraising the learning situation. Depending upon the learning context, two different action patterns are generated. If it is deemed that this context is similar to one previously encountered, an automatic action pattern is followed, and the learner proceeds immediately to goal setting and carrying out an action plan. A learning context that has

not been previously encountered requires additional consideration where learners must complete the appraisal process and determine if the task is: a) within their ability to complete, b) if it represents any threat to their well-being to attempt, and c) if the task is worth completing.

Pintrich (2000) categorizes Boekaerts' model of SRL as a component model in which learners have a fixed set of traits that guide the appraisal process and lead to particular goal processes. This trait-like view of SRL suggests that learners operate similarly across contexts. As a result, studies of SRL by Boekaerts examine SRL as a static component influencing the process of task completion, but also as unchanged by the process of completing this task. Winne and Hadwin (1998) and Zimmerman (2000) disagree with this perception, theorizing instead that the learner's SRL tendencies are influenced by the learning context and can also be developed as a result of completing tasks.

Winne and Hadwin's Information Processing Model of Self-Regulated Learning (1998)

Winne and Hadwin (1998) consider self-regulated learning to be an event-based phenomenon that occurs cyclically and in four distinct phases. Learners, when self-regulating their knowledge acquisition process, are theorized to: 1) define the task at hand, 2) set goals that they would like to attain and develop a plan for their attainment, 3) enact those tactics, and 4) monitor their progress towards goal attainment against a preconceived set of internal standards.

Defining the Task

When defining the task, the learner generates a perception of a task in light of the current environment and conditions, as well as the past experiences he or she has with tasks recognized to be similar in nature. Winne and Hadwin describe these as *task conditions* and *cognitive conditions*. Numerous iterations of phase one occur as the person continually redefines a task as he or she considers past experiences, normal procedures for approaching the task, options in terms of other procedures one might use to complete the task, and perceptions of one's ability to compete the task. This iterative process is based upon learner perceptions of the resources (cognitive and external) that the task requires and their perception of their possession of such resources. The process of task definition requires cognitive control, without which the learners could not advance to the goal setting stage as they would not believe themselves cognitively capable of choosing goals.

To illustrate task definition, let us consider a running example of a female student studying for an exam. The student must define the task by determining the subject of the course, the material the exam will cover, the format of the exam, and the number of days she has to prepare (environment and conditions). The student may recall having completed a similar test in another course (experience) and, if the exam resulted in an acceptable grade (the attainment of the goal) that method of preparation may be followed. The process may be iterative in that, as the student studies, she feels more or less prepared for the test and able to achieve (cognitive conditions) and redefines the studying task as a result.

Setting Goals and Planning

The second phase of the information processing model of SRL requires a cognitive process where the learner pairs decision making skills and information from past memories of similar tasks to frame the task. Once framed, the learner can develop specific goals to be met by actions performed within the task environment, and can plan those actions. Once a goal is established, past successful strategies (expertise) may be recalled and used to develop a plan for goal attainment. Here, if a learner cannot come up with a goal and a plan, it is likely because his or her beliefs about self or the task condition do not warrant task completion. That is to say, learners have a set of internal standards that govern their motivation to complete a task. The learner evaluates how important a goal is to be attained, weighs the effort and resources it would take to attain such a goal, and makes a decision to pursue it or not. If the task seems possible to complete and is worthwhile, the process continues to phase three; if not, the process ends. In order to move on, the learner may employ some type of adaptation to the task conditions or reframe his or her thinking about the task (cognitive conditions) in order to proceed.

Continuing our example, a student may recall a previous test of the same format in a similar course. Having scored well on an objective portion, but poorly on an essay portion, the student may decide to replicate a study strategy, such as memorizing definitions, which resulted in the high objective score, but may choose to add a second study strategy, since memorizing alone did not prepare her for the essay portion of the exam.

Enacting Tactics

Once a goal and plan of action has been determined, the action phase can proceed. In the enacting tactics phase, the learner moves the plan into working memory and begins to complete the set of steps hypothesized to lead to goal attainment. The plan exists in verbal working memory as a set of tactics, defined by Winne and Hadwin (1998) as bundles of memory comprised as conditional knowledge (conditional statements or “ifs” that characterize tactics as appropriate or not), and cognitive operations (conditional statements or “thens” that imply actions based upon a set of conditions). When an “if” is met with a “then”, the tactics are translated into behavior, and feedback is then created based on success or failure of the behavior in achieving the goal.

In our example, the student enacts the plan to study both by memorizing definitions, but also by elaborating upon those definitions in the context of particular case studies, or in response to questions posed by the instructor in previous lessons.

Adapting Metacognition

Depending upon the outcome of an action, the learner will need to adapt his or her metacognition to process the result and continue the SRL process, or declare the goal attained (or unattainable). Winne and Hadwin (1998) describe the monitoring of task and cognitive conditions as major adaptations and as a critical task in the SRL process. Learners, depending upon the success of their tactics, can reinterpret how a tactic influences an event and can resultantly restructure cognitive conditions, tactics, and strategies to create new approaches to completing a task.

The overarching structure of the SRL process is the monitoring and feedback that plays a critical role in each phase. Without monitoring, one cannot compare thoughts or actions to standards or make any judgment about their worth. At every step in the process, the learner monitors his or her thoughts on the situation against an internal set of standards about the worth of the task, his or her ability to complete it, and so on. Monitoring determines if one continues with the process, and also updates one's understanding of the conditions of the task such as one's understanding or goals, and the usefulness of tactics.

Focusing specifically on the student who memorizes definitions of key terms, if she is a self-regulated learner, she will monitor her success by quizzing herself on her retention of definitions. If, when she presents herself a term with the definition obscured and she is able to recall it accurately (as per her internalized standards), she may consider her tactics successful. If she has not met her goal, she may repeat her previous tactics or employ different actions to attempt to meet the goal.

Zimmerman's (2000) Model of Self-Regulation from the Social Cognitive Perspective

While originally conceived by Albert Bandura (1986), Barry Zimmerman and Dale Schunk (1998) have become prominent generators of self-regulation theory from a social cognitive perspective. In the *Handbook of Self-Regulation*, Zimmerman (2000) defines self-regulation as referring to “self-generated thoughts, feelings and actions that are planned and cyclically adapted to the attainment of personal goals” (p.14).

While alternative models of self-regulation exist and each has its own ardent supporters, Zimmerman (2000) defends his model as being superior to single-trait or

metacognitive models of self-regulation. According to Zimmerman, the social cognitive model of self-regulation possesses a greater ability to explain the individual's differential ability to self-regulate across instances, which is mediated by contextual factors from the environment and the person's own beliefs, emotions and past experiences. Depending upon the unique circumstances of a situation, the individual may choose different strategies for self-regulation as a result of either a past experience in a similar situation, a belief that he or she knows a correct way to proceed, or the existence of some environmental stimuli that suggests a particular course of action.

These variables (personal, behavioral or environmental stimuli) that continue to change and influence an individual's self-regulation process are monitored and reacted to by using a variety of feedback loops. Within these feedback loops, the individual chooses a strategy to attain a goal and then adapts that strategy based upon relative success or failure. This success or failure can be impacted by thoughts or feelings, performance, or an outside factor in the environment. To deal with each type of factor, individuals can opt for *behavioral self-regulation* and adjust performance processes, *environmental self-regulation* and change the environmental factors that are inhibiting goal attainment, or *covert self-regulation* where individuals attempt to change their own affective states. By monitoring the success of their strategies and using feedback about potential barriers to goal attainment, the individual can adapt to scenarios and regulate his or her process en route to attaining their intended goals.

This example of studying for an exam can be described with respect to Zimmerman's model above. A student who is placed in a similar learning situation may

choose to self-regulate behaviorally by employing tactics so as to make her performance process (study tactics) result in her goal (a good score). She may self-regulate environmentally and decide that another section of the course utilizes a test format that suits her better, and decides to transfer. She may also self-regulate covertly, determining that she would like a particular score, but as a result of a learning situation she cannot change, she will be satisfied with a passing, but slightly lower score.

Cyclical Phases of Self-Regulation

The ability to self-regulate is not dichotomous in the sense that individuals can either self-regulate or they cannot (Winne, 1997). Rather, individuals' ability to self-regulate is influenced by the quality and quantity of their utilization of self-regulatory processes. Schunk and Zimmerman (2008) describe these processes as occurring cyclically and in three phases.

Individuals first conduct a period of *forethought*, where they analyze the task to be completed in order to achieve the desired goal, and develop a plan to obtain this goal. This plan is then evaluated for its potential for success, which is mediated by one's self-motivational beliefs, including self-efficacy, goal orientation, and outcome expectation. In the *forethought* stage, self-regulation can break down if an individual cannot clearly determine a goal, or cannot develop a plan for reaching it. It can also stagnate if the individual cannot motivate himself or herself to seek such a goal or carry out the determined strategy.

In *forethought*, our student may analyze her task (consider the test date, content, format) and develop a plan (study schedule, activities to complete). This self-defined

study plan would then be evaluated by the student to determine an attainable goal (a passing score, and perhaps a target grade) depending upon self-motivational beliefs as described above.

Once a goal has been identified and the individual intends to carry out a strategy to attain the goal, the individual acts. This stage is referred to by Schunk and Zimmerman (2008) as the *performance* or *volitional control* phase. Here, individuals critique their own strategy use in an attempt to maximize the efficiency of their efforts while carrying out a chosen strategy. Such critiquing may employ self-control strategies including self-instruction, attention focusing, or the use of imagery or task strategies. Additionally, the individual performs self-observation, in the sense that one monitors characteristics of performance and the resulting outcomes, as well as the context in which it occurs. The success of self-monitoring depends upon its timeliness (Bandura, 1986) and the quality of information one gleans about performance (Ericson & Lehman 1996). Self-observation is often enhanced by the cataloging of feedback so one can refer to a record of occurrences, as well as reactions (thoughts and emotions) to such occurrences, and adaptations gained from exposure to similar situations.

As in the example in Winne and Hadwin's theory, our student will conduct performance or volitional control by using monitoring of progress towards the goal. The student may quiz herself and appraise her mastery of content. If necessary, she may redouble her study efforts by walling herself off for a more intensive study session that she thinks will better enable her to perform well on the essay section of the upcoming exam.

After having completed an action and monitored the process and outcome, individuals conduct a *self-reflection* phase where they evaluate their performance and attribute the success or failure of the performance to causal factors. This is called self-judgment by Bandura (1986) and relates to one's self-efficacy, particularly with regard to learning. Additionally, Bandura describes the process of self-evaluation, in which the individual critiques aspects of the performance to a desired level of performance (based on one's own past attempts or the performance results of others) and makes a value judgment upon the performance. Zimmerman (2000) categorizes the four types of criteria people use to evaluate themselves as mastery, previous performance, normative and collaborative. Mastery performances utilize a criterion-referencing strategy to compare one's performance with that of a novice and an expert to determine one's level of expertise (Covington & Roberts, 1994, Ericsson & Lehmann, 1996). Previous performances by an individual can be used to make direct within-subject comparison of attempts (Bandura, 1997). Normative criteria (Zimmerman, 2000) are used to evaluate one's performance against the most common level of performance observed via social comparisons. In situations where an individual works with others towards a goal, collaborative criteria are utilized. The goal of the team is communal and must be reached as a group. As a result, the individual goal of each team member is to maximize the success of their partnership with other team members (Zimmerman, 2000).

Once self-judgments about performance have been made, the individual conducts causal attributions to explain success or failure. This is an important step, as the attributions an individual makes can influence his or her future processes. If an individual

attributes negative outcomes to the self, he or she may decrease in effort and cease goal-directed behavior (Zimmerman, 2000). This can occur when an individual experiences a belief that he or she cannot complete a task, or that an environmental barrier is insurmountable and the goal is then unattainable. This *attributional style* is said by Bandura (1991) to be influenced by one's self-efficacy. Individuals with high self-efficacy for a task will attribute their successes to their abilities and failures to insufficient effort, whereas persons with lower levels of self-efficacy will attribute success as due to good luck, while failures stem from a lower level of ability or preparedness to perform the task (Pajares, 2002). Attributions may influence an individual's self-efficacy and goal orientation in the future.

As a result of attributions, one then makes inferences about how future performances need to be carried out (Zimmerman, Bandura, & Martinez-Pons, 1992). These can be adaptive, where one changes a strategy to achieve a goal or sets a subgoal, or they can be defensive. Defensive self-reactions include helplessness, procrastination, task avoidance, cognitive disengagement, and apathy (Zimmerman, 2000).

Utility of Information Processing and Social Cognitive Theories of Self-Regulation

As described above, the social cognitive perspective takes into account the cognitions and behaviors of the individual, and the individual's situation when placed in a specific environment. The structure of this model lends itself to systematic and efficient experimental methods that can be employed to explain the differential roles that thoughts, actions or external variables can play in the self-regulatory process. When the environment is constrained to an educational context, research on self-regulation can

focus on the learning process (SRL) and experimentation can focus on variables related to the student, instructor and the instructional content and context. By examining the conditions in which students think and act, and by comparing different types of students across different instructional styles and content, much can be learned about the role that self-regulation strategies, monitoring, and appraisal play in student self-regulatory behavior. The remaining difficulty is to determine the best way to measure self-regulated learning.

Methods for Measuring SRL

As described by Pintrich and colleagues (2000) in the *Handbook of Educational Psychology*, self-regulated learning can be interpreted both as an aptitude (trait) and a tendency (state). As such, attempts have been made to measure self-regulated learning tendency in offline settings, which suppose such tendency is fixed and trait-like. Others support the idea that SRL tendency will vary by context and, as a result, have developed situational measures of SRL that measure strategy use while individuals complete tasks.

Numerous tools exist to capture data that describe an individual's SRL ability. The design of each tool depends on theoretical assumptions about the nature of SRL abilities, and on beliefs about whether SRL can be measured across all contexts, or whether it must be measured with respect to a particular SRL task. In an attempt to synthesize the different conceptual models of SRL, Wirth and Leutner (2008) define SRL as a *competence* that is critical to the learning process. Their working definition describes SRL as a "learner's competence to autonomously plan, execute and evaluate learning processes, which involves continuous decisions on cognitive, motivational and behavioral

aspects of the cyclic process of learning” (p.103). Wirth and Leutner argue that for a measure of SRL to be valid, it needs to represent the learner’s competence in making comparisons between a current state and a set of standards to which one’s performance is being judged (Wirth & Leutner, 2008). This description of SRL as competence takes into account the metacognitive tasks of goal setting, planning and monitoring suggested by Boekaerts and Niemivirta (2000), Winne and Hadwin (1998) and Zimmerman (2000) and provides structure for different attempts to measure SRL seen in the literature.

Wirth and Leutner (2008) summarize the methods used to measure SRL by sorting methods into component and process models that utilize online or offline standards and collect qualitative or quantitative data. Measures based off of *component models* treat SRL abilities as prerequisite skills that, when available, allow a learner to regulate their learning experience. These measures reflect the theoretical view of Boekaerts and Niemivirta (2000). Measures that describe SRL as a process assess self-regulatory actions in a cyclical fashion because the process of self-regulation is constantly changing as a result of the environment and previous decisions. This online measurement technique corresponds best to *process models* of SRL by Winne and Hadwin (1998) and Zimmerman (2000). Self-regulation is a recursive process that is adapted to the learning context and task, and requires constant redefinition of the task and the ensuing appropriate strategy that will lead to goal attainment. “Online” measurement, which is used in the present study, allows for examination of this process.

In empirical research, measurement of SRL has mostly occurred using “offline” standards, implicitly adopting a component view of SRL as prerequisite ability. Offline

measures utilize pencil and paper methods to assess the frequency and consistency with which one reports having self-regulated one's own learning on a series of Likert-type items. The benefit of this measurement strategy is versatility, as it can be employed independent of a learning task. The downside of these techniques is a lower validity, as one's ability to recall past learning experiences influences reporting patterns (Wirth & Leutner, 2008). Such calibration between what a learner thinks he or she does and actually does when studying is particularly poor (Winne & Jamieson-Noel, 2002), rendering the validity of offline measures low. Further, if it is true that cognitive, motivational and environmental factors influence one another as theorists (Pintrich, 2000; Winne & Hadwin, 1998) suggest, validity is further decreased as respondents must answer questions about their motivations and cognitions without a task environment specified for their consideration.

Online measures boast higher validity and capture data from within the context of the learning task. Corresponding to process models of SRL, online methods of capturing evidence of SRL record actions through a computer application or by recording learners' narratives of their thoughts and behaviors where the learner is engaging in a learning task. These methods are referred to as trace methodologies and think-aloud protocols, respectively, and are described later in this chapter. The behaviors or statements made by the learner indicate whether the learner is seeking new knowledge or integrating knowledge in order to achieve a goal. While online standards have higher validity than offline standards because of their measurement of SRL in specific task, the measurement technique renders SRL findings less generalizable as data collected correspond only to

one task. This decrease in generalizability is preferable to the questionable validity of offline measurement techniques due to the findings of Winne and Jamieson-Noel (2002) referenced above. Winne and Jamieson-Noel (2002) examined the criterion-related validity of offline SRL measurement. Students' beliefs about how they employ SRL strategies and how they actually operate were found to be poorly calibrated. This poor calibration renders such scales unreliable when they rely on self-report about general SRL tendencies. Further, difficulties with internal consistency and other psychometric properties erode the quality of some specific offline measures, as can be seen in the following section.

Wirth and Leutner (2008) focus entirely on describing categories of SRL measurement, and provide no descriptions of the instruments commonly used to assess SRL. Winne and Perry (2000) focus on the measurement of SRL in more specific terms in the *Handbook of Self-Regulation* and document previous attempts to measure SRL on a method by method basis. They too make a distinction regarding the theoretical belief that SRL should be measured as either an aptitude (like a component) or an event (as evidenced within a task specific learning process) and argue that both are valid forms of measurement. Before summarizing individual instruments or assessment methods, Winne and Perry (2000) describe measuring SRL as a complex process where instruments must be able to capture evidence of subconstructs including motivation and metacognition as well as visible strategic actions. Because some facets of SRL are not readily observable, researchers have attempted different methods of documenting those cognitive and metacognitive events such as goal-setting and monitoring and states such as motivation.

When describing measures of SRL as an aptitude, Winne and Perry (2000) characterize SRL as fixed and universal much like Wirth and Leutner (2008) and report that most attempts at measuring SRL aptitude are conducted via self-report questionnaires, categorization of student responses to questions posed by an observer, and by classification of the proportion and type of notes taken by a learner during a learning task. These methods can be employed in either offline (questionnaire) or online settings, and most can be interpreted quantitatively, or qualitatively. Winne and Perry (2000) break down SRL aptitude into the component parts of metacognitive knowledge abilities and metacognitive monitoring abilities.

Wirth and Leutner (2008) use the word “process” to describe Winne and Hadwin’s (1998) theory of SRL. Winne and Perry (2000) describe this “process” as SRL occurring within the context of a specific “event.” While engaged in an authentic task, instances of self-regulated learning occur where an individual demonstrates an SRL behavior. The three levels stipulated as increasingly complex types of SRL by Winne and Perry include occurrence, contingency and patterned contingency. An occurrence is observed when a learner moves from observably not using SRL to using it. This is a simple dichotomous categorization, which often is noted when a student, when working, makes a comment such as “wow, this is hard.” This comment is evidence of the SRL process where monitoring occurs. The learner recognizes that he or she does not presently know the best way to complete the task, thus identifying the task as difficulty. The learner then acknowledges this identification of difficulty and remarks orally. In documenting this, a researcher may categorize the event as indicative of the

metacognitive monitoring of the difficulty of the task as well as metacognitive control being exercised. Thus, an external reaction to an internal process alerts an outside observer to the existence of an SRL event. In positing whether or not SRL is taking place, this measurement strategy poses an if-then condition. One might suggest that there is a certain level of likelihood that, when engaging in a learning task, the student will switch from not self-regulating to employing SRL. This probability is then determined by repeatedly administering learning tasks to a respondent to determine how often the switch from not self-regulating to employing SRL, or that the “if” results in a “then” (Winne & Perry, 2000). This measurement technique assesses SRL as an event-based phenomenon and is well-suited to Winne and Hadwin’s model of SRL as described above, and to Zimmerman’s (2000) model. Using Zimmerman’s terms, additional categorizations must be made to classify evidence of components of forethought, action and monitoring instead of Winne and Hadwin’s (1998) four steps (defining task, setting goals, enacting tactics, adapting metacognition).

Because measurement of SRL as an event or process occurs in an online setting, data collection occurs within the context of a particular task being completed, but can take different forms. One may quantitatively assess the frequency of employment of different SRL strategies, or one might compare the order of SRL behaviors to an optimum utilization of strategies in the form of expert versus novice comparisons.

The following section catalogs common SRL measures and explains their theoretical underpinnings, their psychometric properties, their advantages and limitations, and then attempts to situate each tool within the categories described by Wirth and

Leutner (2008) and Winne and Perry (2000). Methods of assessment include self-report questionnaires, structured interviews, teacher judgments, think alouds, error detection tasks, trace methodologies and observations of performance.

Self-Report Questionnaires

Self-report questionnaires are commonly used, easy to design, administer and score and can be used across a variety of settings. They provide information about learners' memories and interpretations of their own employment of SRL in past learning tasks. They also provide respondents an opportunity to describe their own cognitive and metacognitive processes, which are unobservable by an outside researcher. Wirth and Leutner (2008) would most likely describe these tools as offline, quantitative tools that ascribe to a component model of SRL. The two most commonly used measures in published research are the Learning and Study Strategies Inventory (LASSI; Weinstein, Schulte, & Palmer, 1987) and the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1991). More recently, the Organization for Economic Cooperation and Development (OECD) built off of the MSLQ and theory by Boekaerts and Niemivirta (2000) and others to create the Self Regulated Learning as a Cross-Curricular Competency (CCC; Peschar, Veenstra, Molenaar, Boomsma, Huisman, & van der Wal, 1999) scale to measure self-regulated learning tendency as part of their Program for International Student Assessment (PISA). Additional scales exist that attempt to measure only individual classes or subsets of SRL behaviors such as goal orientation or intrinsic motivation. Examples of these are described in the methods section and include the Achievement Goals Questionnaire – Revised (Elliot &

Murayama, 2008), the Self-Efficacy for Self Regulated Learning scale (Usher & Pajares, 2008) and the Intrinsic Motivation inventory (Elliot & Church, 1997). Self-report scales that measure SRL and its subconstructs vary considerably in their structure and psychometrics, as can be seen in the following review

The LASSI presents 77 five-point Likert items to respondents who must decide how typical the item's content is of them. The LASSI was normed using a sample of 209 undergraduate students at a southern university and is intended to measure the use of learning and studying strategies employed by young adults. The LASSI includes ten subscales that measure cognitive and metacognitive components, as well as self-reported evidence of employment of learning strategies. The scales are titled: 1) attitude and interest, 2) motivation, diligence, self-discipline and willingness to work hard, 3) use of time management principles for academic tasks, 4) anxiety and worry about school performance, 5) concentration and attention to academic tasks, 6) information processing, acquiring knowledge and reasoning, 7) selecting main ideas and recognizing important information, 8) use of support techniques and materials, 9) self testing, reviewing, and preparing for classes and 10) test strategies and preparing for tests. The items on the instrument were retained from a larger pool of items that was contracted based on item statistics, factor loadings and correlation with social desirability scores. In terms of reliability, scores on the LASSI were found to be stable over 3 weeks, with test-retest coefficients ranging from .72 to .85, and internally consistent, with coefficient alphas ranging from .68 to .86 (Winne & Perry, 2000).

The Motivated Strategies for Learning Questionnaire (MSLQ) was designed by Pintrich, Smith, Garcia, and McKeachie (1991) to assess the motivational orientations of undergraduates and their use of learning strategies within the context of college coursework. The MSLQ contains 81 items that are scored on a 7-point Likert scale that require each respondent to determine “how true of me” the content of the item seems. The MSLQ employs a hierarchical design in which items are divided into the motivation section and the learning strategies section. Within the motivation section, the value subsection is composed of scales for intrinsic goal orientation, extrinsic goal orientation and task value. An expectancy scale measures control of learning beliefs, self-efficacy for learning and performance and test anxiety. Within the learning strategies section, the cognitive and metacognitive strategies subscale scores rehearsal, elaboration, organization, critical thinking and metacognitive self-regulation. A resource management strategies scale scores time and study environment, effort regulation, peer learning and help seeking. Scores are described as means per subsection and sections include some items that require reverse scoring.

The MSLQ was normed using a sample of 356 college undergraduates and an additional 24 individuals attending a community college. While the authors do not provide norms in their manual, subscale item level statistics (M, SD) are reported from the test development process. Coefficient alphas per subscale range from .52 to .92. Factor loadings suggest that the psychometrics of the survey are questionable as their phi coefficients range from -.17 to .83, though the authors seem to believe that the scale is

sound and claim that the factors are valid (Pintrich, Smith, Garcia, and McKeachie 1991, p. 80).

The Self Regulated Learning as a Cross-Curricular Competency (CCC) scale to measure self-regulated learning tendency represents a more recent attempt to develop an offline measure of SRL activities. Developed by the Program for International Student Assessment (PISA; Peschar, Veenstra, Molenaar, Boomsma, Huisman and van der Wal (1999, p. 35). This 52-item instrument utilizes a four-point Likert scale to determine the degree to which statements describe students. Statements include references to academic work in math and reading, as well as general statements about studying. The CCC has 14 scales to distinguish three self-regulated learning dimensions: Learning Strategies, Motivation and Self-Concept. In the scale development process that included children from 22 countries, it was reported by Peschar, Veenstra, Molenaar, Boomsma, Huisman and van der Wal (1999, p. 35) that the scales are of mixed psychometric quality. With regard to the SRL scales of memorizing, elaboration, transformation and control, the elaboration and transformation scales were reported as having acceptable internal consistencies ($\alpha = 0.71$, 0.81). Coefficient alphas for Control strategies scale ranged from $\alpha = 0.62$ to $.81$. The Memorization scale, however, was not internally consistent ($\alpha < 0.7$). As a result, the CCC might be considered an effective tool for measuring aspects of children's tendency toward self-regulated learning, but use of the CCC would provide an incomplete description of learning strategies.

Structured Interviews and Think Aloud Protocols

As described by Winne and Perry (2000) structured interviews employ varying levels of structure to gain insight into the learning process of respondents. Structured

interviews tend to differ from “think alouds” based on prompting. If a student is prompted to reflect on SRL at a point in a task, it is an event based measure, and a “think aloud.” Interviews can be aptitude-based when SRL reflection about *typical* behavior is prompted. In *stimulated recall*, respondents are prompted to reflect back on an experience or view their performance. This can be interpreted as event or as a sample on which one can determine a person’s SRL aptitude. Interviews can be emergent, with questions being driven by previous responses (data driven) or theory driven where the interviewer proceeds through a protocol based on the theoretical assumptions of SRL as it should be employed by the learner. Interviews can also be quantitative if the interviewer records counts or frequencies of types of SRL activities respondents describe. They can also be qualitative if, like a think aloud, the descriptions of thought provided by the learner are used to map SRL as described by Zimmerman and Martinez-Pons (1986).

An example of structured interviews for the measurement of SRL is the Self-Regulated Learning Interview Schedule (SRLIS, Zimmerman & Martinez Pons, 1986; 1988; 1990). The SRLIS was designed for use with high school students and employs a theory-guided, structural protocol that collects data across classes of SRL activities including goal setting and planning, self evaluation, keeping records, seeking information, rehearsal and memorizing, reviewing notes, and others. Data are collected as students consider a contextualized, fictitious task and are given prompts to elicit evidence of self-regulated thinking. Scoring can be completed in multiple ways. Student SRL can be categorized dichotomously where students are said to use or not use each dimension of SRL. Researchers can report that an SRL dimension is utilized after at least one usage, or

they can report the frequency with which individual dimensions are employed.

Corroborating these classifications conducted by a researcher, students are asked to rate how consistently they use classes of SRL on 1-4 scale (Seldom, occasional, frequent, most of time). This survey is highly context dependent as the students evaluate their performance on the recently completed task and not in general, so it should be interpreted with caution as a measure of aptitude. Zimmerman and Martinez-Pons address questions regarding reliability by evaluating inter-rater agreement. After being trained to properly categorize student thinking into SRL dimensions, Zimmerman and Martinez-Pons report 86% agreement between raters when the number of times an SRL behavior was categorized identically was divided by the number of times the behavior was scored uniquely.

Think-Aloud Protocols

An increasingly common method of measuring the SRL process, especially with younger students who are less able to complete lengthy questionnaires that require self-reflection, is the *think aloud protocol*. As in *stimulated recall*, a person is prompted to reflect back on an experience or view their performance. Students explain their thought process as they complete tasks. A think aloud can be unstructured or formally scripted by an observer based on student behavior. The method was originally introduced in the 1960s and has been supported as a viable research method by Ericsson and Simon (1984; 1993) in an extensive literature review. Think alouds are increasingly common in assessment of self-regulated learning as it relates to reading (Pressley & Afflerbach, 1995). Empirical studies have employed samples that vary from the elementary grades

through professors depending upon the research questions. The purpose of a think aloud is to map models of self-regulated learning, and to generate verbal accounts of the thinking that occurs to be analyzed by the researcher for evidence of SRL (Zimmerman & Martinez-Pons, 1986).

The process of a think aloud usually begins with respondents (and often readers) being given a set of goals, often to prepare for a test while reading as they normally would. The dependent variable in this scenario is often the use of information after reading is complete, as evidenced, for example, by a score on a test of free recall. The independent variables are coded verbalizations from the think-aloud protocol and are measured as they occur concurrent to the reading task, making this an online measurement method. Whenever the reader wants, or whenever prompted by the observer (every two minutes, after a sentence, section or the whole task), the reader reports what he or she is thinking (Veenman, 2005).

An advantage to the think aloud protocol is its unique ability to capture cognitive processes. However, across studies that employ think aloud protocols to assess SRL, little standardization exists due to the uniqueness of the context in which they were employed. The same is true of other process measures. Results from think alouds cannot be readily generalized to other learning tasks or contexts. Because they are conducted over the course of an actual (as opposed to theoretical) learning activity, they do, however, possess superior ecological validity when compared to interviews like the SRLIS above.

Teacher Judgments and Observations of Performance

Additional measures that employ an outside observer to make judgments about an individual's SRL include teacher judgments and observations of performance. These methods place considerable weight on the importance of the environment as influential in utilization of SRL. This increases the face validity of the method (Perry & Meisels, 1996), but often at a cost to the rigor of the research design. Zimmerman and Martinez-Pons (1988) developed the Rating Students Self-Regulated Learning Outcomes: A Teacher Scale as a standardized method for teachers to observe SRL in daily classroom activities. The original study was conducted with 80 tenth grade students (44 males) and attempted to measure the influence of SRL on math achievement. Using the same protocol and dimensions of SRL as the SRLIS, teachers completed the ratings, but instead of asking students to report their thoughts based on a task, the teachers responded to questions that were instead worded about observable behaviors of student use of SRL. Teachers then rated SRL behaviors on a five point Likert scale. While Zimmerman and Martinez-Pons report that the psychometrics of this protocol were sound, (Inter-rater reliability on KR20 = .95), they acknowledge an implicit difficulty in measuring student SRL through a teacher's eyes. Namely, does a teacher's observation really reveal enough about student cognitions to make firm statements about students' SRL? Having conducted the teacher observations concurrently with the SRLIS, a measure of criterion validity was obtained using RSSRLO by teachers and SRLIS by students and it was found that the two measures correlated $r = .70$. While this allays some fears regarding the validity of teacher assumptions, concerns remain regarding the ability of an outside

observer to distinguish whether student actions are indicative of the presence or absence of a student's motivation or ability. Additionally, the teacher-rating method begins as a measure of event based SRL and, through usage of larger collections of data and a second hand interpretation of student cognition and metacognition, seems to suggest a trend in the research towards an aptitude view of SRL. Further, teachers have no ability to assess unobservable aspects of SRL, such as metacognitive strategies or goals or motivation, rendering their observations more pertinent towards strategy use.

Other methods of observation of performance are similar to the teacher judgments described above and also take into account the impact of context on student SRL behavior. Contextual factors that influence SRL can include task structure, authority structure, evaluation practices, student self-beliefs, goals and expectations, and student decisions about how to regulate behavior in learning activities (Perry, 1998; Pintrich, Marx, & Boyle 1993). When employed with some type of self-report, think-aloud protocols can provide valuable and objective information about the SRL process.

Trace Methodologies

Another method of documenting learners' SRL behaviors is to employ trace methodologies (Winne & Perry, 2000). In trace methodologies, learners' actions create observable indicators of cognition (called traces, actions or events) that can be noted as students engage in a task. Examples include mouse clicks and keystrokes while conducting navigational actions (clicking next, using arrows) or marking actions (click and drag) like underlines, highlights, notes in margin, and other indications. These all represent the use of classes of cognitive and metacognitive control.

Trace methodologies are increasingly common in research as new computer programs are developed to efficiently record and analyze traces, as well as to systematize trace recording to deal with shortcomings of the methodology. In an early example of trace methodology use, Howard-Rose and Winne (1993) asked students to employ trace methodologies while reading an article. This study highlights some important considerations regarding the validity of the trace methodology task. Depending on the instructions given to the learner, the protocol may prompt learners to make traces when they otherwise would not. As such, the learning task can become contrived as such identification practices may not accurately reflect how a student would act without such a suggestion. This is similar to think aloud protocols where strict rules exist to govern prompting by the experimenter. Some researchers concede that this is the case (Bauer & Koedinger, 2006), but argue that simply placing an individual in a learning situation mimics task environments that are common in the learner's educational experience and thus do not diminish the ecological validity of the traces created by the learner.

As described above regarding the SRLIS interview technique, researchers struggled with the issue of the correctness of coding the occurrence of an event as compared to its frequency (Zimmerman & Martinez-Pons, 1986). This issue remains a concern in trace methodologies; however, the structures of data collection allow for this issue to be addressed by analyzing occurrences, frequencies and patterns of traces. A clearly defined set of rules for interpreting traces across raters minimizes issues of inter-rater reliability.

In a recent example of SRL research using trace methodology, Hadwin, Nesbit, Jamieson-Noel, Code and Winne (2007) opted to use qualitative descriptions and cluster analyses to characterize patterns of trace data to capture the quantity, content and the pattern of strategy use. In the study, 188 learners were exposed to a CBLE in a program called gStudy and conducted a learning task. Using cluster analysis, eight learners were selected as representative of the sample and were studied in greater detail. Log files that recorded their actions provide data representing the number and order of nodes learners visited as well as patterns of strategies used. From these, categorizations of learner types were made using both the quality and the quantity of learners' actions. These methods circumvent some of the difficulties described by Wirth and Leutner (2008) when deciding to treat SRL by quantitative or qualitative means by employment of graphical depictions of quantitative data, revealing a quality of navigational style and tool use. A mixed methods approach such as this provides a richer description of behavior than can be captured by qualitative or quantitative methods alone.

CBLEs that employ trace methodologies like the one used by Hadwin et al. (2007) are being increasingly utilized for online measurement of SRL as data collection tools have been embedded into the learning environment. A series of programs including gStudy (Winne, 2006) and nStudy (Winne & Hadwin, 2009) have been developed to both assess and teach SRL strategy use to learners. Additional discussion of nStudy follows in the methods section.

Current trends in SRL measurement

Recently, offline measures have been discussed as being less valid indicators of strategy use than online measures that take into account a given context (Zimmerman, 2007). Studies conducted by Winne and Jamieson-Noel (2002) and Bråten and Samuelstuen (2007) provide evidence that offline SRL measurement has faults, citing a lack of calibration found between what learners believe they do when completing tasks and what they actually do. Further, they argue that measuring SRL using non-contextualized items renders the authenticity and validity of such results suspect. As a result, current studies of SRL tend to employ online measurement strategies in the form of computer-based trace methodologies (Winne et al., 2006) and think-alouds (Azevedo, Cromley, & Seibert, 2004). In addition to the increased accuracy of these methods that identify SRL strategies as they are being employed, both Zimmerman (2007) and Winne (2008) suggest that event-based measurement has a heightened authenticity in its description of patterns of strategy use. As such, the proposed study employs trace methodologies to observe SRL behaviors in a computer-based learning task. However, it also employs offline measures of SRL to assess their calibration to traced behavior and for reasons pertaining to the theoretical necessity of discussing self-regulated learning in both state and trait terms.

The field of study that focuses on the use of self-regulation to support learning relies on a core assumption that an individual has the ability to regulate his or her own actions (Winne & Hadwin, 1998; Zimmerman, 2000). According to Winne's (1998) theory of self-regulated learning, this regulation is goal directed in that a learner chooses

to employ strategies with the goal of acquiring knowledge. The learner identifies a goal and a series of actions that will bring about attainment of this goal. The learner monitors progress towards the goal and arranges his or her environment so that actions will result in the accomplishment of that goal (i.e. that knowledge will be acquired). It is generally assumed by Winne (1998) that this ability is transferable from one context to another, making such an ability worth identifying in individuals, and worth teaching to those who do not possess it. If self-regulation is truly transferable across situations, it is, by definition, a fixed capacity. If SRL is fixed, it should be possible to measure it in a way that levels of SRL strategy use might correlate across conditions, suggesting a trait-based pattern of self-regulation strategy use.

To date, no offline measure of SRL has been found to possess sufficient psychometric properties to make researchers confident in its ability to identify an unconditionally self-regulated learner (Zimmerman, 2007). Despite that, the study of self-regulated learning relies on the notion that this type of person exists. One could argue then that it is not sufficient to say that offline-SRL measurement instruments are not preferable means of measuring a person's SRL tendency, but instead, as a field, we do not yet possess an instrument that can successfully identify a learner who is consistently self-regulated.

Categorization of SRL Measurement Techniques

Tools used to measure SRL as a process tend to be contextually-based and tend to employ online methods of measurement. When research is conducted using computer-based tasks, this tends to occur quantitatively by documenting frequency and patterns of

use of specific classes of SRL behaviors and qualitatively by describing patterns of self-regulation that occur throughout the course of a specific task (Azevedo & Cromley, 2004; Azevedo, Guthrie, & Seibert, 2004; Hadwin et al., 2007). Beyond the measurement tool one uses to assess SRL, a researcher must also decide whether to treat SRL as a goal in and of itself, or as a behavior that mediates the pursuing of another goal. That is, is SRL to be studied as an outcome variable where an increase in the use self-regulated learning is the goal, or is a student's employment of SRL predictive of their ability in achieving another goal?

Measurement of SRL in This Study

In this study, traces of learner behaviors were derived from log analyses conducted by a computer program called nStudy (Winne, Hadwin, & Beaudoin, 2009). This online measurement technique was employed to assess SRL strategy use within a specific learning context as it influences the successful completion of a computer-based learning task. Online measurement was chosen because it provides a more valid description than self-report of student SRL behaviors by recording actual traces of events reflecting metacognitive actions. Offline measurement of SRL tendency was also employed via a questionnaire and acts as a criterion so that an individual's frequency and pattern of online SRL behaviors might be described as reflecting a contextual phenomenon that may or may not correspond to an individual's perceived enduring SRL tendency.

The data analysis process treats individual classes of SRL behaviors as predictor variables that, when enacted, may influence the amount of knowledge gained during the

learning task. Patterns of SRL behaviors, once documented, can also become predictors. In addition to SRL behaviors, previous research suggests that prior knowledge (Greene & Azevedo, 2007), achievement goal orientation (Nesbit, Winne, Jamieson-Noel, Code, Zhou, & MacAllister, 2006), self-efficacy for self-regulated learning (Bell, 2007; Moos & Azevedo, 2007) may influence knowledge acquisition. These variables are also included as predictors in the regression models used to address research questions.

Having now defined knowledge acquisition and self-regulated learning and operationalized methods for measuring learners' actions, I now document prior research on knowledge acquisition in hypertext and other computer-based learning environments. The following section first conceptualizes the distinction between print-based and computer-based text (hypertext), and situates hypertext within the larger universe of computer-based learning environments. Once these distinctions are made, a review of empirical literature is conducted which focuses on the effect of learner behaviors (including self-regulated learning tactics such as strategy use, navigation and reading strategies, efforts to monitor understanding, and others) learner characteristics, and characteristics of the hypertext environment on knowledge acquisition processes and outcomes.

Reading Print-based Text to Computer-based Hypertext

Within the universe of computer-based learning environments, a variety of different learning environments exist. The *Handbook of Research on Educational Communications and Technology* (Jonassen, 2004), distinguishes *hard technologies* such as television, distance education programs, computer-mediated communication, virtual reality

environments, and others from *soft technologies* such as programmed instruction, games, microworlds and hypertexts. Each technology possesses specific attributes which influence the processes a learner uses to interact with the technology and the outcomes that result. This study focuses specifically on hypertexts, which are defined by Shapiro and Neiderhauser, (2004) as computer-based representations of textual information which are similar to printed text, but possess additional complexity. While elements of reading including character decoding, word recognition, sentence comprehension, and others remains generally unchanged when it is migrated from paper to a computer-based environment (Shapiro & Neiderhauser, 2004), design features of a hypertext may cause the learner to interact with the text in different ways. In a hypertext, new supports and challenges may be introduced into the learning environment that were not present in a print version of the same reading passage. These include new challenges with linearity, provision of tools.

The primary difference between printed text and hypertext is hypertext's nonlinearity (Shapiro & Neiderhauser, 2004). Learners may exercise additional control in a hypertext by navigating its contents in the order of their choosing, allowing for additional learner control beyond what occurs in printed media, which has been organized sequentially on the pages of a document. Shapiro and Neiderhauser (2004) term this option "flexibility of information access" (p. 605) and suggest that these learner variables and others including goals motivation and prior knowledge influence learning in hypertext, as do attributes of the specific hypertext used by the learner.

In most printed materials, passages are displayed linearly. In order to navigate within a written passage, the reader must simply turn a page. In a hypertext, linearity may be preserved when the passage is concise enough to be contained on a single page. More often, a passage may be broken up across multiple pages, or nodes, and the learner must navigate from node to node to complete the reading. This new navigation pattern creates an opportunity for the reader to choose a navigation path (Barab, Bowdish, Young, & Owen, 1996). The reader can choose to proceed linearly or can move from node to node in a non-linear pattern. This difference in design increases the need for the learner to self-regulate his or her decision making process when reading with a goal of knowledge acquisition in mind (Calisir & Gurel, 2003; Potelle & Rouet, 2002). The learner must determine his or her goal and then make a decision about how to advance to new (or back to previously read) node so that he or she might acquire the sought-after knowledge (Salmerón, Cañas, Kintsch, & Fajardo, 2005).

The transition from turning a page of a text to navigating a hypertext also involves the use of a CBLE's navigation tools. Different CBLEs are equipped with different features so that progress from one node to another might be accomplished by a click on a "next" button, an arrow, or potentially a hyperlink naming another area of text. Often, lists of such hyperlinks will appear in tables of contents, an index, or a hierarchical or concept map, allowing the reader to choose his or her path. This feature of a hypertext's design differs sharply from a printed text and can support learners' navigation of content (Potelle & Rouet, 2002).

So how do learners levels of comprehension compare when they read hypertext versus printed text? A meta-analysis by Chen and Rada (1996) found that in 8 of 13 studies which examined learning outcomes for users of hypertext and non-hypertext environments, those using hypertext experienced greater levels of learning. Additionally, they found that task conditions, tool provision and user variables including spatial ability influence the efficiency and effectiveness of hypertext use. Additional studies have been conducted since this meta-analysis that further evaluate attributes of the learner and the hypertext environment and their effect on learning, which is detailed below.

Developing a Model for Learning in Hypertexts

Proficiency in reading in a hypertext is increasingly beneficial to learners as K-12 and higher education institutions increasingly make use of online courses (Setzer & Lewis, 2005; Waits & Lewis, 2003). As a result, educational researchers must identify the variables that influence the acquisition of knowledge by reading in hypertext. A model is needed to explain the impact of learner characteristics, hypertext characteristics, and the interactions between these variables. From this model, educators could then develop instructional theory to teach students skills that help students to self-regulate their learning in hypertexts. Further, those who design instructional materials based on this theory can build computer-based applications that are adapted to students' personal characteristics. Individual characteristics of the learner, including the ability to regulate one's own learning, are critical to the development of traditional literacy and more so to acquiring knowledge in hypertexts and hypermedia (which includes graphic, audio and video content in addition to text; Azevedo, Guthrie, & Seibert, 2004; Azevedo &

Cromley, 2004; Azevedo, Cromley, & Seibert, 2004; Coiro & Dobler, 2007). The next section of this paper reviews empirical studies on learner characteristics and their effect on knowledge acquisition. While a particular focus is placed on studies measuring the role of self-regulation, additional attention must be paid to the individual's prior knowledge as a factor influencing knowledge construction.

Learner characteristics that affect knowledge acquisition in CBLEs

A considerable amount of research has been conducted to identify the methods that learners employ as they attempt to learn from CBLEs (Azevedo, Guthrie, & Seibert, 2004; Coiro & Dobler, 2007; Greene & Azevedo, 2009; Lawless, Schraeder, & Mayall, 2008; Mitchell, Chen, & Macredie, 2005; Moos & Azevedo, 2006, Moos & Azevedo, 2008a, 2008b 2008c; Narciss, Proske, & Koerndle, 2007; Proske, Narciss, & Koerndle, 2007; Salmerón, Cañas, Kintsch, & Fajardo, 2005; Salmerón, Kintsch, & Cañas, 2006).. Specifically, research has been conducted to ascertain the role of certain learner characteristics that influence the ability to learn from different hypertexts and hypermedia environments. These factors include prior knowledge (Moos & Azevedo, 2008) of both subject domain and prior knowledge of the hypertext (Mitchell, Chen, & Macredie, 2005), as well as the ability to self-regulate one's learning (Azevedo, Guthrie, & Seibert, 2004; Azevedo, Cromley, & Seibert, 2004; Azevedo, & Cromley, 2004 Moos & Azevedo, 2008a, 2008b 2008c), and the goals (Moos & Azevedo, 2006)an internal motivation (Moos & Azevedo, 2008c) to pursue learning. The majority of these studies have been conducted using samples of undergraduate students in a variety of cultures (Azevedo, Guthrie, & Seibert, 2004; Greene, & Azevedo, 2009; Moos & Azevedo, 2006,

Moos & Azevedo, 2008a, 2008b 2008c; Narciss, Proske, & Koerndle, 2007; Proske, Narciss, & Koerndle, 2007). Additional studies have been conducted to develop an understanding of the reading strategies learners use to acquire knowledge from different types of hypertext. Such studies also tend to sample undergraduate students (Lawless, Schraeder, & Mayall, 2008; Mitchell, Chen, & Macredie, 2005), though some sample elementary school students and use qualitative measures to observe the process of constructing knowledge in hypertext (Coiro & Dobler, 2007).

Prior Knowledge

Prior knowledge has been studied as a factor promoting gains in additional knowledge as a result of exposure to hypertexts. The complexity of knowledge has also been measured and is described as being connected to the textbase or to the situation model of the hypertext.

Using an isolated set of web pages containing information on genetics, Lawless, Schrader and Mayall (2007) examined the effect of pre-reading on knowledge acquisition in hypertext environments. Forty-two undergraduate and graduate students, 80% of whom were female, completed pretest and posttest measures of domain knowledge. Age, ethnicity and SES were not reported. The experimental group ($n = 20$) read a 500-word passage about genetics before navigating the web pages and increased the number of correct answers on the knowledge measure from pretest ($M = 7.0$; out of 13) to posttest ($M = 8.1$). The control group ($n = 22$) read no passage and experienced a decline in mean knowledge score from pretest ($M = 7.4$) to posttest ($M = 6.5$). Analyzed using a univariate ANCOVA with pretest as covariate and posttest score as dependent variable,

pre-readers improved their knowledge score significantly over time and in comparison to the control group. The effect size in this study is large (partial $\eta^2 = .636$). This suggests that, like as in printed texts, the possession of prior knowledge increases further knowledge acquisition in hypertext environments in samples composed primarily of female students in higher education settings.

Prior knowledge is generally understood to mean knowledge of the domain or subject area contained in the hypertext. Such domains include subjects like science, technology and math, or a subset of knowledge within a domain. Mitchell, Chen and Macredie (2005) examine different types of prior knowledge (domain vs. system) and how they influence learning outcomes in hypertext environments. Seventy-four British computer science undergraduates learned from a non-linear hypertext equipped with a map, index, menu and hierarchical overview. Prior to exposure to the hypertext, participants completed a questionnaire containing demographic and prior knowledge items, as well as items assessing their experience with and perceptions of computers, the Internet, and computer-aided- learning (CAL) programs. They completed pretest and posttest measures (alternate forms) assessing level of knowledge before and after a 15 minute exposure to the hypermedia tutorial. No significant system expertise by domain expertise interaction was found. On measures of learning performance, students with low pretest scores gained significantly more knowledge from the hypertext exposure than students with high pretest scores. This suggests the tutorial was more beneficial to those undergraduates with less knowledge, and unfortunately means that the study was limited in being able to report much about roles of different types of prior knowledge, due to

inadequate instrumentation. This finding would be expected if the hypertext only presented information the novices lacked but experts had; if material that was new to both was contained, both would be helped.

Mitchell, Chen and Macredie (2005) raise an important issue about the nature of prior knowledge and how possession of certain types of prior knowledge may influence a learner's ability to create new knowledge. However, their choice of domain knowledge (on the subject of computers and technology) versus procedural prior knowledge of how to effectively use computers increases the possibility of overlap between types of prior knowledge studied, a replication in another domain might prove useful. This study also suggests that, depending upon the type of prior knowledge an individual has (familiarity with the subject versus familiarity with the medium); the learner will interact differently with the hypertext and gain different types and amounts of knowledge from the learning task. It might be beneficial to employ a think aloud protocol or examine notes taken in a trace methodology to determine what types of prior knowledge is activated and guides learners' navigation of hypertexts. Hypertext reading strategies might be observable using these methods and could provide some insight as to whether gains in knowledge are influenced by prior knowledge of the hypertext system, or of the subject area.

Moos and Azevedo (2008) conducted a similar experiment which examined how prior domain knowledge influenced learning practices when using a hypermedia environment to learn about the circulatory system. When 49 undergraduates completed think alouds during a 40 minute learning task, prior knowledge was found to be positively related to students' tendency to engage in planning and to monitor their

understanding. Low prior knowledge learners, however, depended more on strategy use while learning. When using hypertext, learners' prior knowledge seems to influence the nature of the learning task. Learners who are familiar with the text will activate prior knowledge and use it to develop plans to increase knowledge, while those with a weaker understanding cannot yet monitor their new knowledge against prior knowledge and instead employ strategies which build understanding.

Self-Regulation and Strategy Use

Few researchers purport to examine multifaceted self-regulated learning tendency as an independent variable influencing knowledge acquisition from hypermedia or hypertext. Many, however, focus on reading strategies, which are an important component of SRL. I first document the studies on reading strategies and then apply the rubric of SRL to categorize such strategy use. Reading strategies tend to be studied qualitatively. Researchers most often employ think aloud methodologies by which they can examine the process of hypertext navigation and ask questions about students' motivations and rationales for pursuing their strategies and chosen paths through hypertexts. In addition, these think alouds should be paired with pretest measures of prior knowledge as well as posttests to assess knowledge gained using particular strategies. Researchers can then observe frequencies or patterns of strategy use and connect them with higher or lower amounts of knowledge acquisition. Based on this empirical evidence, theory can be derived about the utility of particular reading strategies when knowledge acquisition is the reader's goal.

By having 11 high-achieving sixth-grade readers think aloud about their strategies for reading online text, Coiro and Dobler (2007) identified methods high achieving middle school students employ to comprehend hypertext passages in a multilayered website format. Eleven of 150 students from three schools in Connecticut and Kansas were selected based upon high state achievement test scores, teacher recommendations, reading grades and student experience questionnaires. Over a two-day period, students completed reading activities (on hurricanes and tigers) while thinking aloud and pre-reading and post-reading interviews. These activities were audio taped and analyzed. Coiro and Dobler identified cognitive strategies readers use to assess meaning of text for comprehension and for guiding future knowledge acquisition steps (Internet searches). As in reading printed text, successful readers self-regulate, draw on prior knowledge and employ inferential reasoning activities. Internet reading, however, required more sophisticated reading abilities. Additional beneficial prior knowledge included increased knowledge of the topic, increased reading ability reading, and familiarity with the Internet and search strategies. Self-regulated reading included recursive and fix-up strategies to comprehend and navigate concise passages. Students made inferences about meaning of texts across layers of web pages and predictions about successful future search strategies. Unlike printed text, readers made a prediction upon arriving at each hyperlink, which suggests a need to plan navigation, which is not required in linear print based settings. In light of these findings, we can posit that successful comprehension of open-ended hypertexts requires the additional types of prior knowledge above and beyond those required to comprehend printed text. Knowledge

acquisition also requires sophisticated self-regulation and inferential abilities to determine how to most successfully navigate a hypertext and make meaning based on context cues that exist in nodes.

Azevedo, Guthrie, and Seibert (2004) investigated undergraduate students' ability to self-regulate their own learning (SRL) of material from a hypermedia unit on circulatory systems, focusing specifically on Pintrich's (2000) SRL process (goal-setting, planning, control, monitoring, and reflection) and the variables within SRL models (cognition, motivation, behavior, and context) that influence progress towards conceptual understanding. Azevedo and colleagues hypothesized that students who employ SRL would more effectively develop deep understanding of a science topic when given one general goal than learners who cannot employ SRL. Twenty-four undergraduates (majority female, senior non-biology majors) studied the circulatory system over 45 minutes using hypermedia representations. Paper-and-pencil pretests and post-tests (30 min) assessing prior knowledge and a think-aloud methodology assessing the learning process were employed. An ordinal scale of mental models was used to classify students' progress from having no model to a complete model of the circulatory system. The group was split into low-jumpers (minimal shift in level of understanding < 1 model on average) and high-jumpers (shift = 4.5 models on average). High-jumpers' process differed from low-jumpers' according to a series of chi-square analyses. High jumpers more often employed planning, monitoring, strategy use, and were able to handle difficult tasks than were low-jumpers. In addition, authors found a correlation between increased SRL use (as defined by a higher proportion of effective strategies) and greater

improvement in conceptual understanding. This correlation suggests that the low prior knowledge undergraduate students who employ SRL are more able to develop deeper understanding using hypermedia representations.

It is important to note that the aforementioned study measures knowledge acquired from hypermedia and not hypertext, and the measurement of sophistication of models here refers not to situation model understanding, but conceptual model of a physical structure (circulatory system). Their findings suggest that increased SRL strategy use leads to greater gains in understanding, particularly for low-prior knowledge learners. This has been supported when learners are exposed to hypermedia but does not suggest increased comprehension from reading alone. The proposed study aims to identify a similar phenomenon when individuals learn from text.

Interaction of the Learner with the Media

In discussing the role that self-regulation plays in the learning process, theorists commonly describe the process of SRL with little regard to context. However, the interaction of a student with instructional media, here a hypertext environment, is implicit in the process models of self-regulation (Winne & Hadwin, 1998; Zimmerman, 2000) where learner behaviors are recursive and based upon experiences in a context. This remains true when we confine our discussion to self-regulated learning in computer-based learning environments. In hypertexts, learners engage in a learning task complete with educational material and, depending upon its design, a set of online tools that have the potential to aid the learner in knowledge construction. In the next section, empirical studies are reviewed that document the role that specific features of a researcher-designed

hypertext play in knowledge acquisition. Of particular import is the typology of the hypertext or hypermedia, with respect to navigation and tool provision. It is not surprising that these aspects of a hypertext tend to interact with characteristics of learners, producing a spectrum of different outcomes in knowledge acquisition.

Hypertext Characteristics that Affect Learner Knowledge Acquisition

In addition to the learner characteristics that influence the knowledge acquisition process, characteristics of the hypertext itself will influence the learner's ability to derive knowledge. These factors are generally referred to as comprising the typology of the hypertext. The typology of a hypertext is a term used to refer to the layout of the nodes that contain content. Hypertexts can be navigated in a linear or non-linear fashion, and navigation can be supported by a variety of tools including an index or table of contents, a conceptual map, a hierarchical map, network map, by simply scrolling or clicking in a linear fashion through arrows or embedded links in text.

While many studies focus on the characteristics of the hypertext, they also tend to include measurement of a learner characteristic, resulting in a 2 x 2 design that examines main effects of learner and hypertext characteristics, and the interaction between the two. Interactions between learner and hypertext characteristics affecting knowledge acquisition will thus be reviewed in this section and similar interactions will be modeled in this study.

Linearity

Unlike printed texts that are generally designed in a linear fashion and paged through in a predetermined order, hypertexts can be navigated in a non-linear fashion.

The non-linearity of hypertexts allows learners to determine the order in which they are presented content by choosing the order in which they visit nodes. A series of studies have been conducted to determine if the layout of a hypertext (linear or non-linear) will influence the knowledge acquired by learners. What these studies reveal is that typography does matter, and it matters differently dependent upon the characteristics of the learner, as well as by the types of tools the learner can use to navigate hypertext.

In hypertext reading, Salmerón, Cañas, Kintsch, and Fajardo (2005) identify readers as employing linear, “top-down,” and mixed reading strategies and hypothesize that reading strategies influence hypertext comprehension of textbase and the ability to make inferences and situation models that tend to be coherent. In their first study, 40 college students read a 4,000-word, 24-node passage on atmospheric conditions written at the twelfth grade level for 20 minutes. Given an overview diagramming relationships between nodes, readers chose their own reading strategy and were grouped into Order 1 (linear), Order 2 (top of hierarchy to bottom), or Order 3 (mixed). Prior knowledge was assessed using an 8-item true-false measure. The treatment was given, followed by a 22-item textbase recall measure and an 8-item measure assessing ability to make inferences (i.e. situation model). Learners who visited more nodes tended to perform better on measures of textbase comprehension. Order 1 readers visited more nodes than other groups. Participants in Order 1 performed significantly better (84% correct) than Order 2 (71%) or Order 3 (66%) on the situation model measure, meaning they were more able to make inferences based upon their reading. The number of nodes visited predicted differences in textbase comprehension scores for low prior knowledge readers only.

When reading hypertext, there exists a minimum of information that must be acquired for all readers in order to form an understanding of the textbase and this minimum is higher for low prior knowledge readers. Reading hypertext using linear methods also increases a reader's ability to make inferences. For the purposes of future study, grouping students by preferred reading order may not be possible for design reasons, but examining the way a reader chooses to navigate a hypertext may be telling about their knowledge construction process. This suggests that when learners are attempting to acquire simple knowledge, navigating in a linear fashion tends to produce positive results. When designing hypertexts, preserving linear presentation within nodes of a hypertext is wise.

After examining the effects of the path learners took through nodes as they attempted to construct knowledge, additional studies examined differences in navigational paths chosen based upon the learner's preference for a coherent order, or for interesting content. Salmerón, Kintsch and Cañas (2006) conducted two studies to assess differences in reading comprehension when hypertext reading is organized by interest versus coherence criteria. In Experiment one, 73 college students read a 27-node, 4,000-word hypertext passage written at a 12th-grade level designed for this study. Participants were presented text a node at a time, and chose between two different nodes (with high vs. low semantic relationship to the previous section) based on either their interest or the node's apparent coherence (criteria determined post-hoc). Experiment 2 was a replication with 152 participants who were told to choose their next nodes based on either coherence criterion or interest criterion. A pretest was given to assess prior knowledge, then

participants read the passage (untimed) and completed a recall measure, and a situational measure (measuring synthesis of material; akin to a situation model subtest). No significant differences existed in recall between criterion-usage groups in either study. Prior knowledge level interacted significantly with performance on situational measures; those with low prior knowledge performed significantly better using coherence criteria (vs. interest criteria). Participants with some prior knowledge performed similarly irrespective of criteria. Findings held true across both experiments. Additionally, the low prior knowledge group also scored similarly to those who read a linear text without choice of text order. These results indicate that learners benefit from presentation of a coherent reading order to scaffold paths through hypertext. This is especially true for low prior knowledge readers. It seems that navigation using a coherent order is an important aspect of hypertext typology that will promote knowledge acquisition. A series of studies examine this idea and attempt to determine what types of hypertext typology provide a coherent learning experience for different types of learners. As this applies to SRL, a low knowledge learner seemed to learn more when their path through a hypertext was “other-regulated” by the design of the hypertext itself. With respect to learners’ performances when they read based on coherence instead of by interest, it would be beneficial to examine the path that low knowledge learners might take in a hypertext where off-topic nodes are included and individuals must choose to avoid these nodes as they attempt to acquire knowledge from the hypertext. The ability to maintain a coherent reading that corresponds to learning goals should lead to greater knowledge acquisition as compared to others who are distracted by interesting but irrelevant content.

Based on previous studies that indicate that high knowledge (HK) learners and low knowledge learners benefit from different types of tools to organize the process of text comprehension, Potelle and Rouet (2002) assessed whether hierarchical representations of textbase contents can facilitate increased knowledge acquisition for HK learners. Forty-seven French undergraduate psychology students (age 19-44; $n = 27$ low knowledge learners, $n = 25$ high knowledge learners) read seven short (138-word) passages on the subject of social influence. Texts were presented as four-paragraph hypertexts and including title, introduction to topic, description of an experiment, and discussion. Groups read hypertexts organized by alphabetical list, network map and hierarchical map. Participants completed a measure that assessed comprehension of the textbase and of the situation model through a measure including items that tested recall of explicit information and construction of implicit knowledge. Participants completed the measure as pretest, read the hypertext for 20 minutes, and completed the post-test. Median split on pretest scores was used to divide learners into high-knowledge (HK) and low knowledge (LK) groups. A 2x2 ANOVA indicated a main effect of prior knowledge and a significant interaction between prior knowledge and type of content representation for improvements in comprehension of the situation model (but not the textbase). LK learners improved scores significantly more when hypertexts were organized with hierarchical maps than with alphabetical lists or network maps on measures of textbase comprehension, but not of situation model comprehension. The utility of content representation is a function of undergraduate learners' prior knowledge. It seems, then that a hypertext should include a hierarchical map of nodes to aid low knowledge learners

who can use it to scaffold their understanding of how portions of the text relate to one another. High knowledge learners seem to not be influenced by the presence or absence of such a tool and may benefit instead from a tool that lists context in a logical order so they can more easily activate prior knowledge. It may be that there is an interaction between low and high knowledge learners and SRL tendency where learners rely on organizational tools differs as their level of prior knowledge increases. This was explored in this study by examining prior knowledge, navigation pattern and knowledge acquisition following chapter.

Calisir and Gurel (2002) examined the effect of different hypertext typologies on reading comprehension and examined interactions between such typologies with variables of prior knowledge, complexity of the hypertext, and learner's perceived control. Thirty Turkish undergraduates (26 males, mean age = 23) participated in the study, half of whom were non-randomly assigned to the high prior knowledge condition. Learners were randomly assigned to read a hypertext of linear, hierarchical or mixed typology and were assessed for the number of nodes visited, reading comprehension of the passage, and perception of control over learning experience. Learners did not differ in number of nodes visited by typology or by knowledge level. High prior knowledge learners significantly outscored low prior knowledge learners on outcome measures of reading comprehension. A knowledge level by typology interaction was also found where more knowledgeable learners scored higher on measures of reading comprehension for linear hypertexts compared to hypertexts of mixed or hierarchical typology. The authors suggest that prior knowledge can be a helpful tool in providing undergraduate learners

with an understanding of the organization of information to be learned, thus improving their reading comprehension, especially in contexts where structure is not provided, such as in linear hypertexts. Taken in concert with the findings of Potelle and Rouet (2002) above, it seems that high prior knowledge individuals possess an understanding of the overall structure of the content included in a hypertext and rely less on tools to organize their reading as compared to those with lower prior knowledge. It also may be that learners who are already familiar with the topic feel confident that they understand the content of a passage and do not feel the need to reference such a tool to organize their learning. As a result, it makes sense to provide this tool for all learners, but to expect different patterns of utilization. Higher knowledge learners already possess a general knowledge of the topic and may choose not to use tools, while lower knowledge learners may depend on it. Additionally, learners seem to perform better in linear settings despite their prior knowledge level, and linear navigation should be presented as an option to all readers.

While these studies draw conclusions about learner knowledge and its effect on behavior in a hypertext, the process of attributing learners' behaviors to a specific causal factor can be difficult. The pattern of learner behaviors, while similar, can potentially be caused by multiple factors including their self-efficacy, intrinsic motivation, and other factors related to a perceived ease of use of the tools (Venkatesh, 2000). A learner might lack motivation to use the tool, the self-efficacy which would empower the learner to use the tool, or an understanding that a tool can be useful in reaching their goals. With respect to learners who possess high levels of prior knowledge when they enter a hypertext

environment, they simply may not have use for the tool as it provides no benefit to them. It is important, then, that attempts to attribute patterns of behavior to individual factors include measures to assess all theorized potential factors that might lead to the behavior pattern observed. This point relates to the studies reviewed above as they tend to manipulate one or two independent variables, but do not account for additional factors that may be responsible for behaviors. For instance, when measuring SRL tendency, it is necessary to be aware that lack of use of organizational tools may indicate existence of prior knowledge and not lack of SRL strategy use. If a learner is high in SRL tendency or high in prior knowledge, their behaviors may look the same, unless prior knowledge can be accounted for and modeled statistically. As such, it is important to measure prior knowledge and other learner characteristics in addition to traced behaviors.

With an interest in the acquisition of textbase versus situational model knowledge, Müller-Kalthoff and Möller (2006) examine the interaction between prior knowledge and level of hypertext complexity as they affect learners' construction of factual and structural knowledge. Thirty-six German undergraduates (M age = 25, 24 female, primarily juniors) were randomly assigned to study either a complex 2-chapter hypertext or a limited 1-chapter hypertext and then were tested on their learning of factual (textbase) and structural knowledge (situation model). Participants received an introduction and completed a pretest measuring prior factual knowledge and a battery that accounted for subject interest, preference of learning strategies, computer experience and self-concept of computer-related ability. They then studied the hypertext for 30 minutes and completed a posttest assessing factual knowledge and structural knowledge. Prior

knowledge was a significant predictor of both factual and structural knowledge gains, while browsing simpler hypertexts predicted increased structural knowledge gain and lower levels of disorientation. The effects of prior knowledge were dampened when learners used a limited hypertext, suggesting that presentation of simpler hypertexts decreases differences in learning gains amongst students, but may do so at the cost of learning of higher knowledge learners.

Müller-Kalthoff and Möller (2006) suggest that it is possible, then, to improve comprehension of the textbase by low prior knowledge learners (to be even with high prior knowledge learners) by lowering the complexity of a hypertext. This can be advantageous when learning goals are served by exposure to simple hypertexts, but complex learning tasks may require complex hypertexts. This does suggest, however, that greater levels of simplicity within a hypertext will counteract differences in prior knowledge in terms of textbase comprehension, and can move low prior knowledge learners to a place on par with high prior knowledge learners, providing both groups an equal opportunity to comprehend the situation model.

Tool Provision

In addition to providing tools that facilitate navigation through a computer-based reading task, some hypertexts provide additional tools that facilitate the use of additional self-regulated learning strategies. In order to test whether students' use of particular note-taking strategies affected their knowledge acquisition, Bauer and Koedinger (2006) examined the process and review benefits of note taking. They designed a computer-based learning environment in that student could take notes by typing or use of a *paste*

tool to copy and paste sections of its content into a notebook window. This condition was tested against a condition without paste functionality and with a pencil and paper control group. The sample of 52 undergraduates were given posttests after taking notes and then after a one week period both before and after reviewing their notes. All students in all conditions were allowed to take additional (non-pasted) notes. Experimenters coded notes as “verbatim”, “abbreviated”, or “own” in content. Notes that had been copied and pasted were coded verbatim, as were notes that were transcribed verbatim from the text. “Abbreviated” notes were summaries of text, often with words omitted, while “own” represent students’ original phrasing of notes.

Bauer and Koedinger (2006) describe the benefits of note taking in terms of *process benefits*, benefits gained by the act of note taking itself, as well as *review benefits*, which occur when one reviews notes taken. Their study examined the effect of each condition on both the process of the collection of notes, as well as the impact on immediate and delayed retention of content after review. Their research questioned whether students would take a different amount and quality of notes under different conditions and whether such notes would lead to different levels of immediate or delayed knowledge acquisition. Of particular interest was whether a hypertext that could eliminate the cost of taking time to copy content (*paste* condition) would lead to a change in note taking tendencies, and whether it would improve or diminish process benefits.

Using a series of ANOVAs, Bauer and Koedinger (2006) discovered that students in the *paste* condition produced notes with a significantly higher number of total words, but that the number of ideas they recorded were similar to the paper group. Dividing the

number of words recorded by the number of ideas recorded, *paste* students' notes were significantly wordier than notes from other students. *Paste* students produced significantly more verbatim transcriptions than the other two groups while students in the Paper group produced significantly more of their own ideas than the other groups. Despite these findings, no differences in immediate knowledge acquisition occurred due to condition, as evidenced by post-test scores. When students were able to review their notes after a week's time, students in the *paste* condition showed poorer retention on a subtest of free-response items.

Bauer and Koedinger situate these findings within the cognitive process of note taking and postulate two distinct hypotheses about note taking and its effect on learning. They describe note taking as a process that involves identifying important content while reading and then deciding to transcribe a specific portion of text. According to their *attention hypothesis*, note-takers attend to important content and transcribe it, but are limited by the cost (in time) of transcription. Because a copy-paste tool limits this cost, it changes the way students take notes. Bauer and Koedinger suggest that note-taking with a cut and paste function allows a learner to copy and paste more and larger segments of text than they would otherwise, leading to a more superficial amount of processing. When this tool is not available, or the size of a pasted segment is limited, note takers must be more strategic and select fewer and more important words for transcription that will support retention, leading to a deeper level of processing.

With respect to this process benefits associated with note-taking, Kiewra and DuBois (1991) reviewed empirical studies of note taking and found that about half of

studies report significant process benefits, while half do not. It may indeed be the case that cutting and pasting leads to superficial processing and decreased process benefits, an alternative explanation exists. The act of taking a longer note instead of choosing key elements in a more concise note does indeed seem to lend itself to more superficial note taking and less critical processing and attention. However, the act of selecting text via cutting and pasting or similar tools, like highlighting, is also evidence of the identification of an important element of a reading, superficial as it may be. It is possible that this potentially superficial selection and transcription of text segments is better than not taking any notes at all. If this is true, the opportunity to cut and paste itself may be an improvement over taking no notes *and* briefer more strategic notes may be an improvement over less selective transcriptions. With respect to review benefits, reviewing longer notes may be less beneficial as the notes were not strategically created, and are wordier. Additionally, when notes are reviewed separately from their source, they may lack context and do little to improve understanding. This is especially true when they were not strategically transcribed. As such, review of copy and pasted notes is likely to be a less useful strategy than strategic transcribing and annotating, as Bauer and Koedinger (2006) describe in their generation hypothesis. In this study, I explore the utility of a highlighting tool that can be used to denote selections of text. In the learning environment I utilize, these highlights are logged in an “information column” and are highlighted in the body of the passage. A click on the term in the information column will cause the page to scroll to where the term is, so it can be reviewed in context.

Bauer and Koedinger (2006) next suggest in the *generation hypothesis* that “the act of generating words in one’s notes increases processing benefits” (p. 793). The transcription of notes does indeed require a deeper level of processing than mere selecting of text for cutting and pasting. However, the benefits of transcription increase when terms are selected and notes are created using one’s own interpretation of the text, as Bauer and Koedinger label in the notes coded as “own.” This interpretation represents a deeper level of understanding than mere identification (and/or verbatim transcription), and should lead to increased knowledge acquisition as evidenced by post tests. Bauer and Koedinger found no significant effect of the generation of “own” notes on retention scores when compared to verbatim notes. However, based on the greater amount of ideas transcribed by learners in the paper condition and greater ratio of words to ideas in copy and pasted notes versus those transcribed by hand or typing, they suggest that, when designing hypertexts, it is best to limit the size of text that can be selected as a way of making students take more strategic notes.

I test the hypothesis that, if students are allowed to select text *and* be encouraged to annotate it with their own understanding, each action (selection, annotation) will support a deeper level of processing beyond what would occur when reading a hypertext passage. This would be evidenced by increased knowledge gains occurring for those who highlight text and additional increases for those who take notes. In this study, I investigated the influence of selecting text by highlighting (instead of cut and paste) and annotating (selecting text and adding original notes) on knowledge acquisition. The type of notes taken (or traces produced) indicates a level of processing, and in turn, a type of

strategy a learner employs to self-regulate his or her learning. This is an important predictor to study as it may directly affect knowledge acquisition. Additionally, such strategy use has also been linked to the achievement goal orientation of the learner (Nesbit, Winne, Jamieson-Noel, Code, Zhou, & MacAllister, 2006).

Achievement Goal Orientation and Relationship to Tool Use

According to achievement goal orientation theory (Dweck, 1986), learners can approach tasks with a goal of mastering the content presented to them (mastery goals) or can be interested in learning the materials sufficiently so that they may perform well when their comprehension of the material is assessed (performance goals). These constructs are not orthogonal, as learners can be both mastery and performance oriented. Additionally, Elliot and McGregor (2001) describe a second dimension where learners' goal orientation is also characterized by a desire to approach mastery or avoid failing to master material or in the case of a performance orientation, to approach a strong performance and avoid a weak performance when assessed. These two dimensions create a four part structure to achievement goal orientations and when assessed, are measured individually by the Achievement Goals Questionnaire-Revised (Elliot & Murayama, 2008). Research suggests that a relationship between different levels of achievement goal orientation and specific SRL tactics exists.

Nesbit and colleagues (2006) examined learners' usage of annotation tools in an elaborate CBLE called gStudy, which provides a package of tools learners can use to highlight a segment of text, connect an original note to the segment, or create links between segments or notes, which are called *information objects*. Such tools are meant to

enable the learner to enact study tactics while studying a web page. Nesbit collected measures of goal orientation from 307 undergraduate educational psychology students and a subsample of 80 spent sufficient time using gStudy that their CBLE use could be examined. Of specific interest to researchers was the pattern of note taking and highlighting learners conducted as they studied a textbook chapter presented in gStudy. On average, students spent roughly 90 minutes studying the chapter. They created 26.5 (median) highlights and 33.5 (median) notes. A skewed pattern of words per note existed where some learners wrote lengthy notes while others wrote very concise notes. The notes taken were primarily elaborative, rarely copied verbatim from text. Most notes were summaries or definitions of terms.

With respect to goal orientation, students' degree of mastery orientation was inversely correlated to use of the highlighting tool. Researchers describe this tool as a less effective study tactic for the purpose of summarizing information than taking notes. Students with higher mastery approach orientation also spent less time studying the chapter in gStudy, but composed longer notes. The authors determine that such a pattern confirms their belief that those with mastery goals avoid surface processing (indicated by lack of highlighting) and instead choose deep processing tactics such as elaboration and summarizing, which indicate an attempt to develop situation model knowledge, as described by Kintsch (1998). They also suggest that traces of behaviors in gStudy were successful indicators of motivation, preferences and decisions made by learners. If this is the case, much more can be learned from using trace methodologies with learners, especially if these traces are analyzed as they support knowledge acquisition. Individual

difference variables besides goal orientation can be included in such study to determine if a student is likely to study in a particular way, depending upon personal factors.

Recommendations for Designing Hypertexts

From these studies examining hypertext characteristics and their influence on learning outcomes, it seems that it is possible to increase the likelihood that knowledge will be acquired if a hypertext is constructed in a way that provides a text structure that can be navigated by learners with high or low prior knowledge and includes tools which are both helpful and easy to use. A well-designed hypertext would limit redundant information (Mayer et al., 2005) and would provide text in an elegant fashion without distracting stimuli that might distract learners. The design should be structured to provide a clear organization of nodes which indicates an intended path for learners who choose to read in a fashion suggested by the hypertexts' creator, but also provide a tool that provides a non-linear and potentially hierarchical organization should learners prefer to link directly to individual nodes (Calisir & Gurel, 2003; Potelle & Rouet, 2002; Salmerón, Cañas, Kintsch, & Fajardo, 2005; Salmerón, Kintsch, & Cañas, 2006). Evaluation of learning in these hypertexts should include online assessment and monitoring of classes of SRL strategy use that include measures of distractibility, as well as pretests and posttests to measure knowledge acquired. These recommendations were used to design the CBLE for this study.

Need for Further Research on Knowledge Acquisition in Hypertext

According to Kintsch's (1998) theory of reading comprehension summarized in the previous section, a reader must be able to determine the meaning of words and

phrases and then form them into propositional thoughts (textbase). The process of building upon these inferences results in an elaborate structure that organizes acquired knowledge into a coherent whole (situation model). This process underlies the ability to acquire knowledge from written passages of text when presented in linear formats.

As applied to hypertext environments, traditional literacy remains a prerequisite for the process of knowledge construction. For a learner to acquire knowledge from hypertext, the learner must be able to comprehend the content presented in the hypertext. However, because hypertext environments include media that are not always accessed in a linear fashion, in order for readers to acquire knowledge, they must also possess the ability to navigate a hypertext environment and to coordinate the process of comprehension while potentially charting a non-linear course through hypertext, and while synthesizing information from different nodes. Coordination of these activities requires additional cognitive and metacognitive abilities beyond those required for reading comprehension in linear contexts. Theorists have identified factors that influence the ability of learners to acquire knowledge using hypertext. This paper builds a model out of such factors in an attempt to conceptualize the main effects of a set of learner and CBLE factors, as well as the interaction between learners and the hypertext they attempt to comprehend.

At the level of the learner, influences include the learner's motivation and goal orientation, prior knowledge, self-efficacy and strategy use. Learners' motivation to consider the content of a hypertext influences knowledge acquisition, and is discussed in terms of the learners' interest by Salmerón, Kintsch and Cañas (2006). As reviewed

previously, prior knowledge has been studied as a predictor of knowledge gain and has been found to influence the degree to which learners can acquire new, or deeper knowledge from a hypertext (Müller-Kalthoff & Möller, 2006; Potelle & Rouet, 2002). Prior knowledge has also been found to interact with the typology of hypertexts in that high and low-knowledge learners benefit from exposure to different types of text structure (Calisir & Gurel, 2002; Müller-Kalthoff & Möller, 2006; Potelle & Rouet, 2002).

Learners' utilization of reading strategies influences knowledge acquisition when learners are exposed to hypertexts. There exists a continuum of research that focuses on utilizing reading strategies for navigation between individual web pages (Coiro & Dobler, 2007; Cromley & Azevedo, 2009; Lawless, Schrader, & Mayall, 2007) and the navigation of a hypermedia environment via the utilization of self-regulation strategies to monitor reading comprehension (Azevedo, Guthrie, & Seibert, 2004). Theorists vary in the terminology used to describe strategies, and methods used to ascertain such utilization. However, empirical study consistently demonstrates that learners must utilize cognitive and metacognitive strategies to construct knowledge from multiple nodes within a hypertext environment.

Many have studied knowledge acquisition in hypermedia and identify cognitive and metacognitive strategies encompassed by SRL models as critical. Each model of SRL is composed of a series of classes or types of behaviors that can be (and are) assessed individually in online settings, instead of as an overarching construct. However, those who research learning in CBLEs identify behaviors differently, depending upon their

theoretical viewpoint. This study examined individual classes of SRL behaviors and identifies those behaviors that most commonly lead to knowledge acquisition primarily using terminology from process theories of SRL by Zimmerman (2000) and also interpret strategy use as enactment of SRL tactics as per (Winne & Hadwin, 1998).

Across learners, knowledge acquisition is influenced by the content and structure of the hypermedia from which the learner attempts to acquire knowledge. The organization of nodes (Müller-Kalthoff, & Möller, 2006) has been shown to influence navigation, comprehension and retention. Additionally, the complexity of the text itself influences comprehension (Salmerón, Cañas, Kintsch, & Fajardo, 2005), as do the provision of tools to help navigate through hypertexts (Potelle & Rouet, 2002). In this study, the patterns and paths by which learners visited nodes and used tools were documented to determine if a specific path or combination of behaviors lead to greater levels of knowledge acquisition. Patterns were also studied to document differences in patterns between high and low prior knowledge learners. For all learners, the content of the hypertext itself and all tools provided were held consistent so that the results of the study might demonstrate patterns of tool use by different types of learners.

Patterns in the use of tools were analyzed to determine if individual tools supported learners' knowledge acquisition (textbase, situation model, total), and whether knowledge acquisition would differ based on an individual's personal characteristics including prior knowledge, intrinsic motivation, achievement goal orientation, self-efficacy to self-regulate learning and other factors. The use of tools that represent SRL tactics such as seeking information, reviewing notes, elaborating, and monitoring

understanding have been shown to correlate with different goal orientations (Nesbit et al., 2006). Highlighting correlated negatively and note taking positively with students' level of mastery orientation. CBLEs that provide tools have the potential to enable students who self-regulate to acquire knowledge by supporting their SRL tendencies. What needs to be investigated is whether tool use correlates not just with goal orientation, but also with knowledge acquisition. This would suggest that usage of such tools enables self-regulated learners to learn more than those who choose not to utilize them.

The studies described sample a variety of age groups and content areas and collectively provide insight into the degrees to which learner and CBLE variables influence knowledge acquisition. Studies that explore hypertext design sample primarily undergraduate students from multiple cultures. The majority of research on reading strategies employs qualitative methods with elementary school students. Studies to date have primarily focused on amounts of knowledge acquired by learners, but paid less attention to differences in how learners conduct their process of knowledge acquisition. An ideal methodology for future study would retain assessments of knowledge acquisition as influenced by learner and CBLE variables, but would do so through the employment of online measurement techniques in concert with pretest and posttest measures of knowledge acquisition and learner characteristics to explore the processes that leads to increased comprehension of the textbase and situation model. Using this methodology, additional conclusions could be drawn from a study that demonstrates how different types of individuals are differently supported by structures in a computer-based learning environment as they attempt to complete a learning task. Finally, because a

number of individual variables (prior knowledge, SRL, motivation) and hypertext variables (typology, text complexity) have been identified as influential in the knowledge acquisition process, it is important to model their individual and interacting effects.

Study Design and Research Questions

This study was designed to explore the effect that learner characteristics, behaviors and design features of a computer-based learning environment have on students' knowledge acquisition. All learners were given access to a resource rich computer-based learning environment (nStudy; Winne, & Beaudoin, 2009) that included navigational tools, annotation tools (for highlighting and note taking), and an information panel that logs user generated highlights and notes for the purposes of review. By tracing student behaviors in the CBLE, it was possible to determine the effects that the employment of particular SRL tactics had on knowledge acquisition. Additionally, participants completed a battery of offline instruments that measured specific self-reported SRL tendencies, achievement goal orientation, intrinsic motivation, self-efficacy to self-regulate learning and demographic variables to determine if learners who possess particular traits exhibit specific behavior patterns or achieve different levels of knowledge.

This study built on the work of Nesbit and colleagues (2006) and Bauer and Koedinger (2006) by providing additional information about how achievement goal orientations can predict the employment of SRL tactic and how traces of such online learning behaviors can predict knowledge acquisition. A series of research questions were addressed to explore the relationships between achievement goals, self-regulated learning

and knowledge acquisition in order to answer questions posed by Nesbit and colleagues (2006) relating goal orientation and behaviors to knowledge acquisition, and to provide additional support for or revision of the attention and generation hypotheses as proposed by Bauer and Koedinger (2006). In light of this previous research, I posed four research questions with an expectation that the following will occur.

Research Question 1

Does employing more SRL tactics influence knowledge acquisition? I expected that the more classes of SRL tactics a student enacts (evidenced by indicators in the last column of Table 4), the greater their gains in knowledge from pretest to posttest will be. If this is true, it suggests that students who self-regulate their studying of online reading passages gain more knowledge than those who do not.

Research Question 2

Do students gain more knowledge when they use particular tools to study a reading passage? As hypothesized above, I expect all students' knowledge to increase over time and those who employ more SRL tactics to improve scores more than those who use fewer. Further, I expect that those who make notes with original content will gain more knowledge than those who do not make notes. I also expect those who make more strategic highlights (as evidenced by fewer words highlighted per idea), will gain more knowledge than those who use the highlighter more liberally. And finally, I expect that while the ability to cut and paste notes is theorized to lead to superficial processing (Bauer & Koedinger, 2006) and did not improve immediate or delayed retention, I expect that students who utilize the highlighter will gain more knowledge than those who do not.

I believe that unlike cutting and pasting into a separate document, which serves as a “notebook” of sorts, the highlighting and preservation of a selection of text in a passage allows learners to focus on the selected text in context and process it. This preservation of context should increase the likelihood that the text will remain meaningful upon review, and allow increased review benefits without the encumbrance of longer selections required to give context to selections when isolated from the main passage. That is, highlighting a segment within the text will limit the need to select more words needed to clarify the intent of the selection as the neighboring unmarked words remain and provide context. Viewed in this light, the review benefits may differ when the same segment of text is highlighted versus cut and pasted. The process benefits of highlighting are similar to cut and paste in that the number of words selected may reflect the superficiality of the tactic.

These analyses will be used to provide further support for or clarification of Bauer and Koedinger’s (2006) attention hypothesis (that suggests copying and pasting or highlighting reduces attention to detail) and generation hypothesis (that generating one’s own notes leads to an increase in the benefit of processing).

Follow-up analyses will be conducted to determine if a) any individual difference variables significantly predict the tendency to highlight or take notes and if a learner characteristic X SRL tactic interaction leads to greater knowledge gain.

If my findings support these hypotheses, it has implications for the design of CBLEs that aim to support learning. The use of specific tools could be shown to elicit deeper levels of text processing, which would suggest that such tools should be provided

to learners, and that learners should be encouraged to use them to support knowledge acquisition. If a particular tool can be shown to have benefits for all or a subset of learners, this would have implications for the design of CBLEs for particular populations.

Research Question 3

Does prior knowledge influence learners' knowledge acquisition process when studying hypertext? This can be examined with respect to learner's pattern of tool use and navigation of the hypertext.

I anticipate that learners who possess higher amounts of prior knowledge will utilize tools differently than those with less prior knowledge. For marking tools, this would be confirmed by: 1) pretest score being inversely related to highlighting but 2) unrelated to traces of note taking. If this is true, I may be able to confirm that students with high prior knowledge may be less likely to use tools that support strategy use (like a highlighter; as found by Moos & Azevedo, 2008), but that it is important to provide students with the option to use other tools that support deeper processing (such as annotating tools, as well as tools that can be used to plan learning, monitor understanding and make connections between segments of text) and further knowledge acquisition. Note taking is theorized to support the process of inference making (Kintsch, 1998) and the use of notes should lead to increased scores on the situation model subtest.

Secondly, by conducting an analysis that compares prior knowledge to a pattern of navigation (hierarchical, linear, and mixed) to posttest scores, I may be able to identify whether navigation strategy and its interaction with prior knowledge predict knowledge gain. Such a finding would identify patterns of navigation that support knowledge gain.

Prior research has shown that linear search strategies generally lead to higher knowledge acquisition (Potelle & Rouet, 2002; Salmerón, Cañas, Kintsch, & Fajardo, 2005), but that high prior knowledge learners can efficiently search non-linear text passages (Byrnes & Guthrie, 1992). Additionally, if navigation patterns differ, I can confirm Potelle and Rouet's (2002) finding that prior knowledge predicts navigational patterns and that a CBLE that is flexible in its navigation options may be more adaptable to differently knowledgeable learners.

Research Question 4

Does goal orientation influence the use of SRL behaviors, and does this result in different amounts of knowledge gained? Nesbit and colleagues (2006) found that mastery orientation negatively predicted highlighting, but did not investigate whether this pattern of behavior influenced knowledge acquisition. I hypothesized that mastery orientation should correlate positively with knowledge acquisition scores. I also expected that, while students who are more mastery oriented (both approach and avoid) will highlight less often, they will be more likely to write original notes, which indicates inference making and will lead to increases in scores on situation model subtests and knowledge gain overall. This finding would further connect mastery orientations to a pattern of learning behavior that pursues understanding of the situation model of a reading passage.

Implications for SRL theory and design of CBLEs

If my hypotheses regarding SRL strategy use predicting knowledge acquisition are supported, it will provide confirmatory evidence for theories by Azevedo (2005) that the

exposure to instructional hypertext in a CBLE promotes learning, and that specific design features increase the potential for learning. As such, this knowledge would enable designers of CBLEs to improve the educational benefit of CBLEs by adding particular functionalities to support users' tendencies to learn in strategic ways. If the additional hypotheses about differences in posttest knowledge scores amongst learners are also supported, I can conclude that, while learning occurs in CBLEs, different amounts of learning occur for different individuals, depending upon the characteristics of the learner completing the learning task.

CHAPTER 3: METHOD

Participants

Participants were recruited from eight sections of undergraduate education courses. The content of these courses included human development, testing and assessment, introduction to special education, and the sociology of education. The learning task, a brief reading comprehension task on ADHD, was germane (but optional) to students' coursework as preservice teachers. Participants who enrolled were awarded 10 points of additional course credit for their participation by their respective instructor. Those who chose not to participate were given the option of completing an alternative assignment to obtain this course credit.

Across these eight sections, 275 students were registered in courses and could potentially have completed the study. A total of 185 responded to recruitment efforts and completed the consent form and at least a portion of the instruments used in the study. A final sample of 160 students completed all measures and their data were used to address research questions. Of these 160 students, 88 completed sessions in a group setting where multiple users completed all portions of the study individually in a computer lab. The remaining 72 completed individually scheduled sessions in my office.

Of these 160 undergraduate education students, 72% were female ($n = 115$) and 81.3% were Caucasian ($n = 130$). African American and Asian American students each composed 6.3% of the sample ($n = 10$). Three participants reported their ethnicity as Latino/Hispanic (1.9%) and six individuals (3.7%) reported their ethnicity as "other." One participant did not indicate an ethnicity. Participants were, on average, 21.75 years

old ($SD = 3.60$) and had completed 3.75 semesters ($SD = 1.78$) of post-secondary education. Their self-reported mean GPA was 3.17 ($SD = .390$) and their self-reported mean SAT verbal and math scores were 576 ($SD = 74.06$) and 548 ($SD = 81.80$), respectively. Seventy three were elementary education majors, 50 were secondary education majors, and 37 had yet to declare an education major that was specific to a grade level.

A power analysis was conducted using G*Power 3 (Faul, Erdfelder, Lang & Buchner, 2007) to determine the minimum sample size necessary to detect a medium effect size in each proposed analysis. To obtain significant findings with a minimum effect size of $R^2 = 0.15$ in the most complex regression equation (seven predictors) would require a sample of $N = 153$ who have data for all the variables. Additional regression models include subsets of this sample and a selection of predictor variables that relate to the research question. These analyses will enter fewer variables and require smaller sample sizes accordingly. As such, the sample of 160 exceeded the necessary sample size ($N = 153$) for all analyses. A summary of descriptive statistics for this sample is provided in Table 1.

Table 1. Descriptive statistics for demographic variables

Variable	N	M	SD	Skew	Skew SE	Kurtosis	SE
age in years	160	21.774	3.637	3.544	.192	14.998	.381
HE semesters complete	160	3.756	1.776	.259	.192	-.448	.381
GPA	158	3.170	.390	-.290	.193	.249	.384
SAT verbal	115	575.617	74.068	.107	.226	.268	.447
SAT math	117	548.453	81.796	-.562	.224	1.441	.444

Measures

Participants completed a battery of measures prior to the online learning task. These include a survey of demographic characteristics and a self-report of academic achievement (GPA, SAT). In addition, participants completed the Achievement Goals Questionnaire-Revised (Elliot & Murayama, 2008), academic self-efficacy items from the Children's Self-Efficacy Scale (CSES; Bandura, 2006) as adapted by Usher and Pajares (2008) and titled the Self-Efficacy for Self-Regulated Learning Scale, and a selection of five items (items 42, 53, 63, 66 & 67) from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1991) that corresponded to traceable behaviors. Finally, learners completed a knowledge measure as a pretest and a posttest. These measures are next described in detail beginning with the knowledge scale and demographic survey, both of which were designed for this study.

Offline Measures

Knowledge scale

A knowledge measure designed specifically for this study was administered as both pretest and posttest to assess knowledge of the textbase and situation model, as described by Kintsch (1998). The topic of the reading passage was Attention Deficit Hyperactivity Disorder (ADHD), as this topic was relevant to the content of all education courses from which students were sampled.

During the piloting process, the original version of the measure included 17 multiple choice items to assess comprehension of the textbase and four restricted response essays to assess knowledge of the situation model. Textbase items assessed recall of facts which appear in the reading. Situation model items were designed to assess respondents' ability to draw inferences from the reading and accurately and completely compose an explanation of how multiple portions of the reading relate to one another.

The essay items were coded using a three-point scale (0, 1, and 2) to correspond to learners' answers demonstrating no, partial and complete comprehension of the subsection of the reading passage. Using a holistic rubric, two independent raters scored each response. A full description of inter-rater reliability, included percent agreement and kappa statistics appears later in the methods section. The maximum number of points available on the measure was 25 (textbase subscale was 17 and for situation model was 8). The measure appears as Appendix A.

In a pilot study, a sample of 50 undergraduate education majors completed the measure as a pretest, spent 20 minutes reading the passage proposed as the learning task

in this experiment, and completed a the measure a second time as a posttest.

Descriptive statistics of scores per subtest and overall for both pretest and posttest are included below in Table 2, as are item difficulty and discriminating power statistics in Table 3.

During the pilot study, pretest the mean score (considered to be prior knowledge) of respondents was $M = 7.94$ ($SD = 1.94$) for the textbase subscale (TB) and $M = 4.23$ ($SD = 1.39$) on the situation model (SM) subscale. Mean scores increased for both subscales after reading and completing the posttest (knowledge gain) (SM $M = 14.36$, TB $M = 6.28$). Overall, knowledge scores rose by an average of 9.20 points from pretest to posttest, suggesting that knowledge acquisition occurred as a result of completing the learning task. Knowledge gain occurred on both subtests (TB $M = 6.90$, SM $M = 2.30$), suggesting that completing the learning task improved both textbase and situation model dimensions of comprehension. Content validity was maintained by sampling items from a larger bank of items provided from a test publisher which corresponded to the reading passage and were categorized as representing factual and conceptual level knowledge.

As can be seen in the results from the pilot study in Table 2, variance in respondent scores existed at both time points for each subtest and for the overall measure, suggesting that individual factors in addition to the learning task are responsible for differences in prior knowledge and knowledge gain scores, and warrant investigation. There appeared to be no floor or ceiling effects for this scale at either time point. The minimum score on the pretest was greater than 0 (one person scored a 6) and only one individual scored a perfect 25 out of 25 on the posttest.

Table 2. Descriptive Statistics of Pretest and Posttest on Knowledge Measures ($N = 50$)

Condition	(Sub)Test	M	SD	VAR	Max	Med	Min
Pretest	Total	12.17	2.6	6.75	18	12	6
	Textbase	7.94	1.94	3.76	13	8	4
	Situation Model	4.23	1.39	1.92	6	4	0
Posttest	Total	20.64	2.81	7.91	25	21.5	13
	Textbase	14.36	2.11	4.44	17	15	8
	Situation Model	6.28	1.18	1.39	8	6	3
Difference Scores	Total	9.2	4.62	21.35	23	10	-3
	Textbase	6.9	3.51	12.34	16	7	-3
	Situation Model	2.3	1.79	3.19	7	2	-2

In terms of item statistics, item difficulty varied considerably on the pretest. Nine items were answered correctly by less than 33% of respondents and an additional five were answered correctly by only 66%; the measure includes a range of easy medium and hard items across both subtests. At the posttest, each item is correctly answered by 66% or more of respondents, with the exception of items four and six in the TB subtest and item 21 in the SM subtest. Additionally, twenty four of the twenty five items returned positive discrimination between the top and bottom third in the sample based on posttest scores. Since all items with positive coefficients can be retained in order to add discriminating power to the measure (Miller, Linn, & Gronlund, 2009), the revised

version included all but item four. The revised version of the measure used in this study contained a 16 multiple choice item textbase subtest and a four essay subtest of situation model comprehension. The maximum overall score on the revised test was 24.

Table 3. Item Statistics for the Knowledge Measure ($N = 50$)

item	Pretest		Posttest	
	percent correct	item difficulty	percent correct	discriminating power
1	0.27	Hard	0.94	0.2
2	0.92	Easy	0.96	0.13
3	0.8	Easy	0.84	0.47
4	0.55	Medium	0.34	-0.07
5	0.27	Hard	0.86	0.47
6	0.69	Medium	0.62	0.53
7	0.29	Hard	0.96	0.13
8	0.1	Hard	0.8	0.6
9	0.06	Hard	0.84	0.4
10	0.88	Easy	0.94	0.13
11	0.57	Medium	0.92	0.27
12	0.45	Medium	0.94	0.2
13	0.2	Hard	0.82	0.53
14	0.27	Hard	0.92	0.2
15	0.67	Easy	0.92	0.13
16	0.67	Easy	0.98	0.13
17	0.2	Hard	0.72	0.6
18	0.76	Easy	0.93	0.23
19	0.53	Medium	0.81	0.27
20	0.67	Easy	0.93	0.17
21	0.07	Hard	0.42	0.5

Note. Item 4 was omitted from the revised version of the knowledge measure used in the study.

Demographic Survey and Self Report of GPA

A brief demographic survey was administered to determine if personal characteristics influence knowledge acquisition. Participants were asked to indicate their sex, ethnicity, and age at time of participation as well as their number of semesters enrolled past high school. Additionally, participants were asked to self-report their cumulative GPA as of their most recently completed semester and their SAT Math and Verbal scores. The scale appears as Appendix B. Kuncel (2005) investigated the reliability of self-reported GPA and SAT scores and describes participant's reporting as highly reliable and adequate for research use.

Achievement Goals Questionnaire - Revised

The Achievement Goals Questionnaire- Revised (Elliot & Murayama, 2008) is a 12-item measure that measures learners' orientation according to a 2 x 2 model. Learners are classified as possessing an achievement or performance orientation and as being motivated either by a fear of failure (avoid) versus a motivation to do well (approach). This measure is a redesign of Elliot and McGregor's (2001) Achievement Goal Questionnaire (AGQ). The AGQ-R was normed using a sample of 229 undergraduates and represents an improvement in predictive utility and structural validity, while maintaining the levels of internal consistency of the original scale (all coefficient alphas exceed $\alpha = .83$). The coefficient alphas for each scale range from $\alpha = .763$ to $\alpha = .817$. The items in the AGQ-R are domain specific to the extent that they are written so they can be answered in the context of a specific class or learning task. For example, item 1 is

one of three items in the Mastery Approach subscale and read, “My aim is to completely master the material presented in this class.” While these are specific to a learning context, they are non-specific to any academic subject.

To assure construct validity, Elliot and Murayama (2008) examined the factor structure of the AGQ-R using standard confirmatory factor analytic techniques. All factor loadings were highly significant ($p < .001$). The discriminant validity of the AGQ-R was confirmed by comparisons with the original Achievement Goal Orientation questionnaire, as well as the five-item short form of the Performance Failure Appraisal Inventory (Conroy, 2001). The scale appears as Appendix C.

Intrinsic motivation

Elliot and Church’s (1997) eight-item measure was used to assess participants’ intrinsic motivation for the learning task used in this study. Items were phrased in reference to a class. Items were adapted for this study by replacing the word “class” with the word “exercise” (e.g. “I think this class was interesting” becomes “I think this exercise was interesting”). Participants responded using a seven-point Likert scale of 1 (*strongly disagree*) to 7 (*strongly agree*); after reverse scoring two negatively worded items, the items are averaged to form the intrinsic motivation index, that is collected after the task and used as a measure of interest. Internal consistency for the scale as reported by Elliot and Church (1997) is Cronbach’s $\alpha = .92$. For this sample, $\alpha = .856$. The adapted scale appears as Appendix D.

Self-Efficacy

The Self-Efficacy for Self-Regulated Learning Scale is a seven item scale created by Usher and Pajares (2008) from items within Bandura's Multidimensional Scales of Perceived Self-Efficacy, which is currently published as a subset of items in the Children's Self-Efficacy Scale (CSES; Bandura, 2006). This seven-item scale was normed on six groups of middle and high school students and was found to possess an internal consistency of $\alpha = .83$. For this sample, $\alpha = .757$. Participants responded using a six-point Likert scale of 1 (*strongly disagree*) to 6 (*strongly agree*).

Usher and Pajares conducted a confirmatory factor analysis and specified five measurement models to determine the fit of models for males, and females across elementary middle and high school age groups. Most relevant to the sample in this study, the fit statistics for 11th grade high school students represent acceptable fit ($\chi^2[14] = 71.72, p < .0001, CFI = .96, RMSEA = .07, SRMR = .04$). The scale appears as Appendix E.

Offline Self Regulated Learning Items

Numerous scales that purport to measure SRL in an offline setting exist. These include the LASSI, CCC, PALS and MSLQ documented previously. Despite their existence and past use, recent evidence suggests that self-report measures of SRL are poorly calibrated to actual SRL behavior conducted when measured in online study (Bråten & Samuelstuen, 2007; Hadwin et al., 2007; Winne & Jamieson-Noel, 2002). As a result, theorists and researchers have begun to question the appropriateness of offline measurement of SRL (Zimmerman, 2008) as it is difficult to measure accurately and

because SRL behaviors are situationally employed, depending upon the task conditions. Accordingly, this study employs a selection of items that are to be considered indicative of a self-reported tendency toward specific SRL behavior classes that can also be measured in an online environment. Relevant items were drawn from the MSLQ (items 36, 38, 42, 53, 63, 66, 67, 71, 72, 76; response scale 1 = not at all true of me to 7 really true of me) as previously utilized by Hadwin, Nesbit, Jamieson-Noel, Code and Winne (2007). A subset of five of these items that directly relate to SRL tactics traceable in nStudy appear as Appendix F. These items will be used to examine the relationship between learner self-reports of individual classes of SRL behavior in typical academic environments (the questionnaire items) and traces of SRL behaviors in the online task. Such tacit indicators will be used to determine if learners' self-perceptions of tendency towards SRL can be used to predict achievement or patterns of strategy use. Such a methodology has been employed by Hadwin and colleagues (2007) to draw comparisons between learners' response patterns to MSLQ items and their types of navigational patterns through a CBLE. While Hadwin and colleagues (2007) found that MSLQ response patterns were poorly calibrated to corresponding traces of SRL behavior. It is useful to attempt to replicate this finding as use of the MSLQ is widespread despite evidence of poor calibration. As can be seen in Appendix F, participants complete only items that correspond to learners' highlighting of important ideas (MSLQ item 42) or traces of inference making (through note-taking or establishing links; items 53, 63, 66, 67). As these items are selected from a larger measure, no measure of internal consistency is available. When calculated for this sample, $\alpha = .668$. This suggests that the

items, though not meant to be a scale, are related enough that they approach acceptable levels of internal consistency (usually $\alpha > .80$). While employment of different SRL tactics are all indicative of a thoughtful approach to learning, items which focus on individual tactics are not measures of the same construct, which leaves their validity suspect. The collection of SRL tactics which the MSLQ attempts to capture include diverse strategies that are not uniformly used by learners, which may lead to more variance in responses to individual items.

Online measures

nStudy overview

The computer-based learning environment employed in this study is nStudy (Winne, Hadwin, & Beaudoin, 2009). NStudy is an Internet based CBLE where learners can navigate to any web page and can browse its contents. The nStudy environment provides students with tools they can use to interact with the web page such as highlighters, note templates, a glossary, a link creator, and a library that records their marks on the webpage content to facilitate review of marks and links made. NStudy then tracks learners' activities within the webpage and creates a time stamped log of traces of student behavior. This log file can be used to analyze the occurrence, frequency, timing and pattern of learner behaviors and examine their relationship to knowledge acquisition and other outcomes. Additional tools available in nStudy that are not activated for this study include a concept map and search tool, as well as collaborative tools like chat and help functions. A screen shot of the nStudy environment showing text used by nStudy developers is shown in Figure 1.

The learning task in nStudy

The learning task was composed of a 20-minute study session during which learners used nStudy to read and navigate a 1,050-word text passage on Attention Deficit Hyperactivity Disorder taken from a lifespan development textbook for educational psychology students (Berk, 2006) and an additional 307-word passage taken from the webpage of Division 12 of American Psychological Association summarizing childhood disorders (APA Division 12, 2009). The reading passage was broken up across a set of five pages of content with links to an additional 10 pages that defined terms in the main reading. Users could navigate to these definition pages via the 10 hyperlinked words in the main passage. Content pages were linked in a manner so that the participant could navigate linearly from the index through to the end of the reading by clicking on a next link. The participant can also navigate nonlinearly, by using the “back to index” link on each node. Pages and linking structures appear in Appendix G. The contents of page node can be seen as the subsections of the reading passage, which appears in Appendix H.

In addition to the content pages, a Learning Goals page and a Study Checklist page were included in order to track planning and monitoring behavior. These pages could be accessed from the index page. The two additional pages appear as Appendix I and Appendix J. All pages were designed and saved as html files on the nStudy server, that was be accessed by participants during the session through the nStudy browser described below.

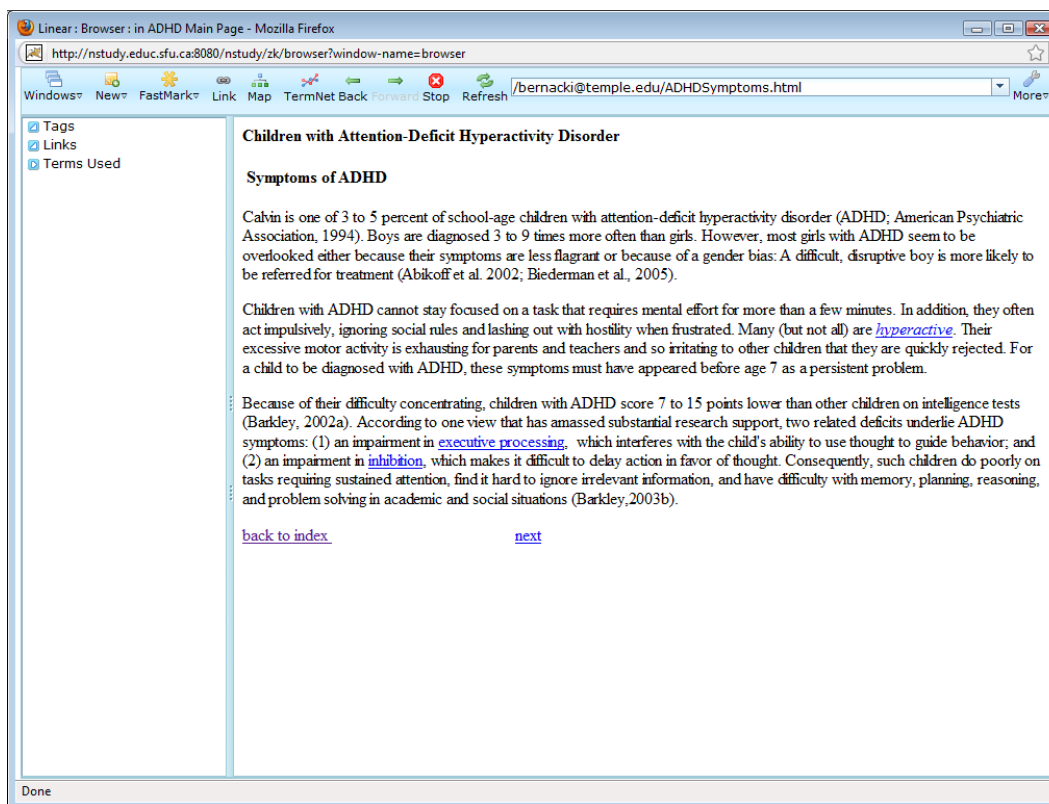


Figure 1. The nStudy browser.

Before participants began their study session, they received a brief (15 slide) self-paced tutorial presentation that explained the purpose of the nStudy Browser and how to use its tools. This tutorial contained annotated screenshots of the nStudy browser and its functionality. The goal of the slide show was to ensure learners would understand how to use the marking tools available. Participants generally completed this in less than five minutes.

Instrument Scoring

Online instrument – nStudy log

The measurement of SRL through online assessment follows from the assumption of Winne and Hadwin (1998) and Zimmerman (2000) that SRL is best understood as an

iterative process that changes throughout the course of a task. As a result, records obtained from the log analyzer tool in nStudy were used to assess whether individuals who demonstrate SRL tendencies in a CBLE as evidenced by utilization of tools that support self-regulation of learning.

In order to score the online measurement of SRL behaviors, categorizations were made as to whether the participant demonstrated individual classes of SRL strategy use as described by Zimmerman and Martinez-Pons (1986) in the Self Regulated Learning Interview Schedule. In the SRLIS, individuals were determined to have demonstrated a class of strategy use if they utilized a tool once. For this study, multiple indicators were used to determine whether, and to what degree, individuals employed an SRL tactic.

Table 4. Expanded table of SRL classes to include indicators of behavior in nStudy corresponding to classes of SRL as defined by Zimmerman and Martinez-Pons (1986).

Class of SRL	Behavior	variables representing SRL tactics			
		timestamp	%	Freq.	dichotomous
Goal setting and planning	use of page of learning goals	timeLG		freqLG	vLG
Self-evaluation	use of page containing a review checklist	timeCheck		freqCheck	vCheck
Keeping records	use of highlighter tool use of note tool			numhigh numnote	usehigh usenote
Seeking information	time spent in CBLE visits to pages with definitions of terms	CBLEtime		countterm	
Rehearsal & Memorizing	clicks in library frame to review notes			revtot	userev
Review Notes	double clicks in information panel to open and read user generated notes			revtotal	revnote
Off task behaviors (negative predictor)	percentage of total time spent on "Other" page; no content relevant to objectives		pct time Other	freqOther	vOther

Note. Zimmerman and Martinez- Pons propose additional classes for environmental structuring, organizing and transforming, self-consequating, reviewing previous tests, and seeking assistance. No corresponding behavior could be logged for these classes in the current study using trace data provided by nStudy.

When a learner completes a learning task in nStudy, the software records every action the user completes. These include navigations to a page, clicks to select text, and clicks to utilize features of the environment like the highlight tool, information panel, note tool, and the buttons that correspond to these features. Additionally, each recorded action is stamped with the time it occurred, making it possible to analyze the amount of time between actions, or the amount of time spent on a page. As a result, researchers who interpret the data that nStudy provided must choose whether to represent behaviors using the amount (or “count”) of times an event occurs, the duration of an event, or whether a clicking action to utilize a feature represents use. Each type of data is appropriate for representing one type of behavior, and inappropriate for others. For instance, if one is interested in representing the time that a learner spends on a particular web page, the time stamp for visiting the page can be subtracted from the time stamp for leaving the page to return a time spent value. This can return a measure of time on a task or subtask. One can additionally use timestamps on specific pages divided by the time spent on all pages to obtain a percent of time allocated to specific content areas or learning behaviors, such as using the review checklist, or studying a particular page of content.

While the time stamps may be useful to trace the order of tool use and the time elapsed between actions, the number of clicks on a tool are more useful for assessing the amount of times that a learner uses a tool to make an annotation. A count of uses of the highlight tool might give researchers an impression of the frequency with which learners choose to utilize the tool. This count can either be used to determine frequency, or collapsed into a dichotomous use versus lack of use variable. NStudy also records the

selections of text learners choose to highlight or link to a note, which allows for content analysis for other considerations such as the number of words per note or the overlap between highlighted text and learning objectives for the task.

In order to test the hypothesis that the use of SRL strategies would lead to knowledge acquisition, different types of strategies needed to be modeled using different data types. The proxy variables listed in Table 4 were used to represent each class of SRL behaviors created by Zimmerman and Martinez-Pons (1986). This table is an elaboration the original table of SRL behaviors as named by Zimmerman and Martinez-Pons as it also includes operational definitions for this study including proportion of time spent on a page, frequency of use of a tool or visit to a page, and the dichotomous use or disuse of a tool.

Offline instruments

All offline instruments were administered using Blackboard Academic Suite during the same session as the learning task. Data were downloaded daily into a statistical package and raw scores were calculated for pretest and posttest scores as well as all predictors. Demographic data was also stored in the same dataset.

Inter rater reliability

Two independent raters scored each item using a predesigned rubric that included ordinal categories valued worth 0, 1, or 2 points for an answer's accuracy and completeness. In order to assess inter-rater reliability for situation model items (17, 18, 19 and 20), percent agreement and a Kappa statistic (κ) was calculated. According to Cohen (1960), κ represents the proportion of agreement, corrected for chance, between

two raters classifying cases into multiple categories. Its scale varies from negative to positive one. Zero reflects a level of agreement equivalent to chance, while positive and negative values reflect better or poorer than chance agreement. Sim and Wright (2005) suggest that κ is an appropriate statistics for measuring rater agreement.

Table 5 displays κ values and calculated a test of significant difference from chance agreement. Kappa values for agreement on all items are greater than or equal to $k = .762$, and on each of these items, agreement is significantly different from chance agreement ($p < .001$). While some suggest descriptions of ranges of κ statistics are arbitrary, Landis and Koch (1977) identify κ scores between 0.40 and .059 as “moderate”, between 0.60 and 0.79 as “substantial” and 0.80 or larger as “outstanding.” As can be seen, rater agreement on item 20 is in the outstanding range, and rater agreement approaches outstanding on items 17, 18 and 19.

Table 5. Kappa statistics used to determine inter rater reliability for situation model knowledge items.

Item	percent agreement	κ	SE	confidence interval	p
17	87.2	.762	.032	0.699 to 0.824	>.001
18	86.4	.782	.028	0.727 to 0.837	>.001
19	89.2	.773	.032	0.710 to 0.836	>.001
20	96.5	.918	.022	0.875 to 0.961	>.001

To provide further assurance that rater agreement is significantly greater than an “acceptable” level as described by Landis and Koch (1997) and referenced by Sim and Wright (2005), I calculated a confidence interval to indicate a range of plausible values for the true value of each κ with the equation in Figure 2.

$$\text{Lower bound} = \kappa - (\text{z score for desired confidence level, 95\%,} \times \text{standard error})$$

$$\text{Upper bound} = \kappa + (\text{z score for desired confidence level, 95\%,} \times \text{standard error})$$

Figure 2. Equations used to calculate confidence interval for Kappa statistic.

Considering the lower bound of the confidence interval, each remains above a 0.40 cutoff. The null hypothesis that kappa is no greater than zero (chance) can be rejected as can a null hypothesis that κ is no greater than 0.40 (an acceptable level). Based on these statistics, we can proceed with using the items in this subscale as a measure of comprehension at the level of the situation model (Kintsch, 1988). Learners who successfully answer these items can draw inferences from the reading and construct original answers that are accurate and complete.

Procedure

Recruitment and Assignment

Participants were recruited from education courses at Temple University by the author. The study was introduced as an investigation of the impact of computer-based educational materials on different types of learners. Participation was explained as

optional and confidential, that participation in the study session would require less than one hour of a participant's time, and that enrollment would result in 10 points of extra credit in their education course. Once participants indicated their interest, a session was scheduled. At a session, they signed a consent form, and completed the battery of assessments. Participants received a unique identifier that was paired with their name on only one document that was password protected and kept separate from other data or consent forms. Consent forms were stored in a locked file in Ritter Annex Room 293. This consent form appears as Appendix K.

Procedure

With the exception of a written informed consent procedure, all instruments were presented electronically. Detailed descriptions of both offline and online measures are described below. A summary of the schedule for the session is presented in Table 6.

Table 6. Schedule for Data Collection Sessions

Time to complete (min)	Cumulative time	Content of event
prior to session	0:00	Participant recruitment
:03	0:03	Consent process (pencil and paper)
:04	0:07	Demographic Questionnaire and 7-item Self Efficacy Scale
:04	0:11	Achievement Goal Questionnaire - Revised
:02	0:13	Offline SRL assessment
:04	0:17	nStudy tutorial
:10	0:27	Pretest
:20	0:47	Online task (nStudy learning kit)
:12	0:59	Posttest and Interest Inventory
:01	0:60	Debriefing (End of session)

After a paper-based consent form was signed, participants completed all measures on a computer equipped with the required software (Microsoft PowerPoint 2007, Mozilla Firefox version 3.5) and hardware (flat screen color monitor, full sized keyboard, two-button mouse). Offline measures were completed first, then participants viewed the nStudy tutorial and were logged into the nStudy environment. Once they were logged in, the following directions were read to each participant:

This is the main page for the learning task you are asked to complete.

You have 20 minutes to study its contents in any way you wish. There is a timer on the desk that I [the researcher] will start. When you feel you are finished learning and are ready to take the posttest, press the stop button and I [the researcher] will help you log out. You will then take the post-test and the session will be over.

Learners then completed their session, logged out, and completed the posttest. They were then debriefed and dismissed. Notification was sent to their instructor at the end of the semester that they had completed the study and should be awarded credit. All measures were administered using the nStudy browser (online assessments) and through the test manager in Blackboard Academic Suite.

Data Analysis

To address the research questions proposed in Chapter 2, a series of correlational and regression analyses were conducted with posttest knowledge scores as the dependent variable in most cases. Offline predictors included measures of prior knowledge (pretest textbase and situation model knowledge scores), achievement goal orientation scores (raw scores for Mastery Approach, Mastery Avoidance, Performance Approach and Performance Avoidance), Intrinsic motivation, and Self Efficacy for SRL. Online predictors included raw counts of individual SRL tactics employed, the dichotomous tendency to employ or not employ tactics, and an SRL tactics score which summed the number of SRL tactics a learner employed at least once during the learning task.

Analyses which examine relationships between these variables appear in the Results section of the dissertation (Chapter 4).

CHAPTER 4: RESULTS

The results section is divided into preliminary analyses, principal analyses, and supplemental analyses. Preliminary analyses include descriptive statistics of all demographic and predictor variables. Principal analyses include all analyses conducted to address the research questions specified above. The supplemental analyses section contains select analyses conducted to further investigate significant findings from the research questions. The implications of principal and supplemental analyses are drawn in the discussion chapter (Chapter 5).

Preliminary analyses

Before analyses were conducted to address the proposed research questions, a series of descriptive statistics and frequencies were conducted for all measures. Demographic variables were analyzed to obtain a summary of the characteristics of the sample (see Table 1).

For each interval/ratio scaled variable, a check was conducted to identify outliers, and to ensure that the skewness or kurtosis of each scale did not exceed acceptable levels (1.0, 1.0 respectively). Values for the mean, standard deviation, skewness and kurtosis of each scale are included in Table 7 and Table 8. The only variables with skewness exceeding 1.0 were age and SAT Math scores. Age has a high positive skew where 14 outliers fell one standard deviation above the mean of 21.76 and seven fell two standard deviations above. Age was not significantly correlated to the dependent variables in analyses (posttest scores on the knowledge measure or knowledge gain), though there was a significant inverse relationship between age in months and variables related to

highlighting. For each additional 3 months of age, a person could be expected make approximately one fewer highlight. As age was not specified as a theorized predictor, it will not be included as an additional predictor in analyses and this skewness is not considered problematic otherwise.

For SAT math scores, the skewness is under 1.0 and the kurtosis (1.394) exceeds a 1.0 cutoff only slightly. Most participants cluster tightly around the mean score of 549, which makes sense given the similarity of scores of individuals who attend an institution based on their performance on a standardized test used for admission. This is very close to the university and college average, suggesting they reported accurately. As such, this high kurtosis is considered an artifact of the context from which students were sampled, and results of the study, as before, should be used to generalize to other populations with similar attributes.

With respect to dependent variables, the posttest knowledge score was highly kurtotic (Kurtosis = 8.724). As a result, posttest knowledge scores were squared to normalize the distribution so that parametric analyses could be performed. Additionally, because pretest scores on textbase and situation model subtests were included as predictor variables in analyses, these subtests were also transformed using the same squaring process so that their scale matched posttest score. For each regression analysis, equations were analyzed with transformed posttest knowledge replacing original posttest knowledge score as the dependent variable in order to ensure that significant findings were not influenced by this kurtosis.

Self-efficacy for SRL, Intrinsic Motivation and Goal Achievement Orientation

The mean scores on measures of self-efficacy for self-regulated learning, goal orientation and intrinsic motivation are presented in Table 7.

Table 7. Descriptive Statistics for Self-efficacy for SRL, Achievement Goal Orientation and Intrinsic Motivation Scales ($N = 160$)

Scale	α	Score	SD	Skewness	SE	Kurtosis	SE
SRL self-efficacy Score	.757	25.244	6.348	-.004	.192	-.153	.381
Performance Approach Score	.817	13.441	4.352	.010	.192	-.856	.381
Performance Avoidance Score	.816	13.058	4.636	-.065	.192	-.673	.381
Mastery Approach Score	.815	15.896	3.761	-.548	.192	-.532	.381
Mastery Avoidance Score	.763	12.592	5.057	.159	.192	-1.051	.381
Intrinsic Motivation Score	.856	4.317	.993	.244	.192	.085	.381

Knowledge measures

Participants' performances on the textbase and situation model sections of the pretest and posttest can be found in Table 8. The average participant earned 10.98 points (of a possible 24) on the pretest and 18.86 points on the posttest, increasing his or her knowledge score by 7.88 points after completing the learning task.

A large number of individuals answered the majority of items correctly after the learning task ($M = 13.350$, $SD = 2.152$) that results in a negative skewness, and because the majority of students mastered similar amounts of content and answered similar numbers of items correctly, posttest scores cluster tightly around the higher end of the scale, which explains the kurtosis. This trend is responsible for the similar distribution in total posttest scores, though they are muted by their combination with situation model scores.

The relationship between prior knowledge, posttest scores and knowledge gain was examined, and the results had implications for the use of the knowledge scales as dependent variables in future analyses. A correlation matrix including pretest, posttest and difference scores for the textbase subtest, situation model subtest and total score appears in Tables 9 and 10 (transformed scores). There are three important points to be gleaned from the data contained in Table 8 and this matrix.

Table 8. Descriptive Statistics for Knowledge Scales ($N = 160$)

Variable	M	SD	Skewness	Kurtosis
textbase pretest score	7.369	1.951	-.386	.708
textbase posttest score	13.350	2.152	-2.038	9.179
situation model pretest score	3.600	1.356	-.406	.177
situation model posttest score	5.481	1.327	-.924	1.257
total score on pretest	10.969	2.590	-.502	1.250
total score on posttest	18.831	3.049	-1.904	8.724
squared textbase pretest score	58.081	27.953	0.437	-.566
squared textbase posttest score	182.825	49.616	-0.593	.678
squared situation model pretest score	14.788	9.387	0.628	-.157
squared situation model posttest score	31.794	13.215	-0.136	-.550
squared total score on pretest	126.981	54.711	0.387	-.168
squared total score on posttest	363.856	100.345	-0.461	.564
TB knowledge gain	5.981	2.415	-.111	-.072
SM knowledge gain	1.881	1.627	.301	.461
Total knowledge gain	7.863	3.127	-.057	-.195

First, mean knowledge scores increase for learners from pretest to posttest, which indicates that learning did occur ($t [159] = 31.802, p < .001$). This increase was also significant for transformed scores ($t [159] = 30.459, p < .001$). Second, pretest scores are

significantly and positively related to posttest scores on both subtests and on the overall test. This suggests that students who began the task with higher prior knowledge also tended to have higher knowledge scores at posttest. The third point is that knowledge gain scores tend to correlate negatively with pretest scores, suggesting that those who began the task with higher prior knowledge increased their score *less* than those with lower prior knowledge. This required further review as it conflicted with the second finding. When frequencies of posttest scores were analyzed, it was found that 22 of the 160 participants learned enough from the task to answer all textbase items correctly. As such, the textbase posttest scores experienced a modest ceiling effect, though not so constraining as to reduce variance substantially. Knowledge gain scores are influenced by this, and were not used in future analyses. Instead, posttest scores were used as the criterion variable in regression analyses, and the pretest scores on textbase and situation model subtests were entered as predictors in all models.

Table 9. Correlation Matrix of Pretest Posttest and Knowledge Scores ($N = 160$)

	1	2	3	4	5	6	7	8	9
1. textbase (TB) pretest	--	.311**	.201*	.252**	.858**	.329**	-.531**	.038	-.391**
2. TB posttest		--	.234**	.509**	.356**	.927**	.640**	.220**	.609**
3. situation model (SM) pretest			--	.265**	.675**	.280**	.046	-.618**	-.286**
4. SM posttest				--	.328**	.794**	.250**	.595**	.503**
5. Total pretest					--	.394**	-.376**	-.295**	-.444**
6. Total posttest						--	.561**	.414**	.649**
7. TB gain							--	.166*	.858**
8. SM gain								--	.648**
9. Total knowledge gain									--

Note. * = $p < .05$, ** = $p < .01$

Table 10. Correlation Matrix of Transformed Knowledge Scores ($N = 160$)

	1	2	3	4	5	6	7	8	9
1. TB pretest ²	-	.205**	.155*	.180*	.859**	.227	-.582**	.010	-.444**
2. TB posttest ²		--	.210**	.457**	.260**	.908	.661**	.211**	.621**
3. SM pretest ²			--	.286**	.625**	.278	.061	-.570**	-.249**
4. SM posttest ²				--	.274**	.786	.241**	.588**	.492**
5. Total pretest ²					--	.308	-.432**	-.306**	-.492**
6. Total posttest ²						--	.570**	.428**	.662**
7. TB gain							--	.166*	.858**
8. SM gain								--	.648**
9. Total gain									--

Note. * = $p < .05$, ** = $p < .01$

Self-report SRL tendency

Five individual items were included in the survey to gauge participants' impressions of their tendency toward self-regulated learning. These five items from the Motivated Strategies for Learning Questionnaire correspond to five of the behaviors that were traced in nStudy during the learning task. Self-reported tendencies toward SRL on these five items can be found in Table 11. The most common SRL behavior reported by students is that they attempt to find important ideas. These tendencies were compared to

traced actions of analogous behaviors traced in nStudy. The traced behavior appears in parentheses for each item and is discussed later in this dissertation.

Online behaviors

Traces of online behaviors were recorded by the nStudy software and compiled into a single database. Selection functions were used to retrieve specific subsets of these data to answer individual research questions. As described previously in Table 4, classes of SRL behaviors were specified by Zimmerman and Martinez-Pons (1986) and an analogous behavior that is traceable in nStudy was identified for all possible behaviors. Tables 12 and 13 detail all forms of trace data corresponding to each SRL behavior as specified by Zimmerman and Martinez-Pons. Select variables were used to test specific hypotheses and are explained, per research question, in the principal analysis section.

Table 11. Descriptive Statistics for MSLQ items

Item	M	SD	Skewness	Kurtosis
When I study for a course, I go through readings and my class notes and try to find the most important ideas. (highlight)	4.981	1.532	-.362	-.084
When I study for a class, I pull together information from different sources such as lectures, readings, and discussions. (link between two highlighted segments of text in note content)	4.731	1.593	-.203	-.338
When I study for a course, I go over my class notes and make an outline of important concepts (organization in note content).	3.881	2.00	.228	-1.096
I try to play around with ideas of my own related to what I am learning in this course (elaborative note content).	3.856	1.829	.240	-.772
When I study for a course, I write brief summaries of the main ideas from the readings and the concepts from lectures (summarization in note content).	3.088	1.905	.542	-.748

Note. Maximum score on each item is 6. Students tend to report themselves as at least moderately self-regulated.

Table 12. Descriptive Statistics of Count of Online Behaviors

Variable	N	M	SD	Skewness		Kurtosis	
				Statistic	SE	Statistic	SE
total number of visits to index page	160	5.44	3.319	1.434	.192	3.150	.381
intro page	160	2.08	1.163	1.067	.192	1.088	.381
symptoms page	160	2.88	2.099	1.683	.192	3.945	.381
origins page	160	2.26	1.515	1.556	.192	4.043	.381
treatment page	160	2.20	1.529	1.818	.192	5.438	.381
other page	160	1.57	.969	1.883	.192	4.169	.381
total number of visits to learning goals	160	.84	.669	.829	.192	1.804	.381
total number of visits to checklist	160	.78	.688	1.135	.192	3.337	.381
total number of visits to terms pages	160	1.33	2.124	2.179	.192	5.454	.381
total number of pages visited	160	20.29	10.451	1.142	.192	2.464	.381
total number of words highlighted	160	133.250	137.965	.690	.192	-.431	.381
number of notes created	160	.488	1.946	6.843	.192	51.964	.381

Table 12. (continued)

number of highlights created	160	11.056	11.159	.585	.192	-.783	.381
number of words selected per note	27	12.461	8.604	1.144	.448	1.216	.872
Number of words entered per note	7	13.867 [^]	13.027 [^]	--	--	--	--
number of words per highlight	100	12.411	4.263	.164	.241	-.892	.478
number of clicks to review notes	49	4.306	7.389	2.618	.340	7.442	.668
number of clicks to review highlights	50	2.460	3.693	2.722	.337	7.789	.662
number of total clicks in review panel	160	2.088	5.406	3.736	.192	15.233	.381

Note. [^] - refers to a local mean and local standard deviation. Only 15 of 78 notes included annotation.

Highlighting and note taking. Across all participants, a total of 1,847 annotations were made, including 78 notes and 1,769 highlights. However, a review of the notes taken revealed that, of these 78 notes, only fifteen of them included any annotation content while the remainder included a selection of text, akin to a highlight, without any

additional content in the note window. Content analysis of the fifteen notes with annotations revealed that they were created by seven users. Eight of the notes were summaries or abbreviations of the content of the page where the selected text existed. Three were annotated with one to three word statements that reworded the selected text. Only the four remaining annotations consisted of elaborative content created by the learner. Given these findings, note taking as measured in this study seems to be a questionable indicator of true note taking processes and is tentatively analyzed as a predictor in models. Reasons for learners' failure to more consistently make use of the note taking tool appear in the discussion section. Table 11 includes data for all learners to represent the tendency to create notes using nStudy, as well as data for those seven participants who created notes that contained annotations. Statistics below refer to note taking as conducted by the entire sample.

The vast majority of traces made were highlights, 95.77% (Notes = 4.23% of traces). Of the 169 students who completed the task, 100 used the highlight tool and 27 selected text using the note taking tool. On average students created 11.056 highlights ($SD = 11.159$) including 133.250 words ($SD = 137.965$), making the average highlight 12.411 words long ($SD = 4.263$).

Of the 160 students who completed the learning task, only 100 of them made highlights (62.5%). The number of participants who reviewed their selections of text was determined by tracing the number of clicks in the information panel where highlights and notes are logged by the browser. Thirty five of the 100 who created highlights reviewed them.

Time spent in CBLE and navigation patterns. The total amount of time spent in the learning environment and on each page was calculated to determine how participants chose to commit and divide their time in the task. Additionally, patterns of navigation were determined by counting the number of visits to each page and the amount of time spent on each page both on the initial visit and overall. Table 11 contains a summary of the average amount (in minutes and seconds) and percentage of time spent on each page of the learning environment total and upon first visit and the average number of visits to each page.

On average, participants spent 11 minutes and 37 seconds on the task ($SD = 5:11$). Participants spent most of their time (85.48%) on content nodes (introduction through other disorders), including hyperlinked definitions of terms. They spent 9.37% of their time navigating the learning environment using the index page and 2.91% of their time using the learning objectives and review pages. The remainder of participants' time in the task was spent creating or reviewing notes. More than 94% of participants visited all content pages, while 71% visited at least one of the pages containing tools to scaffold learning (list of learning objectives, review checklist). Forty-four percent of participants made use of the hyperlinks that provided definitions of key terms in the reading passage on separate pages. A breakdown of the raw number of seconds and percentages of time spent can be found in Table 13.

Table 13. Descriptive Statistics of Amount and Percentage of Time Spent in CBLE by
Page (N=160).

Page	% visited	N visited	Time spent on page			
			Percent time spent	SD	Seconds on page	SD
Index	100.00	160	7.63	.066	54.13	67.370
Introduction	98.125	157	8.12	.047	53.37	37.792
Symptoms	98.125	157	22.56	.078	158.89	93.740
Origins	98.125	157	14.92	.050	106.91	67.395
Treatment	97.500	156	25.08	.071	174.99	86.357
other disorders	98.125	157	15.27	.067	103.54	62.415
learning goals	71.875	115	1.67	.023	12.35	19.251
review checklist	66.875	107	1.19	.041	11.73	56.215
Notes	9.490	27	2.37	.069	19.34	54.356
Terms	44.438	71	1.21	.020	8.98	17.952

In terms of navigational patterns, participants' logs of traces made in the nStudy environment were reviewed to determine the order in which they visited pages, and the number of times they visited each page. Participants' navigational patterns were categorized as either linear or nonlinearly. Those who were classified as using a linear navigation pattern began with the index and advanced from page to page using the "next" buttons as opposed to revisiting the index between visits to pages. Nonlinear navigators were coded as such because they returned to the index between pages. Most commonly, participants used a linear navigation pattern, visited each node once and then logged out of the environment. However, after visiting all pages, some participants completed additional visits to at least some pages, visiting a majority of pages a second time ($n = 88$) and others conducting a third visit to pages ($n = 17$). Each round of navigation was coded using the same process. In their first navigation through the CBLE, 135 participants (84%) navigated linearly, and 25 (15.7%) navigated nonlinearly. After visiting all content nodes once and returning to the index (no "next" button was available on the last content page) 88 participants chose to conduct additional navigation of content pages. Of these 88, half ($n = 44$) navigated linearly and half ($n = 44$) navigated nonlinearly. On their second pass through the hypertext, 42 of the 88 participants (47%) maintained their original navigation style, while the majority of those who switched styles progressed from a linear navigation style to a nonlinear one. Finally, all seventeen of those who conducted a third round of review of the hypertext did so nonlinearly. This suggests that learners, especially those who used scaffolding tools like the information panel to review their highlights and notes or the learning goals or review checklist pages

likely used the index to navigate to specific pages where they determined that additional study was required. This trend will be further analyzed in research question four (below under “Principal Analyses”).

Principal analyses

Research Question 1

I hypothesized that those participants who demonstrate classes of SRL strategy use through traces of multiple studying tactics (evidenced by indicators in the last column of Table 4) would experience greater gains in knowledge from pretest to posttest than those who did not. In order to test this hypothesis, a series of transformation and summations of online data needed to be completed. The SRL tactics of interest were the number of highlights made, the number of notes created, number of clicks to review highlights and notes in the information panel, and the number of visits to the Learning Goals, Checklist, Terms and Other (an off-task behavior; inverse predictor) pages. These variables represented SRL tactics including keeping records (note and highlight), reviewing notes/rehearsal & memorizing (information panel), and planning (Learning Goals), monitoring (Checklist), information seeking (Terms), and avoiding off task behavior (Other) respectively. When the frequencies of each SRL tactic were observed, they were found to be non-normally distributed, as a large proportion of subjects had not employed each tactic individually. Table 14 includes mean, median, standard deviation, and skewness and kurtosis statistics for the frequency variables for all six SRL tactics.

Table 14. Descriptive Statistics for Frequencies of SRL Tactics Employed in the Learning Task ($N = 160$)

Variable	M	SD	Skewness		Kurtosis	
			Statistic	SE	Statistic	SE
number of highlights created	11.056	11.159	0.585	0.192	-0.783	0.381
number of notes created with annotations	0.094	0.486	5.888	0.192	37.266	0.381
number of total clicks in review panel	2.088	5.406	3.736	0.192	15.233	0.381
total number of visits to learning goals page	0.844	0.669	0.829	0.192	1.804	0.381
total number of visits to checklist page	0.781	0.688	1.135	0.192	3.337	0.381
total number of visits to the 10 terms pages	1.325	2.124	2.179	0.192	5.454	0.381
total number of visits to other page	1.569	0.969	1.883	0.192	4.169	0.381
SRLtactics	2.956	1.519	-0.187	0.192	-0.689	0.381

Because of these distributions, and because it has been done previously by Zimmerman, Bandura and Martinez-Pons (1992) it made more sense to represent the SRL variables dichotomously using the variables listed in Table 4. They argue that the tendency of learners to exhibit a SRL behavior indicates that they know to do it when it is advantageous, and that the amount of times the behavior is repeated is indicative not of additional self-regulation, but of task conditions that require repeated use of the SRL tactic. I repeated this method and aggregated the use of SRL tactics to demonstrate the

range of SRL tactics learners could employ. I then tested whether employment of multiple SRL tactics would influence knowledge acquisition.

Once they were scaled as 1 (employed the SRL tactic) or 0 (no SRL tactic use), the variables were summed into an interval scaled variable called “SRLtactics” using the equation in Figure 3 that yields a total tactics score that can range from zero (if no SRL tactics are used) to six (use all SRL tactics). Descriptive statistics for SRL Tactics appear in Table 14, and suggest that the variable approaches a normal distribution with acceptable skewness and kurtosis.

$$\text{SRLtactics} = (\text{usehigh}) + (\text{truenotetaker}) + (\text{userev}) + (\text{vterms}) + (\text{vLG}) + (\text{vCheck}) + (\text{AvOfftask})$$

Figure 3. Equation to calculate SRLtactics score.

A linear regression was conducted to determine if SRL tactics could predict the amount of increase in knowledge scores resulting from completing the learning task. When transformed posttest knowledge scores were regressed on SRL tactics and transformed TB and SM pretests (to account for prior knowledge), the number of classes of SRL tactics used was found to be a significant predictor of posttest knowledge ($F [3,159] = 9.807, p < .001$). For each additional SRL tactic used, a participants should score just under two points higher on the posttest ($B = 15.60$, fourth root is 1.98; $t [149] = 3.219, \beta = .233, p = .002$). Along with pretest scores, SRL tactics predicted 15.9% of the variance in posttest knowledge scores. This regression model appears as model 0 in Table 15. These results suggest that learners who self-regulate their learning do indeed learn

more during the learning task than those who do not. The next research question disaggregates the dichotomous variables used to create the SRLtactics variable and models them as individual predictors of posttest knowledge.

While this dichotomous coding is a replication of the method used by Zimmerman and Martinez-Pons (1986), measuring use of SRL tactics by traced actions may include additional “false positives.” For instance, when learners click on a page of learning objectives, they may do so because they truly are interested in the objectives listed and will use them to plan their use of the hypertext. However, a curious learner who sees a hyperlink to a page may click on it based on curiosity, with no intention of using the tool for its intended purpose. As such, development of additional indicators which constitute a valid trace of use should be considered.

Because a single click could represent either learner curiosity or an actual SRL behavior, a more stringent threshold of two traces of each counting indicator (highlight made, note made, click in review panel, visitation of a term) was used to dichotomously code this set of SRL classes. For other traces (visit checklist, visit learning goals, avoid off task behavior) time spent using a tool is more indicative of true SRL behavior than number of clicks, so a threshold of second spent on a page was set. Ten seconds was used as a threshold as for the learning goals, review checklist, and other child disorders pages, as a typical reader could briefly assess each page’s content in that time and decide whether their curiosity had been satisfied (and thus move on) or whether the tool was of use for planning or monitoring purposes. This series of revised thresholds were used to recalculate a *Revised SRL tactics* using an equation analogous to that in Figure 3 was

calculated to produce an interval scale. When the revised predictor replaced the original in the regression model, it remains a significant predictor of posttest knowledge scores ($t [159] = 1.993, \beta = .152, p = .048$). This suggests that the finding that more SRL behaviors leads to higher post-test knowledge scores appears to be robust.

Table 15. Summary of Regression Models predicting Posttest Knowledge Scores

Variable (DV = posttest knowledge score ²)	Model 0				Model 1				Model 1a			
	B	SE B	β	P	B	SE B	β	P	B	SE B	β	p
textbase pretest score ²	0.567	0.269	0.161	0.034*	2.075	0.833	0.194	.014*	0.717	0.271	0.200	0.009*
situation model pretest score ²	2.184	.811	0.186	0.08*	0.754	0.275	0.210	.007*	2.598	0.822	0.243	0.002*
SRL tactics	15.604	5.316	0.223	0.004*								
Usehigh (threshold = 2)					40.214	16.555	0.195	.016*				
Truenotetaker (threshold = 2)					-7.708	27.446	-0.022	.779				
Userev (threshold = 2)					-13.136	19.441	-0.056	.500				
Vterms (threshold = 2)					-4.168	16.761	-0.019	.804				
vLG (for 10 or more seconds)					28.647	21.392	0.104	.183				
vCheck (for 10 or more seconds)					13.191	16.660	0.063	.430				
AvOffTask (for 10 or less seconds)					-77.677	48.517	-0.121	.111				
number of notes created									-6.915	3.918	-0.134	0.080
words per highlights									1.198	1.385	0.082	0.388
number of highlights created									0.788	0.859	0.088	0.360
UseHighXTotalPre												
SRL self-efficacy score												
Performance Approach Score												
Performance Avoidance Score												
Mastery Approach Score												
Mastery Avoidance Score												
Intrinsic Motivation Score												
age in months												
HE semesters complete												
F (df) = , p	(3, 159)	9.807	p <.001		(9,159)	3.730	p <.001		(5,159)	5.324	p <.001	
R ²		15.9%				18.3%				14.7%		

Table 15. (continued)

variable	Model 2				Model 3				Model 4			
	B	SE B	β	<i>p</i>	B	SE B	β	<i>p</i>	B	SE B	β	<i>p</i>
textbase pretest score ²	1.524	0.335	0.424	0.000*	1.480	0.345	0.412	0.000*	1.582	0.334	0.441	0.000*
situation model pretest score ²	4.632	0.978	0.433	0.000*	4.681	1.028	0.438	0.000*	4.574	0.986	0.428	0.000*
SRL tactics												
Usehigh	279.636	65.291	1.353	0.000*	262.538	67.897	1.271	0.000*	273.847	65.319	1.325	0.000*
Truenotetaker												
Userev												
Vterms												
vLG												
vCheck												
AvOffTask												
number of notes created												
words per highlights												
number of highlights created												
UseHighXTotalPre	-22.412	5.848	-1.281	0.00*	-21.203	6.016	-1.212	0.001*	-21.830	5.848	-1.247	0.000*
SRL self-efficacy score					-1.601	1.224	-0.101	0.193				
Performance Approach Score					2.704	2.464	0.117	0.274				
Performance Avoidance Score					-6.338	2.645	-0.293	0.018*	-4.300	2.056	-0.199	0.038*
Mastery Approach Score					0.020	2.447	0.001	0.994				
Mastery Avoidance Score					4.471	2.047	0.225	0.031*	3.531	1.877	0.178	0.062
Intrinsic Motivation Score					-1.796	8.394	-0.018	0.831				
age in months					-0.237	0.181	-0.103	0.192				
HE semesters complete					1.183	4.362	0.021	0.787				
F (<i>df</i>), <i>p</i>	(4, 159)	10.681 <i>p</i> <.001			(12,159)	4.348 <i>p</i> <.001			(6,159)	8.057 <i>p</i> <.001		
<i>R</i> ²		21.6%				26.2%				24.0%		

Research Question 2

Findings in research question two demonstrate that the use of multiple SRL tactics predicts increases in posttest knowledge scores. To test the hypothesis that the use of *specific* classes of SRL tactics would predict increases in posttest knowledge scores, each dichotomous variable from Table 4 was entered into a regression equation. These seven dichotomous predictors were used to represent the learner's tendency to use the highlighter, make notes, use the information panel to review, seek further knowledge on terms pages, conduct planning using the learning goals page, monitor understanding using the review checklist node, and avoid off task behaviors by not visiting off topic pages. When transformed posttest knowledge scores were regressed on these predictors, the overall model was significant ($F [9,159] = 5.067, p < .001$); however, the only individual predictor that was significant was the *use of the highlighter* ($t = 2.429, p = .016$). After controlling for pretest textbase and situation model scores, highlighting significantly predicted posttest knowledge scores, transformed posttest knowledge scores, and when using the more conservative threshold of two highlights made to indicate use. Those who used the highlighter were predicted to scores 2.51 points higher on the posttest than those who do not. Statistics for each predictor in the original model appear under Model 1 in Table 15. Examining the effect of highlighting on textbase and situation model knowledge scores, two regression equations indicate that highlighting significantly predicted higher posttest textbase knowledge scores ($t = 2.531, \beta = .188, p = .012$) as well as situation model knowledge scores ($t = 2.007, \beta = .154, p = .046$), after controlling for the effect of textbase and situation model prior knowledge, respectively.

In Chapter 2, I specifically hypothesized that: (a) participants who made notes with original content would gain more knowledge than those who do not make notes, (b) those who make more strategic highlights (as evidenced by fewer words per highlight), would gain more knowledge than those who use the highlighter more liberally and c) that while the ability to cut and paste notes is theorized to lead to superficial processing (Bauer & Koedinger, 2006) that should not improve knowledge acquisition, students who utilized the highlighter would gain more knowledge than those who did not. To test these three hypotheses, posttest knowledge scores were regressed on the two prior knowledge scores (textbase and situation model) and variables representing number of notes created (truenumnotes), the average word count of highlights (wordspershigh) and number of highlights (numhighs). None of these variables were significant predictors of posttest knowledge scores. A summary of the analysis appears as Model 1a in Table 15.

Research Question 3

Prior research (e.g., Moos & Azevedo, 2008) suggests that learners' level of prior knowledge influences their use of tactics when learning in CBLEs. I hypothesized that learners who possess higher amounts of prior knowledge will utilize tools differently than those with less prior knowledge. Specifically, I expected that pretest scores would be inversely related to highlighting (because participants presumably do not need to focus on the textbase of the passage) but unrelated to traces of note taking (as this supports the making of inferences and comprehension of the situation model). A correlation matrix that documents the relationship between frequency and time variables for each SRL tactic

(see Table 4) and measures of prior knowledge and posttest knowledge appears in Table 16.

No significant relationship was found between the number of highlights ($r [160] = .052, p = .515$) or notes ($r [160] = .104, p = .190$) made with overall pretest scores. This suggests that the level of prior knowledge one possesses going into a learning task is unlikely to influence the tendency to use marking tools, at least in this experimental context. This finding disconfirms my belief that students with high prior knowledge may be less likely to use a highlighter. However, two other SRL tactics were associated with prior knowledge. It is important to Learners with higher prior knowledge also spent less time on the off topic node, "Other Interesting Childhood Disorders," than those with lower prior knowledge ($r [160] = -.188, p = .017$). This may suggest that knowing more about a topic at pretest may help one to stay focused and not be distracted by information that is not germane to the learning task. However, this relationship may also be influenced by higher prior knowledge learners' tendency to be performance oriented, or less curious. An exploratory analyses regressing seconds spent on the Other Disorders page on pretest scores, performance approach, performance avoidance, self-efficacy to SRL and intrinsic motivation was non-significant and yielded no significant predictors.

Table 16. Correlation Matrix of Traced SRL Tactics Predicting Posttest Knowledge

		Total			Total		
		TB pre	SM pre	pre	TB post	SM post	post
total number of visits to learning goals page	<i>R</i>	.223**	.146	.244**	.148	.163*	.175*
	<i>P</i>	.005	.066	.002	.063	.039	.027
lg total time	<i>R</i>	.092	.098	.121	.114	.257**	.192*
	<i>P</i>	.246	.217	.128	.153	.001	.015
total number of visits to checklist page	<i>R</i>	.042	.175*	.123	.145	.178*	.180*
	<i>P</i>	.601	.027	.121	.067	.024	.023
check total time	<i>R</i>	.062	.027	.061	.145	.085	.139
	<i>P</i>	.434	.737	.444	.067	.288	.079
Combined number of visits to LG + Check pages	<i>R</i>	.141	.173*	.196*	.157*	.183*	.191*
	<i>P</i>	.076	.029	.013	.047	.020	.016
Combined seconds at Learning Goals + Check page	<i>R</i>	.087	.056	.095	.171*	.160*	.190*
	<i>P</i>	.273	.481	.232	.031	.043	.016

Table 16. (continued)

number of highlights created	<i>R</i>	-.008	.111	.052	.114	.185*	.161*
	<i>P</i>	.915	.161	.515	.153	.019	.043
number of annotated notes created	<i>R</i>	.056	.057	.072	.071	.027	.062
	<i>P</i>	.481	.462	.364	.375	.734	.439
number of total clicks in information panel	<i>R</i>	.008	.040	.027	.025	-.065	-.010
	<i>P</i>	.923	.616	.738	.749	.417	.899
total visits to terms pages	<i>R</i>	.062	.104	.101	.041	.056	.053
	<i>P</i>	.436	.189	.202	.607	.484	.504
terms total time	<i>R</i>	.045	.076	.073	.014	.072	.041
	<i>P</i>	.576	.342	.358	.862	.368	.607
total visits to other page	<i>R</i>	-.022	.093	.032	.049	-.082	-.001
	<i>P</i>	.784	.243	.686	.541	.302	.986
other total time	<i>R</i>	-.188*	.024	-.130	.073	.030	.065
	<i>P</i>	.017	.768	.103	.359	.702	.416

To review, results indicate no significant relationships between posttest knowledge and learner's achievement goal orientations. However, prior knowledge and a

learner's tendency to enact SRL tactics are significant predictors of posttest knowledge scores. Among individual SRL tactics measured, the use of a highlighting tool significantly predicted knowledge posttest knowledge scores. Note taking, use of an indexed information panel to review traces of highlighting and note taking, use of a review page to monitor understanding, clicking on linked terms to obtain definitions, use of a learning goals page and limiting time spent on off-task pages did not significantly predict post-test knowledge scores. I next conducted a series of supplemental analyses to further investigate how these predictors of posttest knowledge effect scores of different types of learners and develop more complex models to

Research Question 4

Goal orientation and SRL behaviors

Based on the findings of Nesbit and colleagues (2006) I hypothesized that: (a) students who are more mastery oriented (both approach and avoidance) will highlight less often and (b) they would be more likely to write more original notes.

I attempted to replicate the findings of Nesbit and colleagues across correlations, canonical correlations, and regression analyses and obtained mixed results. Recall that scores on mastery approach and avoidance and performance approach and avoidance were based on a set of 12 items (3 each) and could range from one to five (higher scores mean stronger orientation).

Results of bivariate correlations of highlighting and mastery orientations (approach, avoidance) indicated no significant correlations between the number of highlights made with either mastery approach ($r [160] = .093, p = .244$) or mastery

avoidance ($r [160] = -.040, p = .620$) goal orientation scores. So, it was not the case that students self-reported mastery orientation scores were inversely associated with likelihood to make highlights, as was found by Nesbit and colleagues (2006). To further illustrate the lack of difference in number of highlights made between high and low scorers on achievement goal orientation scales, learners were trichotomized by their orientation score (split at 33rd and 66th percentile) into high middle and low groups. Group means for number of highlights were calculated and appear in Table 17. The number of highlights that high and low groups made were non-significantly different on each variable when tested using a one-way ANOVA and a post-hoc Scheffe test, further confirming that goal orientation scores are unrelated to patterns of highlighting.

Table 17. Mean Mastery and Performance Orientation Scores and Corresponding Highlights Made

Group		number of highlights	SD
Mastery Approach	High	9.06	10.48
	Low	8.21	10.50
Mastery Avoidance	High	10.02	10.59
	Low	9.72	11.39
Performance Approach	High	10.30	11.01
	Low	11.62	12.18
Performance Avoidance	High	9.66	10.31
	Low	11.55	11.18

Note. High and Low groups are individuals falling above the 66th and below the 33rd percentile, respectively. For each group, $n = 53$

The number of notes taken by participants was highly skewed as described in the preliminary analyses. Bivariate correlations between the number of notes taken and mastery approach ($r [160] = -.125, p = .115$) and mastery avoidance ($r [160] = .092, p = .245$) were also non significant, though the limited notes learners took in this task seem an insufficient base to draw conclusions. While I found no relationship between highlighting and mastery approach or mastery avoidance, I did confirm Nesbit and colleagues' finding that performance avoidance scores were marginally and negatively correlated ($r [160] = -.139, p = .08$) with word productivity (log 10 transformation of total number of words in all notes). While this was derived from a very limited number of notes ($n = 27$ across 160 learners), there does seem to be some tentative evidence that students who strive to avoid performing poorly were less likely to write detailed notes.

A set of canonical correlations was calculated between the four goal orientation variables and the four learning activities chosen by Nesbit and colleagues (time invested in CBLE, number of highlights, number of notes, number of words selected). With all four parts of canonical variates included, no statistically significant relationship was detected. As a result, no interpretation can be made regarding learners' goal orientation scores as predictive of any set of tendencies to conduct learning activities as they were measured here.

Next, these variables were then modeled as predictors of the seven dependent variables created by Nesbit and colleagues (time invested, the number of highlights made and notes taken, word entered, highlight and note rates, and word productivity). Nesbit and colleagues found no explanatory variable to be a significant predictor of any criterion

variable. In this study, I found mastery approach scores were marginal and positive predictors of time invested ($\beta = .164, t = 1.74, p = .084$) and the number of highlights recorded ($\beta = .178, t = 1.89, p = .061$). No other orientation scores predicted any dependent variable. A correlation matrix between goal orientations and highlighting variables can be found in Table 18 and a further treatment of these findings follows in the discussion section.

Achievement goals and knowledge acquisition

In terms of achievement goals, I also hypothesized that mastery orientation should correlate positively with knowledge acquisition scores. A bivariate correlation between mastery orientation scores and posttest knowledge scores indicated no significant relationship between total knowledge and mastery approach [$r(160) = -.021, p = .789$] or mastery avoidance scores [$r(160) = .047, p = .557$]. A correlation matrix between goal orientations and highlighting variables can be found in Table 18. These results were consistent for correlations between transformed posttest knowledge scores with both mastery approach ($r[160] = -.027, p = .735$) and mastery avoidance ($r[160] = .000, p = .995$).

In sum, I was unable to fully confirm the findings of Nesbit and colleagues (2006) in this study and I failed to support my hypothesis that mastery goal orientations would be associated with higher posttest knowledge scores. Achievement goal orientation scores were not consistently related to the tendency to make highlights, or to differences in knowledge scores.

Table 18. Correlation of Achievement Goal Orientations with Note Taking and Highlighting and with Knowledge Scores ($N = 160$)

Achievement Goal Orientation	number of notes	number of highlights	Textbase Posttest Score	Situation Model Posttest Score	Total Posttest Score
	r (p)	r (p)	r (p)	r (p)	r (p)
Performance Approach Score	.019 (.807)	-.057 (.471)	-.018 (.817)	-.108 (.175)	-.060 (.452)
Performance Avoidance Score	.046 (.567)	-.024 (.763)	-.142(.072)	-.089 (.264)	-.139(.079)
Mastery Approach Score	.026 (.740)	.093 (.244)	.012 (.877)	-.069(.387)	-.021(.789)
Mastery Avoidance Score	-.012 (.884)	-.040 (.620)	-.028 (.729)	-.063(.431)	.047(.557)
Mastery	.005 (.946)	.020(.805)	-.012(.877)	-.076 (.339)	-.042(.600)
Performance	.036 (.655)	-.043 (.585)	-.089 (.263)	-.106 (.183)	-.109 (.171)

Supplemental Analyses

The purpose of this study was to determine how prior knowledge and self-regulated learning affect knowledge acquisition, and whether SRL tactics are differently beneficial for different types of learners. To this end, a series of three follow-up analyses was conducted to further investigate significant findings and to support recommendations for hypertext use for individual learners based upon their characteristics.

First, a model was created to determine how the enactment of SRL tactics interacts with prior knowledge to determine if tactics were differentially effective for high versus low prior knowledge learners. Second, I examined the relationship between knowledge scores and other learner variables including self-reported tendency toward self-regulation, self-efficacy for self regulated learning, and intrinsic motivation to determine if these characteristics had additional effects on knowledge scores at posttest. Lastly, I combined SRL tactics and learner characteristics to specify a final model that predicts the greatest amount of variance in posttest scores.

The interaction of SRL tactics and prior knowledge

The enactment of SRL tactics, including use of a highlighter was found to affect knowledge scores in the learning task. Is this tool differently effective for high versus low prior knowledge learners? An additional regression analysis was conducted to determine if the interactions of Highlighter use by Total pretest score had a significant effect above and beyond the effect of highlighting individually. The results of this analysis showed that the interaction was significant and negative, meaning that use of the highlighter tool was more beneficial for lower knowledge learners than higher prior knowledge learners. For each additional point earned on their pretest textbase scores, learners were predicted

to increase their total posttest score by 1.225 points and for each additional SM point on the pretest, posttest scores were predicted to increase by 2.152 points. Use of the highlighter predicted an increase of 16 points for all learners, but this was decreased by 2.176 points for each additional point earned on the pretest. As such, highlighting was beneficial for all learners, but was more beneficial for those learners with lower levels of prior knowledge. Collectively, these predictors explain 21.6% of variance in posttest scores. A summary of this model appears as Model 2 in Table 15.

Additional predictors of post test knowledge

As discussed in Chapter 2, characteristics of the learner have been associated with SRL and knowledge acquisition in CBLEs including self-efficacy (Moos & Azevedo, 2009; Usher and Pajares, 2008), achievement goal orientation (Nesbit et al. 2006) and intrinsic motivation to complete a task (Boekaerts & Niemivirta, 2000). In order to determine the effect of these factors on SRL and post test knowledge scores after this task, participants completed the Achievement Goal Orientation Questionnaire Revised (Elliot & Murayama, 2008), an Intrinsic Motivation Scale (Elliot & Church, 1997), and a measure of self-efficacy for self-regulated learning (Usher & Pajares, 2006). The correlation between each of these scales with posttest knowledge and each self-regulated learning behavior was analyzed. The correlation matrix is presented in Table 19. Significant correlations are denoted with an asterisk and p -values both significant and marginally significant correlations are included in parentheses.

Learners' intrinsic motivation score was positively correlated to their tendency to use the highlighter ($r [160] = .179, p = .024$). This should be considered in combination

with Nesbit and colleagues (2006) finding that mastery orientations were associated with lower levels of highlighting, and this studies failure to confirm this inverse correlation. The relationship between these motivational constructs is explored in the discussion.

Table 19. Correlation of Learner Variables with Traced SRL Behaviors ($N = 160$).

	SRL			Sems	
	Self- efficacy	Intrinsic Motivation	Age	GPA	of college
number of visits to learning goals page	.048	.097	-.092	-.102	.063
number of visits to checklist page	.073	.121	.033	-.076	.013
Freqscaffolds	.065	.118	-.031	-.095	.040
number of highlights created	.005	.179 ^a	-.177 ^b	.009	-.117
number of notes created	.110	-.011	-.058	.128	-.158 ^c
number of total clicks in review panel	-.033	-.034	-.044	.110	-.039
number of visits to terms pages	.075	.117	.209 ^d	.083	.001
number of visits to other page	.015	.094	-.007	-.020	.026
other total time	-.121	.038	.096	-.082	.047

Note. ^a $p = .024$; ^b $p = .025$; ^c $p = .046$; ^d $p = .008$.

Some of these learner variables correlate to traces of SRL behaviors, which in turn were significant predictors of post-test knowledge scores. As a result, these learner characteristics should be tested to determine whether their inclusion in a regression model improves its ability to predict posttest knowledge scores.

Building a final model to explain variance in knowledge acquisition

The ultimate goal of this project was to determine what factors would influence knowledge gain in a computer-based learning task. A series of regression analyses have already been conducted that identify sets of variables and interactions that significantly predict posttest knowledge scores. These models appear in Table 15. In Model 0, prior knowledge scores were found to be significant predictors of posttest knowledge, as was the tendency to enact SRL tactics. When SRL tactics were disaggregated in Model 1, highlighter use and use of the review checklist were found to be significant and marginally significant predictors, respectively. Model 2 included interaction terms that multiplied these SRL tactics by prior knowledge scores, resulting in products that were negative predictors of posttest knowledge scores.

To determine the effect of these learner characteristics on knowledge acquisition, self efficacy scores, intrinsic motivation scores, and all four AGO scores were added to Model 2 as potential additional predictors, as were age and semesters of college experience. As can be seen in Table 15, when these variables are incorporated into one model (Model 3), prior knowledge, SRL tactics and their interactions remain significant predictors of posttest knowledge. Mastery avoidance (positive) and performance avoidance (negative) orientation scores also significantly predict posttest knowledge scores. The inclusion of these additional significant predictors in Model 3 predicted 26.2% of the variance in posttest knowledge scores, an increase (ΔR^2) of 4.6% compared to Model 2. However, the addition of these 8 predictors in Model 3 is not justified by the change in F statistic ($\Delta F = 6.333$). This suggests the parsimonious model (Model 2) has

better fit and should be retained. When all affective and demographic variables that were not significant predictors were removed, the new model; (Model 4 in Table 15) predicted 24.0% of the variance while sacrificing only 2 degrees of freedom. This combination of change in R^2 ($\Delta R^2 = 2.4\%$; Model 2 to Model 4) and F statistics ($\Delta F = 2.624$, $p > .05$) suggests that the increased amount of variance explained by this model is warranted given the non-significant change in F statistic (critical value for $F [2,159] = 3.05$). As a result, Model 4 should be accepted as the final model. Twenty-four percent of the variance in posttest knowledge scores could be explained by learners pretest scores on textbase and situation model subtests, tendency to use the highlighter and performance avoidance and mastery avoidance scores.

A confirmatory factor analysis was conducted to further explore the relationship between items on the achievement goals, self-efficacy and intrinsic motivation scales. Results of the analysis including all questionnaire items confirmed that each item loaded strongest on its respective scale or subscale. This indicated that the scales and subscales were reliable for this sample, and ultimately provided no additional insight to influence the interpretation of findings relating to master and performance avoidance.

One final analysis was conducted to determine if the setting in which the participants completed the learning task effected their process or outcome. In the study, 88 participants completed the task privately, during a scheduled appointment. The remainder ($n = 72$) completed sessions within a class session at a computer lab. These environments differed in terms of the level of supervision by the researcher, the presence of others conducting the same task, among other factors. A series of t-tests found that

session setting had no significant effect on pretest or posttest knowledge scores, the amount of time spent on the task, or goal orientation or self-efficacy scores. However, the setting did influence learners' intrinsic motivation score ($t [158] = 2.952, p = .004$) as, well as tendency to review annotations. Mean scores on the intrinsic motivation scale were 4.57 for learners in the group setting and 4.11 for those who completed the task in a private session. Learners in the group setting made more use of the information panel to review their annotations of the text ($t [158] = 2.675, p = .008$). Highlighting behavior was unaffected by setting, and setting was a non-significant predictor of post-test knowledge when added to the models in Table 17.

CHAPTER 5

DISCUSSION

Summary of findings

This study examined the relationships between learner characteristics and prior knowledge, the enactment of SRL tactics, and achievement in a hypertext learning task. Research questions examined whether learner characteristics including prior knowledge, achievement goal orientation, intrinsic motivation, and self-efficacy to self-regulate learning were associated with self-regulated learning and with post-test knowledge scores. After accounting for the effect of pretest scores, the use of multiple classes of self-regulated learning behavior while learning from a hypertext environment was a significant predictor of posttest knowledge scores. When SRL behaviors were disaggregated, the tendency to highlight was found to predict posttest knowledge scores, as was an interaction between highlighting and pretest score, where increases in pretest score limit the effect of highlighting on posttest knowledge scores. Mastery avoidance and performance avoidance scores were also significant predictors of posttest knowledge scores when included in a model with pretest scores, highlighting behavior and interactions between prior knowledge and highlighting. Achievement goal orientation scores were found to be non-significantly related to SRL behaviors including highlighting, which conflicts with previous findings by Nesbit and colleagues (2006). I next explore the meaning of each of these findings, relate it to prior research and suggest potential theoretical implications below.

Self-Regulated Learning Behaviors

In this study, learners who employed multiple classes of SRL behaviors tended to score higher on the post-test than those who used fewer classes of SRL behaviors. When aggregated into an interval variable, this finding demonstrates that learners benefit from employing multiple SRL tactics in a hypertext learning task. Taken in concert with the primarily non-significant results for the model (Model 2) which disaggregates SRL tactics, this suggests that each SRL tactic may be beneficial to an individual, even if it is not consistently beneficial across all individuals. These findings were consistent when a more stringent threshold to determining use was employed, which implies that the finding is robust.

While previous studies (Greene & Azevedo, 2009, Moos & Azevedo, 2008a; Moos & Azevedo, 2008b, Moos & Azevedo, 2008c) have primarily focused on the frequency of SRL behaviors as predictors of knowledge acquisition, findings from this study underscore that the breadth of different SRL tactics employed may also be important. Prior research has shown that the employing specific macro-level SRL behaviors (e.g. monitoring; Greene & Azevedo, 2009) leads to more sophisticated understanding of the content of a hypermedia environment, and suggest that particular SRL behaviors are more often employed by different types of learners (e.g. rehearsal for low prior knowledge learners and monitoring for high prior knowledge learners; Moos & Azevedo, 2008b). A prominent theory of self-regulated learning (Winne & Hadwin, 1998), however, suggests that learners select the tactics they believe are most likely to lead to attainment of their goals, employ these tactics and monitor progress towards

goals. Learners may choose to employ a variety of tactics, or to employ individual tactics multiple times, depending upon the task conditions. Accordingly, it makes sense measure the frequency with which a tactic is employed to gauge its effectiveness for particular learning goals, but data should also be collected on the variety, combinations, and potentially, order of tactics that are employed and support goal attainment (in this case, knowledge acquisition). Recent evidence (Moos, 2010) points to the limitations of repeated use of the same SRL tactics. When learners employ monitoring tactics with great frequency, they are more likely to score higher on posttests than those who monitor sparingly. However, posttest knowledge scores are non-significantly different between those who employ high and intermediate amounts of monitoring behavior. This suggests that, while individual micro- and macro-level SRL processes are important predictors of knowledge acquisition, each has a limit to its usefulness. When that limit is reached and additional knowledge remains for the learner to acquire, learners must be flexible in their self-regulation process and switch to another tactic which might support about knowledge acquisition. Measurement of the number of classes of SRL behavior in this study was conducted using dichotomous scoring using liberal and conservative thresholds. Additional studies might combine this method of identifying a multiplicity of SRL behaviors employed and also assess the frequency of employment, to determine what combinations lead to greatest levels of knowledge acquisition. Moos (2010) attempts this, to an extent, using an accumulative logistic regression model.

Highlighting

Regression analyses identified use of the highlighter as a significant predictor of posttest knowledge, and an interaction between highlighting and pretest score where increases in pretest score limit the effect of highlighting on posttest knowledge scores. These findings stand in contrast to those by Bauer and Koedinger (2006) who studied the effects of cut-and-paste functionality on annotation behavior and knowledge acquisition when using hypertext. While having the option to cut-and-paste text into a notebook (instead of manually transcribing them) changed the quality and quantity of annotations, differences in these behaviors did not, lead to differences in post-test knowledge scores immediately after the learning task.

Based on their findings, Bauer and Koedinger (2006) arrived at the conclusion that learners who use a cut-and-paste tool experience diminished processing benefits as the tool changes the way the learner reads the text. Because cut-and-paste ability speeds transcription, it diminishes the cost of recording notes and allows learners to process text at a more superficial level, and to record more notes without regard for the precision of their content. They term this belief the “attention hypothesis.” One would expect this attention hypothesis to hold true when learners are given a highlighting tool that can be used in the same manner as a cut-and-paste tool to select and record identified selections of text. However, in this study, use of the tool was found to support learning, as evidenced by posttest scores. The differences in findings may stem from the difficulty of the material being studied, or perhaps the level of understanding required in order to answer items correctly on the knowledge measures.

In this study, the learning task was short and fairly simple. The reading passage was short (roughly two textbook pages), and the posttest was comprised primarily of items testing textbase level comprehension. Highlighting, though described by Bauer and Koedinger as superficial, was an appropriate tactic to support learning as defined in this context. This is evidence that those students who successfully considered task conditions and chose a tactic which matched the task demands, both important self-regulated learning behaviors identified by Winne and Hadwin (1998) and captured in think-aloud protocols, did score higher on the posttest when controlling for their pretest score. As such, a superficial tactic like highlighting may not support deeper learning goals on its own, but for those who seek to increase their understanding of the textbase of a reading passage, it is an appropriate and effective tool. This is evidenced by differences in posttest textbase knowledge scores for those who did and did not employ the highlighter while completing the learning task. Further, the strategic use of the tool (and arguably, evidence of additional self-regulation of learning behaviors) leads to greater gains in textbase knowledge. While this type of knowledge is unlikely to lead to deeper understanding of a reading passage, comprehension of the textbase is an imperative to understanding the situation model of a passage (Kintsch, 1998) and is an important, if early, step towards deeper and more robust learning. As such, including a highlighter as a tool for the study of hypertext seems to be a good idea for hypertext designers.

Achievement goal orientations

Achievement Goals and SRL Behavior

Results from this study indicate that highlighting behavior is not significantly associated with mastery orientations as measured by the *Achievement Goal Questionnaire – Revised* (Elliot & Murayama, 2008). This finding conflicts with results from a similar study by Nesbit and colleagues (2006) which traced undergraduates' behaviors using gStudy while they studied a chapter in an educational psychology course. These conflicting findings may be due to differences in task conditions including task complexity, and level of pressure caused by the learning goals given to participants.

The samples in both studies were primarily Caucasian female undergraduates studying educational psychology (though majors differed; liberal arts versus education), and both studies employed a CBLE with similar features. The achievement goal measures differed slightly (*Achievement Goal Questionnaire*; Elliot & McGregor, 2001 versus *Achievement Goal Questionnaire–Revised*; Elliot & Murayama, 2008), though they contained similar items and the same four-construct design. Identical traces of behavior were recorded and statistics were calculated using the same methods. A difference in sample size is rendered unimportant as the significant correlations in question were found in the smaller and not the larger sample. What remains, then, is a learning task that differed in content, magnitude, complexity and task value.

In the first task, learners studied a textbook chapter on memory that was assigned reading in a course. They tended to log 90 minutes of study across multiple sessions. In the second task, the content was equivalent to a two page reading on Attention Deficit

Hyperactivity Disorder (ADHD), from a lifespan development textbook. Learners studied for no more than 20 minutes in a single session. In addition to differences in topic and length, a full textbook chapter is likely a more complex passage as multiple ideas tend to be connected to an overarching topic. For instance, notes referenced by Nesbit and colleagues are linked to long-term memory and serial position effect, which both relate to the chapter topic of memory. In the second task, subtopics including symptoms, origins and treatment relate to the topic of ADHD, but are treated in far less detail. Lastly, learners should have placed higher value on the learning task that was part of a course and on that they would be tested. Task value was not reported by Nesbit and colleagues and was not assessed in this study.

Despite these differences in task structure, achievement orientation scores were similar, suggesting students approached the task with similar intentions regarding mastery and performance. The nature of these two learning tasks, however, led to differences in students' use of tools. Compared to learning in the first task, which was presumably assessed by some of the 60 items on the final exam, learning in the second task was assessed at a much finer granularity. It was unlikely that an idea summarized in a sentence in the memory chapter would be the basis of an item on the final exam, but in a two-page reading assessed with 16 multiple choice items, the likelihood of a sentence being the basis of an item was considerably higher. As a result, highlighting was a more advantageous strategy in the smaller task, while in the larger task, elaborative notes connecting smaller ideas were more likely to capture the germane content in the chapter.

From these results, we can conclude that learners' achievement orientation remains constant across learning tasks, but their enactment of SRL tactics reflects a consideration of task conditions. These findings are consistent with an early meta-analysis of goal orientation and achievement by Utman (1997), who found that individuals with learning goals were more likely to gain knowledge than those with performance goals, but that this difference held true in complex learning tasks but was diminished in simpler ones. This effect was also stronger in situations where learning goals were moderately pressuring. It makes sense that in this task (which was short, relatively simple and had no direct connection to course curriculum) that no relationship between goal orientation and achievement was found. I now turn my attention to the effect of highlighting and note taking on knowledge acquisition in a computer-based learning task.

Achievement Goals and Knowledge Scores

While Nesbit and colleagues (2006) did not examine the relationship between achievement goal orientations and knowledge acquisition, it was anticipated that learners' goal orientation would affect not only their learning process, but their outcomes as well. Mastery avoidance and performance avoidance scores were significant predictors of posttest knowledge scores when included in a model with pretest scores, highlighting behavior and interactions between prior knowledge and highlighting. After accounting for the effect of pretest knowledge scores, highlighter use, performance avoidance orientation scores and mastery avoidance orientation scores predicted posttest knowledge scores. Using the language from Dweck's (1986) goal orientation theory,

learners' performance orientation indicates the degree to which they complete a task to obtain a positive performance. In terms of the avoidance dimension as measured by Elliot and Murayama's (2008) scale, learners endorse positively, items which state "My goal is to avoid performing poorly compared to others." Because this negatively predicts posttest knowledge, desiring to avoid a poor performance is an ineffective way to approach this learning task. According to Dweck, (1986) possession of a mastery orientation would suggest that learners complete a task in order to master its content or a skill. On the mastery avoidance orientation subscale (Elliot & Murayama, 2008), learners positively endorsed items such as "I am striving to avoid an incomplete understanding of the course material."

Both avoidance subscales highlight learners' tendency to avoid a negative outcome with respect to their learning or their performance. Learners who perform best in this task adopt an orientation where they intend to avoid missing out on some knowledge, and put little stock in out performing their peers. Taken collectively, this suggests that in a task which had no bearing on a grade and only a loose association with current course objectives, learners excel when they care little about their performance and approach the task with a degree of motivation to learn even if they do not intend to approach a mastery of the material.

Study Implications, Limitations and Future Directions

Implications for the design of CBLEs

This study shows that learners can successfully use highlighting tools to support their study of a reading passage and increase the knowledge they acquire. Additionally, it

provides evidence that students with higher levels of prior knowledge are more likely to use tools that can be used for monitoring understanding like review checklists and a list of learning objectives when they are provided. The use of these tools marginally predicts knowledge acquisition, suggesting that provision of such scaffolds can be useful for some, if not all learners.

Implications for instructors' and learners' use of CBLEs

While designers should take care to provide students with specific tools that are likely to enhance their knowledge acquisition, the characteristics learners possess going into a computer-based learning task have implications for their performance. While Nesbit and colleagues (2006) found goal orientation to predict highlighter use, this study did not. In this study, learners' intrinsic motivation predicted their use of the highlighter. This implies that learners' characteristics may influence performance differently depending upon the learning task they are presented. Instructors should be aware of the conditions of the learning tasks they present to students, and based on the nature of the task and related research findings, students should be prepared to assure the best fit between their motivational and affective characteristics and the task.

Limitations and Future Directions

The primary limitation of this study is the inclusion of only one learning task, which may have influenced learners' annotation behavior. Because the task was brief and relatively simple, findings do not generalize to more complex learning tasks or to learning tasks across disciplines. Despite design features aimed at tracing students' note

taking behaviors, learners in this task eschewed the note taking tool and used the highlighter almost exclusively. The learning task in this study was brief and learners demonstrated that they could master its content without using the notes tool. Additionally, the note taking tool itself was complex as it presented multiple fields in which to enter text, formatting options and options for designing templates of notes. These features may be beneficial for more complex and longer tasks where setting up different types of notes will facilitate more efficient note taking and review. In this task, however, they were unnecessary. As a result, the far more elaborate notes tool received little use, whereas a simple highlighter was utilized often. In a way, not using the note taking tool itself could be construed as an example of assessing task conditions, an element of self-regulation.

The tutorial that was presented to students seemed to be effective in teaching them how to use tools (many succeeded in practice), but did not convince them that the note taking tool was particularly beneficial to their studying. Given the simplicity of the task and the lack of pressure to perform well on the task, such avoidance of a complex tool may be appropriate. Future studies should be doubly certain that learners are aware of how tools work and the advantages to using them.

Future research that aims to investigate note taking tendencies and the benefit of such a tool should include a longer and more complex task and potentially study it in the context of a course to ensure that the value of completing the task increases the effort participants are willing to commit. It would also be useful to interview participants after they have finished and to ask them why they did or did not use particular tools.

In addition to these design issues, the generalizability of findings from this study is limited to other populations of undergraduate education students completing brief reading comprehension tasks in a hypertext environment. In order to be more certain that these findings generalize across disciplines and to tasks that are more time intensive and of greater complexity, this type of study should be replicated with additional samples, and with different types of learning tasks. Ideally, such replication would occur in more naturalistic settings. Additional analysis of these research questions should occur, but they should be tested with a larger, more complex learning task embedded in a course, as used by Nesbit and colleagues (2006). This would afford the opportunity to further analyze the influence of achievement goal orientations on both the enactment of SRL tactics, as well as on knowledge acquisition scores.

Additional research should also be conducted to determine how learners' individual characteristics predict their knowledge acquisition. Some higher knowledge learners appeared to learn less than lower knowledge learners as they achieved the maximum score, but could have gained knowledge not assessed by the test (though the variance remained high). This limited the conclusions that could be drawn about interactions between prior knowledge and tool use as they predict learning. Future studies should employ more challenging knowledge measures so that the mediating effect of prior knowledge on the benefits of highlighting can be confirmed.

Because data failed to confirm Nesbit and colleagues' (2006) finding that achievement goal orientation scores predicted a pattern of highlighting, future research should continue to examine this relationship and should expand investigation to include

additional learner characteristics which might explain conflicting results. This study found that learners' intrinsic motivation scores predicted their use of the highlighter, which supports the idea that learner's affective and motivational characteristics likely play a role in how they study and what learning results. If future researchers can more consistently and more precisely identify motivational constructs and other learner characteristics that effect enactment of SRL tactics, learning tasks can be designed to increase motivation or alter some learner characteristics so that learners are more likely to study in ways that support learning. It is possible that there were students who had a mastery orientation to college in general, but not to this specific task. Adding an achievement goal orientation measure which is specific to the learning task might demonstrate these differences.

A final opportunity for future research might include a mixed methods analysis that includes examination of the content of students' highlights in addition to their frequency. Bauer and Koedinger (2006) identified note takers' tendency to transcribe notes that were verbatim or abbreviated transcriptions or contained novel content. They also coded notes as representing ideas from the text and found that different task conditions like providing electronic versions of a document with and without cut-and-paste functionality influenced the proportion of types of notes. While this study examined only one electronic medium with highlighting functionality, a similar process could be conducted to determine if different approaches to using a highlighter would produce amounts of knowledge acquisition. Learners' highlights could be classified in terms of relatedness to a specific learning objective, relating to the situation model of the text, or

as extraneous to learning objectives. The frequency and quality of these highlights may bear a relationship to other measures of SRL, or result in different amounts of knowledge acquisition at the level of textbase and situation model comprehension. The lack of notes taken by learners in this study precludes analysis, but a parallel opportunity exists for note content. These more qualitative findings could qualify and enrich the quantitative findings of this study.

This and other studies have partially explained how learners operate in computer based learning environments, and have identified behaviors which are more and less likely to support learning. As classroom materials continue to be transitioned into computer-based formats, this growing body of knowledge can support the appropriate design and utilization of CBLEs for classroom learning. Recent findings underscore the importance of incorporating diagnostic tools to assess learners' level of prior knowledge, highlighting tools to support strategic reading, and scaffolds like review checklists to help students monitor their understanding. As additional design features which support learning are identified, educators will be further empowered to choose educational products that effectively support learning and enable teachers to maximize the amount of learning that occurs in their classrooms.

REFERENCES

- Azevedo, R. (2005). 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., & Seibert, D. (2004). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia? *Contemporary Educational Psychology, 29*(3), 344-370.
- 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), 87-111.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall, Inc.
- Bandura, A. (1991). Self-regulation of motivation through anticipatory and self-regulatory mechanisms. In R. A. Dienstbier (Ed.), *Perspectives on motivation: Nebraska symposium on motivation* (Vol. 38, pp. 69-164). Lincoln, NE: University of Nebraska Press.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

- Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. J. Pajares & Urdan, T. (Eds.), *Self efficacy beliefs of adolescents* (pp. 307-337). Greenwich, CT: Information Age Publishing.
- Barab, S. A., Bowdish, B. E., Young, M. F. & Owen, S. V. (1996). Understanding kiosk navigation: Using log files to capture hypermedia searches. *Instructional Science*, 24 (5), 377-395.
- Bauer, A. & Koedinger, K. (2006). Pasting and encoding: note taking in online courses. *Proceedings of the Sixth IEEE International Conference on Advanced Learning Technologies* (pp. 789-793).
- Baumeister, R. F., & Vohs, K. D. (2004). *Handbook of self-regulation: Research, theory, and applications*. New York, NY US: Guilford Press.
- Berk, L. E. (2006). *Development through the lifespan*. Boston, MA: Pearson
- 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, M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation*. (pp. 417-450). San Diego, CA US: Academic Press.
- Boekaerts, M., Pintrich, P. R., & Zeidner, M. (2000). *Handbook of self-regulation*. San Diego, CA US: Academic Press.
- Bråten, I. & Samuelstuen, M.S. (2007). Measuring strategic processing: comparing task-specific self-reports to traces. *Metacognition and Learning*, 2 (1), 1-20.
- Byrnes, J.P. & Guthrie, J.T. (1992). Prior conceptual knowledge and textbook search. *Contemporary Educational Psychology*, 17, 8-29.

- Calisir, F., & Gurel, Z. (2003). Influence of text structure and prior knowledge of the learner on reading comprehension, browsing and perceived control. *Computers in Human Behavior, 19*(2), 135-145.
- Chen, C. & Rada, R. (1996). Interacting with hypertext: A meta-analysis of experimental studies. *Human-Computer Interaction, 11*, 125-156.
- Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*(1), 155-159.
- Coiro, J., & Dobler, E. (2007). Exploring the online reading comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet. *Reading Research Quarterly, 42*(2), 214-257.
- Conroy, D. E. (2001). Progress in the development of a multidimensional measure of fear of failure: The Performance Failure Appraisal Inventory (PFAI). *Anxiety, Stress, and Coping: An International Journal, 14*, 431-452.
- Covington, M. V., & Roberts, B. W. (1994). Self-worth and college achievement: Motivational and personality correlates. In P. R. Pintrich, D. R. Brown & C. E. Weinstein (Eds.), *Student motivation, cognition, and learning: Essays in honor of Wilbert J. McKeachie*. (pp. 157-187). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Cromley, J. G., & Azevedo, R. (2009, August). *Measuring strategy use in context with multiple choice items*. Paper presented at the Biennial Meeting of the European Association for Research on Learning and Instruction, Amsterdam.
- Dweck, C. (1986). Motivational processes affecting learning. *American Psychologist, 41*, 1040-1048.

- Elliot, A. J., & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 72*(1), 218-232.
- Elliot, A. J., & McGregor, H. A. (2001). A 2 X 2 achievement goal framework. *Journal of Personality and Social Psychology, 80*(3), 501-519.
- Elliot, A. J., & Murayama, K. (2008). On the measurement of achievement goals: Critique, illustration, and application. *Journal of Educational Psychology, 100*(3), 613-628.
- Ericsson, K. A., & Lehmann, A. C. (1996). Expert and exceptional performance: Evidence of maximal adaptation to task constraints. *Annual Review of Psychology, 47*, 273-305.
- Ericsson, K. A., & Simon, H. A. (1984). *Protocol analysis: Verbal reports as data*. Cambridge, MA US: The MIT Press.
- Faul, F., Erdfelder, E., Lang, A., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.
- Greene, J. A., & Azevedo, R. (2009). A macro-level analysis of SRL processes and their relations to the acquisition of a sophisticated mental model of a complex system. *Contemporary Educational Psychology, 34*(1), 18-29.
- Hadwin, A. F., Nesbit, J. C., Jamieson-Noel, D., Code, J., & Winne, P. H. (2007). Examining trace data to explore self-regulated learning. *Metacognition and Learning, 2*(2), 107-124.

- Heyman, G. D., & Dweck, C. S. (1998). Children's thinking about traits: Implications for judgments of the self and others. *Child Development, 69*(2), 391-403.
- Howard-Rose, D., & Winne, P. H. (1993). Measuring component and sets of cognitive processes in self-regulated learning. *Journal of Educational Psychology, 85*(4), 591-604.
- Jonassen, D. H. (2004). *Handbook of Research on Educational Communication and Technology*. Mahwah, NJ: Lawrence Earlbaum Associates.
- K-12 Computing BluePrint. (2010) Sister Sites and Partners of Interest. Online. Retrieved April 18, 2010 from <http://www.k12blueprint.com/k12/blueprint/resources.php?menu=resources>
- Kiewra, K.A. & DuBois. (1991). Note-taking functions and techniques. *Journal of Educational Psychology, 83*(2), 240-245.
- Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York, NY US: Cambridge University Press.
- Kuncel, N. R., Credé, M., & Thomas, L. L. (2005). The validity of self-reported grade point averages, class ranks, and test scores: A meta-analysis and review of the literature. *Review of Educational Research, 75*(1), 63-82.
- Lawless, K. A., Schrader, P. G., & Mayall, H. J. (2007). Acquisition of information online: Knowledge, navigation and learning outcomes. *Journal of Literacy Research, 39*(3), 289-306.
- Lowther, D.L., Strahl, J.A., Inan , F. A., & Bates, J. (2007). Freedom to Learn Program: Michigan 2005-2006 Evaluation Report: Prepared for Freedom to Learn and the

One-to-One Institute. Memphis, TN: Center for Research in Educational Policy. Online. Retrieved April 18, 2010 from http://www.memphis.edu/crep/pdfs/Michigan_Freedom_to_Learn_Laptop_Program.pdf

- Mayer, R. E. (2005). In Mayer R. E. (Ed.), *The Cambridge Handbook of Multimedia Learning*. New York, NY US: Cambridge University Press.
- Miller, M. D., Linn, R. L. & Gronlund, N. E. (2009). *Measurement and Assessment in Teaching* (10th ed.). Upper Saddle River, NJ: Pearson.
- Mitchell, T. J. F., Chen, S. Y., & Macredie, R. D. (2005). Hypermedia learning and prior knowledge: Domain expertise vs. system expertise. *Journal of Computer Assisted Learning, 21*(1), 53-64.
- Moos, D. C., & Azevedo, R. (2006). The role of goal structure in undergraduates' use of self-regulatory processes in two hypermedia learning task. *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.

- Moos, D. C., & Azevedo, R. (2008c). Exploring the fluctuation of motivation and use of self-regulatory processes during learning with hypermedia. *Instructional Science: An International Journal of the Learning Sciences*, 36(3), 203-231.
- Moos, D.C. (2010). Self-Regulated Learning with Hypermedia: Too Much of a Good Thing? *Journal of Educational Multimedia and Hypermedia*, 19 (1), 59-77.
- Müller-Kalthoff, T., & Möller, J. (2006). Browsing while reading: Effects of instructional design and learners' prior knowledge. *Journal of Research in Learning Technology*, 14(2), 183-198.
- 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.
- One Laptop Per Child (2009). One Laptop Per Child Retrieved April 24, 2009 online at <http://laptop.media.mit.edu/>
- Pajares, F. (2002). *Self-efficacy beliefs in academic contexts: An outline*. Retrieved April 19, 2010 from <http://des.emory.edu/mfp/efftalk.html>.
- Pea, R. D., Wulf, W.A., Elliot, S. W. & Darling, M.A. (2003). (Eds.) *Planning for two transformations in education and learning technology: Reports from a workshop*. Washington, DC: National Academies Press.

- Perry, N. E. (1998). Young children's self-regulated learning and contexts that support it. *Journal of Educational Psychology, 90*(4), 715-729.
- Perry, N. E., Meisels, S. J., & National Opinion, R. C. (1996). *How accurate are teacher judgments of students' academic performance? working paper series*
- Peschar, J.L., Veenstra, R., Molenaar, I. W., Boomsma, A., Huisman, M. & van der Wal, M. (1999). Synthesis Report: Self-Regulated Learning as a Cross-Curricular Competency - he Construction of Instruments in 22 Countries for the PISA Main Study 2000. Presented at the Network A Meeting in Echternach, Luxembourg October 27-29, 1999. American Institutes for Research (AIR)
- Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, M. Zeidner, M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation*. (pp. 451-502). San Diego, CA US: Academic Press.
- Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research, 63*(2), 167-199.
- Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). Motivated strategies for learning questionnaire.
- Potelle, H., & Rouet, J. (2003). Effects of content representation and readers' prior knowledge on the comprehension of hypertext. *International Journal of Human-Computer Studies, 58*(3), 327-345.

- Pressley, M., & Afflerbach, P. (1995). *Verbal protocols of reading: The nature of constructively responsive reading*. Hillsdale NJ: Erlbaum.
- Proske, A., Narciss, S., & Koerndle, H. (2007). Interactivity and learners' achievement in web-based learning. *Journal of Interactive Learning Research, 18*(4), 511-531.
- Salmerón, L., Cañas, J. J., Kintsch, W., & Fajardo, I. (2005). Reading strategies and hypertext comprehension. *Discourse Processes, 40*(3), 171-191.
- Salmerón, L., Kintsch, W., & Cañas, J. J. (2006). Coherence or interest as basis for improving hypertext comprehension. *Information Design Journal, 14*(1), 45-55.
- Sawyer, R. K. (2006). Conclusion. In R. K. Sawyer (Ed.), *the Cambridge Handbook of the Learning Sciences* (pp. 567-580). Cambridge University Press: New York.
- Schunk, D. H., & Zimmerman, B. J. (2008). *Motivation and self-regulated learning: Theory, research, and applications*. Mahwah, NJ US: Lawrence Erlbaum Associates Publishers.
- Setzer, J. C., Lewis, L., National Center for, E. S., & Westat, Inc., Rockville, M.D. (2005). *Distance education courses for public elementary and secondary school students. 2002-03. E.D. tab. NCES 2005-010* US Department of Education.
- Shapiro, A. M. (1999). The relationship between prior knowledge and interactive overviews during hypermedia-aided learning. *Journal of Educational Computing Research, 20*(2), 143.
- Shapiro, A. & Neiderhauser, D. (2004). Learning from hypertext: research issues and findings. In D. H. Jonassen (Ed.), *Handbook of research on educational*

communications and technology. (pp. 605-620). Mahwah, NJ US: Lawrence Earlbaum Associates.

Silvernail, D. L., & Gritter, A. K. (2007). Maine's middle school laptop program:

Creating better writers. Retrieved April 19, 2010, from

http://www.usm.maine.edu/cepare/Impact_on_Student_Writing_Brief.pdf

Sloan Consortium (2008). *Staying the Course: Online Education in the United States*.

The Sloan Consortium, 2008. Retrieved 3/27/09 from

http://www.sloanc.org/publications/survey/pdf/staying_the_course.pdf

Usher, E. L., & Pajares, F. (2008). Self-efficacy for self-regulated learning: A validation

study. *Educational & Psychological Measurement*, 68(3), 443-463.

Utman, C.H. (1997). Performance effects of motivational state: a meta-analysis.

Personality and Social Psychology Review, 1, 170-182.

van Merriënboer, J. G. & Sweller, J. (2005). Cognitive load theory and complex learning:

Recent developments and future directions. *Educational Psychology Review*,

17(2), 147-177.

Veenman, M.V.J. (2005). The assessment of metacognitive skills: What can be learned

from multi-method designs. In C.Artelt & B.Moschner (Eds.), *Lernstrategien und*

Metakognition. Implikationen für Forschung und Praxis [Learning strategies and

metacognition. Theoretical and practical implications] (pp. 77-99). Münster:

Waxmann.

- Venkatesh, V. (2000). Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model. *Information Systems Research, 11*(4), 342–365.
- Waits, T. & Lewis, L. (2003). *Distance Education at Degree-Granting Postsecondary Institutions: 2000–2001*, (NCES 2003-017) Washington, DC: U.S. Department of Education, National Center for Education Statistics.
- Weinstein, C. E., Schulte, A. C., & Palmer, D. R. (2002). Learning and study strategies inventory, second edition.
- Winne, P. H. (1995). Inherent details in self-regulated learning. *Educational Psychologist, 30*(4), 173-187.
- Winne, P. H. (1997). Experimenting to bootstrap self-regulated learning. *Journal of Educational Psychology, 89*(3), 397-410.
- 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., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, A. C. Graesser, D. J. Hacker, J. Dunlosky & A. C. Graesser (Eds.), *Metacognition in educational theory and practice*. (pp. 277-304). Mahwah, NJ US: Lawrence Erlbaum Associates Publishers.
- Winne, P. H., Hadwin, A. F., & Beaudoin, L. (2009). *nStudy: A web application for researching and promoting self-regulated learning* (version 1.02) [computer program]. Simon Fraser University, Burnaby, BC, Canada.

- 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., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. R. Pintrich, M. Zeidner, M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation*. (pp. 531-566). San Diego, CA US: Academic Press.
- Wirth, J., & Leutner, D. (2008). Self-regulated learning as a competence: Implications of theoretical models for assessment methods. *Zeitschrift Für Psychologie/Journal of Psychology, 216*(2), 102-110.
- Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology, 81*(3), 329-339.
- Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, M. Zeidner, M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation*. (pp. 13-39). San Diego, CA US: Academic Press.
- Zimmerman, B. J. (2008). 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., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal, 29*(3), 663-676.

- 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., & Martinez-Pons, M. (1992). Perceptions of efficacy and strategy use in the self-regulation of learning. In D. H. Schunk, J. L. Meece, D. H. Schunk & J. L. Meece (Eds.), *Student perceptions in the classroom*. (pp. 185-207). Hillsdale, NJ England: Lawrence Erlbaum Associates, Inc.
- Zumbach, J. (2006). Cognitive overhead in hypertext learning reexamined: Overcoming the myths. *Journal of Educational Multimedia and Hypermedia*, 15(4), 411-432.

APPENDIX A
KNOWLEDGE SCALE

Directions

For the following question, choose the letter that best answers the question or completes the statement.

Textbase Subtest

- 1 What percentage of school-aged children does ADHD affect?
 - a) Less than 1 percent
 - b) 3 to 5 percent
 - c) 10-20 percent
 - d) 50 percent
- 2 Which ratio characterizes diagnosis rates of ADHD by gender?
 - a) Boys are diagnosed slightly more often than girls.
 - b) Girls are diagnosed slightly more often than boys.
 - c) Boys are diagnosed more often than girls by a ratio of more than 3 to 1.
 - d) Girls are diagnosed slightly more often than boys by a ratio of more than 3 to 1.
 - e) There are no differences in diagnosis rate by gender.
- 3 Attention-deficit hyperactivity disorder (ADHD) is a condition defined by the American Psychiatric Association to describe individuals who experience
 - a) involuntary movements, called motor tics, and uncontrollable vocalizations, called vocal or phonic tics.
 - b) impairments in three major domains: socialization, communication, and behavior.
 - c) inattention, impulsivity, and excessive motor activity resulting in academic and social problems.
 - d) impaired social interactions, limited repetitive patterns of behavior, and often are clumsy.

- 4 At what age must symptoms have appeared for a child to be diagnosed as having ADHD?
- a) 5
 - b) 7
 - c) 12
 - d) ADHD can be diagnosed at any age once symptoms begin to appear
- 5 According to research, children with ADHD score 7 to 15 points lower than other children on intelligence tests. To what behavior has this been attributed?
- a) Difficulty concentrating
 - b) Inattention
 - c) Impulsivity
 - d) Excessive motor activity
- 6 Which statement describes the genetic characteristics of ADHD?
- a) ADHD is highly heritable.
 - b) ADHD is a sex linked trait.
 - c) ADHD is not heritable.
- 7 The brains of children with ADHD differ from normal brain function in that they
- a) Have increased electrical and blood flow in the cerebellum
 - b) Have reduced electrical and blood flow in the cerebellum
 - c) Have increased electrical and blood flow in the frontal lobes of the cerebral cortex.
 - d) Have reduced electrical and blood flow in the frontal lobes of the cerebral cortex.

- 8 How do the brains of children with ADHD compare to their peers?
- a) Their brains are exactly the same size.
 - b) Their brains are slightly larger.
 - c) Their brains are slightly smaller.
 - d) Their brains are the same size, but the proportions of white and grey matter are different.
- 9 The genes which have been implicated in ADHD affect
- a) muscle tone.
 - b) proprioception.
 - c) neural communication.
 - d) sleep patterns.
- 10 How does prenatal exposure to teratogens relate to inattention and hyperactivity?
- a) There is no impact of exposure to teratogens on the child's attention or activity levels.
 - b) Short-term exposure has been linked to inattention and hyperactivity.
 - c) Long-term exposure has been linked to inattention and hyperactivity.
 - d) Long-term exposure has been linked to inattention and hyperactivity.
- 11 The most common medication prescribed for treatment of ADHD is
- a) a stimulant.
 - b) a depressant.
 - c) an anti-depressant.
 - d) an anxiolytic.

- 12 What effect does this medication have on the child?
- a) The medication causes an increase in frontal lobe activity, improving attention and inhibiting off task behavior.
 - b) The medication causes a decrease in frontal lobe activity, improving attention and inhibiting off task behavior.
 - c) The medication causes an increase in activity in the cerebellum, improving attention and inhibiting off task behavior.
 - d) The medication causes a decrease in activity in the cerebellum, improving attention and inhibiting off task behavior.
- 13 What unwanted side effect does the most common medication prescribed for ADHD carry?
- a) Potential impairment of liver functioning
 - b) Potential impairment of kidney functioning
 - c) Potential impairment of respiratory functioning
 - d) Potential impairment of heart functioning
- 14 According to the American Academy of Pediatrics, what is the most effective approach for treating ADHD?
- a) Medication only.
 - b) Interventions that model appropriate behaviors only.
 - c) Interventions that extinguish negative behaviors only.
 - d) Medication and interventions that model appropriate behaviors.
 - e) Medication and interventions that extinguish negative behaviors.

- 15 After symptoms appear, how long does ADHD persist?
- a) ADHD persists through childhood only.
 - b) ADHD persists from childhood through adolescence.
 - c) ADHD persists from childhood through young adulthood.
 - d) ADHD persists from childhood through the remainder of the lifespan.
- 16 According to research, ADHD sufferers are at risk for what other problems?
- a) obsessive compulsive disorder (OCD)
 - b) depression
 - c) oppositional defiant disorder (ODD)
 - d) autism

Situation Model Subtest

- 17 If a child was to be diagnosed with ADHD, what symptoms or characteristics might the child exhibit?
- 18 According to published research studies, what are some factors that might cause a child to have ADHD?
- 19 How would a team of professionals including a teacher, psychiatrist and therapist ideally treat a child with ADHD?
- 20 How would you characterize the trends in recent history in ADHD diagnosis?

APPENDIX B

DEMOGRAPHIC QUESTIONNAIRE

Directions

Please answer the following questions that will provide important information about your personal characteristics.

1 What is your sex (radio buttons)

Answer Male Female

2 How old are you in years and months? (drop down)

Answer Years: plus Months:

3 What is your ethnicity? (Drop down with text box for other)

Answer Caucasian , African or African American, Hispanic/Latino, Asian or Asian American, Other (specify)

4 How many semesters (credits) of college coursework have you completed to date?

Answer Multiple choice

5 What is your current GPA? (as of your last semester completed).

Answer Textbox – numerical with two decimal places

6 What was your highest score on the VERBAL section of the SAT?

Answer Textbox – numerical

7 What was your highest score on the MATH section of the SAT?

Answer Textbox – numerical

APPENDIX C
ACHIEVEMENT GOALS QUESTIONNAIRE - REVISED

Directions

The following statements concern your attitudes toward learning and performance in this education class. Please respond to the following items by indicating the degree to which the statement is true of you using the scale provided.

Scale = 5-point Likert variety ranging 1 (*strongly disagree*) to 5 (*strongly agree*)

(five radio buttons provided per item)

- 1 My aim is to completely master the material presented in this class.
- 2 I am striving to do well compared to other students.
- 3 My goal is to learn as much as possible.
- 4 My aim is to perform well relative to other students.
- 5 My aim is to avoid learning less than I possibly could.
- 6 My goal is to avoid performing poorly compared to others.
- 7 I am striving to understand the content of this course as thoroughly as possible.
- 8 My goal is to perform better than the other students.
- 9 My goal is to avoid learning less than it is possible to learn.
- 10 I am striving to avoid performing worse than others.
- 11 I am striving to avoid an incomplete understanding of the course material.
- 12 My aim is to avoid doing worse than other students.

Note. Performance-approach = Items 2, 4, 8; performance-avoidance = Items 6, 10, 12; mastery avoidance = Items 5, 9 11; mastery-approach = Items 1, 3, 7. Items are summed to form the mastery-approach, performance-approach, mastery-avoidance, and performance-avoidance indexes.

APPENDIX D

INTRINSIC MOTIVATION INVENTORY (ELLIOT & CHURCH 1997)

Directions

The following statements concern your attitudes toward learning and performance in this exercise you just completed. Please respond to the following items by indicating the degree to which the statement is true of you using the scale provided.

Scale = 7-point Likert variety ranging 1 (*strongly disagree*) to 7 (*strongly agree*)

(seven radio buttons provided per item)

- 1 I think this exercise is interesting.
- 2 I am enjoying this exercise very much.
- 3 I think this exercise is a waste of my time.
- 4 I think this exercise is fun.
- 5 I think this exercise is boring.
- 6 I'm glad I took part in this exercise.
- 7 I don't like this exercise at all.
- 8 I intend to recommend this exercise to others.

Note. Items 3, 5, and 7 are reverse scored. After reverse scoring, items are averaged to form an intrinsic motivation index.

APPENDIX E

ADAPTED SELF-EFFICACY FOR SELF-REGULATED LEARNING SCALE

(USHER & PAJARES, 2008)

Directions

Read each statement and respond as honestly as you can by rating from 1, *not well at all*, to 6, *very well*, how well you can carry out the following activity.

(six radio buttons provided per item)

- 1 How well can you finish your coursework on time?
- 2 How well can you study when there are other interesting things to do?
- 3 How well can you concentrate on your school work?
- 4 How well can you remember information presented in class and in your course materials?
- 5 How well can you arrange a place to study at home where you won't get distracted?
- 6 How well can you motivate yourself to do schoolwork?
- 7 How well can you participate in class discussions?

APPENDIX F

Offline SRL items from the Motivated Strategies for Learning Questionnaire

Directions

Read each statement and rate yourself from 1, *not at all true of me*, to 7, *very true of me*.

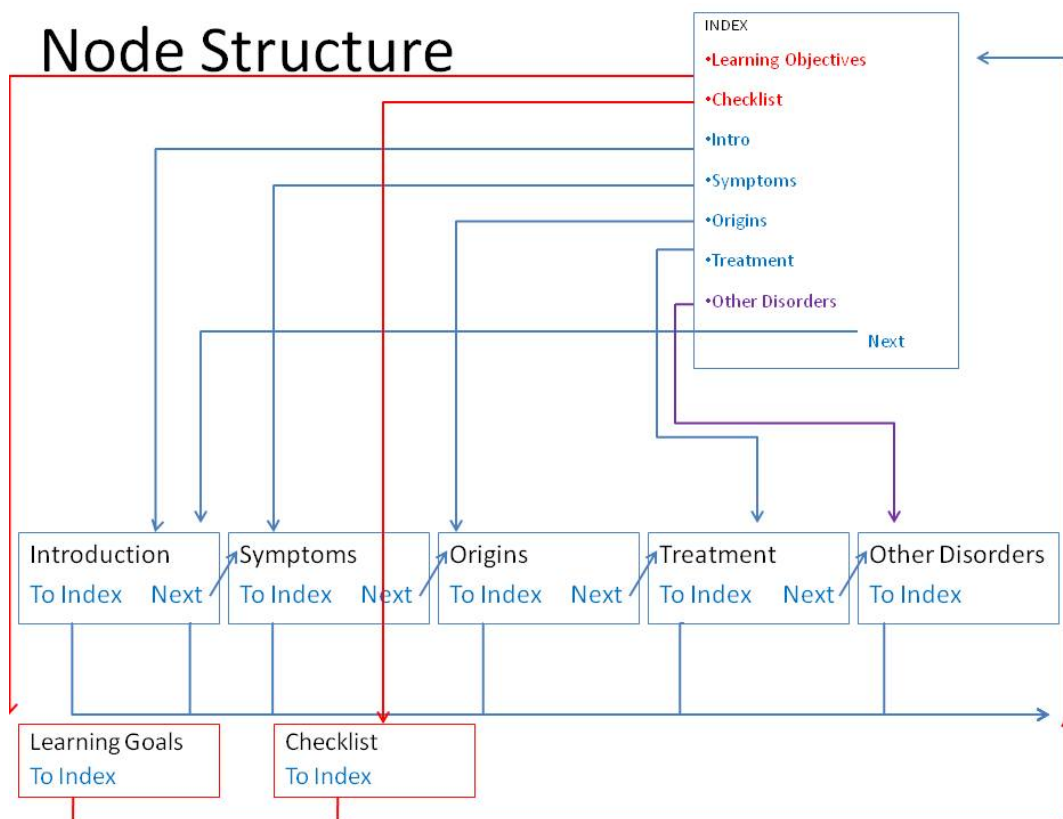
(seven radio buttons provided per item)

- 42 When I study for a course, I go through readings and my class notes and try to find the most important ideas.
- 53 When I study for a class, I pull together information from different sources such as lectures, readings, and discussions.
- 63 When I study for a course, I go over my class notes and make an outline of important concepts.
- 66 I try to play around with ideas of my own related to what I am learning in this course.
- 67 When I study for a course, I write brief summaries of the main ideas from the readings and the concepts from lectures.

Note. Because these items represent distinct tendencies, no summing or averaging occurs.

Each item will be used as an indicator of typical SRL behavior and compared to online traces of the same behavior. Internal consistency with this sample was $\alpha = .668$.

APPENDIX G
NODE STRUCTURE



APPENDIX H

CHILDREN WITH ATTENTION-DEFICIT HYPERACTIVITY DISORDER

Introduction

While the other fifth graders worked quietly at their desks, Calvin squirmed in his seat, dropped his pencil, looked out the window, fiddled with his shoelaces, and talked aloud. "Hey Joey," he yelled over the heads of several classmates, "wanna play ball after school?" But Joey and the other children weren't eager to play with Calvin. On the playground, Calvin was physically awkward and a poor listener who failed to follow the rules of the game. He had trouble taking turns at bat. In the outfield, he tossed his mitt up in the air and looked elsewhere when the ball came his way. Calvin's desk at school and his room at home were chaotic messes. He often lost pencils, books, and other materials he needed to complete his work, and he had difficulty remembering assignments and when they were due.

Symptoms of ADHD

Calvin is one of 3 to 5 percent of school-age children with attention-deficit hyperactivity disorder (ADHD; American Psychiatric Association, 1994). Boys are diagnosed 3 to 9 times more often than girls. However, most girls with ADHD seem to be overlooked either because their symptoms are less flagrant or because of a gender bias: A difficult, disruptive boy is more likely to be referred for treatment (Abikoff et al. 2002; Biederman et al., 2005).

Children with ADHD cannot stay focused on a task that requires mental effort for more than a few minutes. In addition, they often act impulsively, ignoring social rules and lashing out with hostility when frustrated. Many (but not all) are *hyperactive*. Their excessive motor activity is exhausting for parents and teachers and so irritating to other children that they are quickly rejected. For a child to be diagnosed with ADHD, these symptoms must have appeared before age 7 as a persistent problem.

Because of their difficulty concentrating, children with ADHD score 7 to 15 points lower than other children on intelligence tests (Barkley, 2002a). According to one view that has amassed substantial research support, two related deficits underlie ADHD symptoms: (1) an impairment in executive processing, which interferes with the child's ability to use thought to guide behavior; and (2) an impairment in inhibition, which makes it difficult to delay action in favor of thought. Consequently, such children do poorly on tasks requiring sustained attention, find it hard to ignore irrelevant information, and have difficulty with memory, planning, reasoning, and problem solving in academic and social situations (Barkley, 2003b).

Treating ADHD

Calvin's doctor eventually prescribed stimulant medication, the most common treatment for ADHD. As long as dosage is carefully regulated, these drugs reduce symptoms in 70 percent of children who take them, with benefits for academic performance and peer relations (Greenhill, Halperin, & Abikoff, 1999). Stimulant

medication seems to increase activity in the frontal lobes thereby improving the child's capacity to sustain attention and to inhibit off-task behavior.

In 2006, an advisory panel convened by the US. Food and Drug Administration warned that stimulants might impair heart functioning even causing sudden death in a few individuals, and advocated warning labels describing these potential risks. Debate over the safety of medication for ADHD is likely to intensify. In any case, medication is not enough. Drugs cannot teach children how to compensate for inattention and impulsivity. The most effective treatment approach combines medication with interventions that model and reinforce appropriate academic and social behavior (American Academy of Pediatrics, 2005a). Family intervention is also important. Inattentive, overactive children strain the patience of parents, who are likely to react punitively and inconsistently--a child-rearing style that strengthens inappropriate behavior. Breaking this cycle through training parents in effective child-rearing skills is as important for children with ADHD as it is for the defiant, aggressive youngsters discussed in Chapter 8. In fact, in 45 to 65 percent of cases, these two sets of behavior problems occur together (Barkley, 2002b).

Some media reports suggest that the number of North American children diagnosed with ADHD has increased greatly. But two large surveys yielded similar overall prevalence rates 20 years ago and today. Nevertheless, the incidence of ADHD is much higher in some communities than others. At times, children are overdiagnosed and unnecessarily medicated because their parents and teachers are

impatient with inattentive, active behavior within normal range. In Hong Kong, where academic success is particularly prized, children are diagnosed at more than twice the rate seen in North America. At other times, children are underdiagnosed and do not receive the treatment they need, as occurs in Great Britain, where doctors are hesitant to label a child with ADHD or to prescribe medication (Taylor, 2004).

ADHD is a lifelong disorder. Affected individuals are at risk for persistent antisocial behavior, depression, and other problems (Barkley, 2003a; Fisher et al., 2002). Adults with ADHD continue to need help structuring their environments, regulating negative emotion, choosing appropriate careers, and understanding their condition as a biological deficit rather than a character flaw.

Other Interesting Childhood Disorders

Oppositional Behavior. Oppositional behavior includes things like losing one's temper, arguing with parents or teachers, refusing to follow rules, being mean or seeking revenge, deliberately annoying people, being angry and resentful, blaming others for one's own mistakes, and persistently being stubborn and unwilling to compromise. Usually oppositional behavior occurs at home, but it may also occur at school or in the community. Oppositional behavior is common in both preschool children and in adolescents.

Parent Management Training is well-established as a beneficial treatment for oppositional behavior in children. Parent Management Training involves helping parents learn new skills for dealing with oppositional and defiant behavior. While other psychotherapies may be helpful for treatment of oppositional behavior, they have not been evaluated scientifically in the same way as the treatment listed here.

Encopresis. Encopresis is the inability to control bowel movements, resulting in defecation (bowel movement) in clothing, in the bed, or on the floor. Encopresis is diagnosed in children who are at least 4 years old, although frequently children younger than 4 also cannot control their bowels. Encopresis more commonly affects boys than girls.

Some evidence suggests that behavior modification is beneficial for treatment of encopresis. While other psychotherapies may be helpful for treatment of encopresis, they have not been evaluated scientifically in the same way as the treatment listed here.

Enuresis. Enuresis, commonly known as "bedwetting", is repeated urination during the day or night into bed or clothes. Enuresis is diagnosed in children who are at least 5 years old, although younger children often do have difficulty controlling urination.

Behavioral treatment is well-established as a beneficial treatment for enuresis. Behavioral treatment usually involves the use of a urine alarm device and parent education. While other psychotherapies may be helpful for treatment of enuresis, they have not been evaluated scientifically in the same way as the treatment listed here.

APPENDIX I
LEARNING GOALS NODE

Learning objectives for this reading

By the end of this study session, the reader should be able to:

1. define ADHD.
2. identify symptoms and characteristics of a child with ADHD.
3. identify key statistics describing the incidence of ADHD in different populations.
4. explain the relationship between ADHD and hyperactivity.
5. apply criteria for making an ADHD diagnosis.
6. explain the origins of ADHD
7. identify the academic and social consequences of ADHD
8. describe treatment strategies for children with ADHD
9. interpret trends in ADHD diagnosis

APPENDIX J
CHECKLIST NODE

Children with Attention-Deficit Hyperactivity Disorder

Checklist for chapter review

Can I:

1. define ADHD?
2. identify symptoms and characteristics of a child with ADHD?
3. identify key statistics describing the incidence of ADHD in different populations?
4. explain the relationship between ADHD and hyperactivity?
5. apply criteria for making an ADHD diagnosis?
6. explain the origins of ADHD?
7. identify the academic and social consequences of ADHD?
8. describe treatment strategies for children with ADHD?
9. interpret trends in ADHD diagnosis?