Abstract

Title of thesis: THE ROLE OF GOAL STRUCTURE IN UNDERGRADUATES' USE OF SELF-REGULATORY VARIABLES IN TWO HYPERMEDIA LEARNING TASKS

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Think-aloud and posttest data was collected from 64 undergraduates to examine whether they use a different proportion of self-regulated learning (SRL) variables in two related learning tasks about science topics while using a hypermedia environment. We also manipulated the goal structure of the two learning tasks in order to explore whether goal structure of a learning task is related to the use of SRL variables. Participants were randomly assigned to 1 of 3 conditions [mastery goal structure, performance-approach goal structure, or performance-avoidance goal structure] and participated in two 20 minute learning tasks in which they learned about the circulatory and respiratory system. Results indicate that while a mastery goal structure and a performance-approach goal structure are related to undergraduates' use of a similar proportion of SRL variables in two related learning tasks, a performance-avoidance goal structure is related to undergraduate's use of a different proportion of SRL variables, specifically *planning*.

THE ROLE OF GOAL STRUCTURE IN UNDERGRADUATES' USE OF SELF-REGULATORY VARIABLES IN TWO HYPERMEDIA LEARNING TASKS

by

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Chapter I: Introduction

It goes without saying that educators are keenly interested in promoting high levels of learning in their students. In order to maximize the learning experience for each student, educators should be aware of two factors that are related to their students' learning: Contextual factors in the classroom and student factors. Though there are numerous contextual factors in the classroom, two especially salient factors include the goal structure of assigned learning tasks and the use of technological advances as educational tools, such as hypermedia environments. In addition, though a myriad of student factors affect learning, two critical factors include possessing the necessary skills to learn and the ability to use these skills across contexts and domains. The goal of this study is to examine the influence of contextual factors, in the form of goal structure, on student factors, in the form of self-regulated learning (SRL), in learning with a hypermedia environment. In what will follow, I will describe which factors will be investigated and why they are being investigated.

In reference to the role of contextual factors, teachers should to be aware of variables in the classroom that affect how students learn (Randi & Corno, 2000). Teachers' presentation of learning material and their accompanying expectations create the classroom goal structure. This goal structure may affect students' adoption of individual goals and ultimately their learning (Ames, 1992). Some research from the field of goal orientation has found that the goal structure of an assigned learning task and the students' goal adoption is related to the use of learning strategies (Elliot & Harackiewicz, 1996). For example, some research has suggested that students can adopt three goals, comprising of two types of approach orientation (e.g. to master material and to gain approval) and an avoidance orientation (e.g. to avoid unfavorable judgments from peers and/or teachers). Typically, this research has found that mastery goal orientations are more strongly correlated to higher levels of learning relative to the other two goal orientations (Elliot & Harackiewicz, 1994). However, while it is important to note the relationship between goal orientation and learning, it is equally important to recognize that students may encounter distinct goal structures. Thus, another question that should be addressed concerns whether learning tasks with different goal structures will affect individual goal orientations and learning strategies. For example, if a student is faced with a learning task that has a mastery goal orientation, will he/she maintain this goal orientation when faced with another learning task that has a performance goal structure (e.g. the learning task emphasizes comparison of students)? Furthermore, it is equally important to understand whether students who encounter learning tasks with different goal structures will use the same learning strategies in each learning task.

In addition to the influence of the goal structure in a learning task, student factors such as learning strategies also affect learning. These factors are especially salient for complex topics in a school's curriculum. Mastery of this material requires both factual knowledge and a deep conceptual understanding. However, having the cognitive ability to understand material is necessary, but sometimes not sufficient to master complex topics. Possessing strategies, such as knowing how and when to seek appropriate assistance when learning about a complex topic, may be necessary to progress to a deeper understanding (Azevedo, Guthrie, & Seibert, 2004; Hmelo-Silver & Pfeffer, 2003). Thus, in order to gain deep conceptual knowledge, students must possess certain strategies, and know how and when to use these strategies (Hmelo-Silver & Pfeffer, 2003; in press). In addition, complex topics may present the need for other strategies, such as planning and creating sub-goals, in order to effectively manage the ideas contained in these topics. Without these skills, students may have difficulty learning complex topics.

Research in the field of educational psychology has examined what skills successful students possess. During the 1970s, research examining how students master their own learning revealed that successful students exhibit behavior that is fundamentally different than their peers who have difficulty in school. This behavior was characterizing as having self-regulatory components (Paris & Newman, 1990). While these earlier views of self-regulated learning skills focused on isolated learning, a more comprehensive and multifaceted self-regulated learning model (SRL) emerged in the 1980s. This model offered a perspective in which students are viewed as proactive and strategic learners**,** as opposed to passive learners in their environment. To explain this proactive, strategic orientation, researchers appealed to social, behavioral, motivational, and cognitive variables in several instructional contexts. The SRL model has evolved over the last twenty years, driven in part by the considerable research on the role of SRL in academic achievement (Zimmerman & Schunk, 2001).

However, while research in the field of self-regulation has shed light on skills involved in successful learning, recent technological advances require that research examine students' learning in these unique learning environments. Recent technological advances, such as hypermedia environments, have been developed to help students learn complex topics. Hypermedia environments, which can contain textual information, static diagrams, and digitized video clips, provide students with a visually rich and interactive environment to explore complicated topics such as the circulatory and respiratory system. These nonlinear environments, in which students are provided flexible access and high degree of control, offer students multiple representations (Williams, 1996). However, while technological advances have provided students with additional tools to learn about complex topics, students may need certain skills to effectively use these tools. That is, the nonlinear property of hypermedia environments may present an environment in which students need to use self-regulatory behaviors to learn. For example, recent research has demonstrated that students of all ages have different regulatory skills and that some students fail to display certain self-regulatory skills while using hypermedia environments (see Azevedo, Winters, & Moos, in press). In order to effectively navigate and learn in a flexible, nonlinear learning environment certain self-regulatory skills, such as creating sub-goals and planning, may be required in this learning context (Azevedo, Guthrie, & Seibert, 2004).

It is clear that students are faced with many hurdles while trying to learn in different instructional contexts. Especially salient issues in student learning include (a) understanding how contextual variables (such as the goal structure of assigned learning tasks) affect students' learning, (b) whether students use the same learning strategies in contexts with different goal structures, and (c) what skills allow students to learn complex topics. Furthermore, because computer-based learning environments, such as hypermedia environments, are used as educational tools, research should continue to examine the above issues in the context of these unique educational tools. Student learning with hypermedia may be best understood by examining research from two separate fields: Self-regulated learning and goal orientation. While these two distinct fields of research have examined student learning in different instructional contexts, research has not utilized the most recent trends in measurement to examine the role of goal orientation in students' use of self-regulatory behavior. Thus, in order to best understand the complex phenomena of student learning in the context of hypermedia environments, the findings from these fields should be combined to design one study. In addition, examining how students use recent technological advances, such as hypermedia environments, to learn complex topics would generate significant new findings.

The aims of this thesis are to (a) provide a literature review on the extensive research from the fields of SRL, goal orientation, and learner-controlled instructional technologies, such as hypermedia environments, and (b) describe a study that generates new findings by incorporating research from these fields to examine the role of goal structure in students' use of self-regulatory variables in two hypermedia learning tasks. In the first major section of the second chapter, the theoretical and methodological issues of SRL models will be reviewed. As it will become clear, research in this area has the potential to provide educators with valuable information regarding learning. By considering the ways in which successful and unsuccessful students differ in their knowledge of appropriate strategies, motivation to gain knowledge, and goal orientation to achieve this knowledge, educators will gain insight into the deficiencies of unsuccessful students. However, as the theoretical and methodological sections in this chapter will highlight, the field of SRL has some unanswered questions. These questions will be addressed in the "next steps" section of the second chapter.

An examination of the next steps will reveal that incorporating findings from the field of goal orientation with the field of SRL provides valuable insight into the phenomena of self-regulated learning. Thus, the second major section of the second chapter will provide the theoretical issues in the field of goal orientation. Next, the third major section in the second chapter will provide a brief literature review on hypermedia environments as cognitive tools for students' learning of complex systems. The second chapter will end with the research question and hypotheses of this study. The general question motivating this study is: Does the goal structure of a hypermedia learning context affect undergraduates' use of self-regulatory variables in two complex science topics? The three specific research questions will be addressed at the end of the second chapter. In the third chapter, the methodology of this study will be presented. The fourth chapter will discuss the results of this study and the fifth chapter will provide a discussion

Operational Definitions of Key Terms

Throughout this paper, several key constructs are used as foundations for the study. In order to clarify these constructs and how they are related, operational definitions are provided below.

GOAL: Goal is an internal representation of desired states (Bandura & Locke, 2003)**.**

GOAL ORIENTATION: Goal orientation represents a pattern of beliefs that guide an individual's way of approaching, engaging, and responding to achievement situations. Goal orientations are the reasons why individuals set goals (Ames, 1992).

MASTERY GOAL ORIENTATION: Mastery goal orientation is focused on such goals as mastering material through increasing level of competence and learning as much as possible (Wolters, 2004).

PERFORMANCE – APPROACH: Performance - approach goal orientation is focused on demonstrating ability relative to others (Wolters, 2004).

PERFORMANCE – AVOIDANCE: Performance - avoidance goal orientation is focused on avoiding the demonstration of incompetence or the lack of ability (Wolters, 2004).

SELF-REGULATED LEARNING: Self-regulated learning involves actively constructing strategies and goals, regulating and monitoring certain aspects of cognition, behavior, and motivation, modifying behavior to achieve a desired goal, and an interaction between performance, contextual factors, and personal characteristics (Pintrich, 2000).

HYPERMEDIA: Hypermedia is a computer-based learning environment that is an extension of hypertext in which audio, video, animation, and/or graphics are integrated with the text. This environment is structured in a non-linear format and is student structured (Jonassen & Reeves, 1996).

Chapter II: Literature Review

As noted in Chapter 1, this study will integrate perspectives from SRL, goal orientation, and hypermedia literature. To understand the need for this integration, it is necessary to summarize the major findings and issues of these fields. In what follows, I summarize the relevant portions of the literature on SRL, goal orientation, and hypermedia environments. Chapter two concludes with the specific research question and hypotheses.

Literature Review of Self Regulation

Theoretical Perspectives

In order to properly present the underlying theoretical perspectives of the SRL model, the constructs and assumptions of this model need to be delineated. At the outset, it is important to note that the field of SRL research consists of many camps and perspectives that sometimes focus on different constructs. However, these perspectives share some common assumptions that provide the foundations for all SRL models (Pintrich, 2000). For example, an underlying construct of most SRL models is that all learners are proactive in a constructive process of learning. Learners are assumed to actively construct their own strategies, goals, and meaning from information available in their own minds as well as from the external world. Second, most SRL models assumes that learners can potentially regulate and monitor certain aspects of their cognition, behavior, and motivation. Due to the influence of contextual variables, individual differences, and developmental constraints, individuals do not constantly monitor and control their cognition, behavior, and adoption of goals in all contexts. Third, most models assume that all human behavior is goal-directed and that self-regulated learners modify their behavior to achieve a desired goal. That is, individuals set goals for their learning, monitor their progress towards these goals, and then adapt and regulate their behavior, cognition, and motivation to reach those goals. Lastly, most models assume that self-regulatory behavior is a mediator between (a) an individual's performance, (b) contextual factors, and (c) personal characteristics.

These basic assumptions provide the foundation for the SRL model adopted in this study but, as previously mentioned, there are several distinct perspectives that provide more detailed accounts of self-regulated learning and provide insight as to how students become self-regulated learners. For example, Pintrich (2000) offers a detailed account by characterizing SRL as having four different phases and four different areas. The four phases include: *planning, monitoring, control,* and *reflection.* These phases are intended to reflect common assumptions shared by many SRL models (Zimmerman, 2001). In phase one, the learner plans, sets goals, and activates knowledge about the context, text, and self. Phase two is defined when the learner exhibits metacognitive awareness and monitoring of cognition. In phase three, the learner selects cognitive strategies and regulates different aspects of the context, task, and self. Lastly, in phase four, the learner makes cognitive judgments and reflections on the context, task, and self.

Pintrich (2000) indicates that there are underlying assumptions associated with the progression of these phases. First and foremost, it is assumed that learning does not necessarily involve all these phases. Furthermore, it has not been empirically demonstrated that these phases are hierarchical in the sense that later phases must always occur after earlier phases. In fact, due to the assumption of most SRL models, phases can occur concurrently and dynamically. For example, a learner may continue to adjust and adapt his/her goals based on feedback. Thus, these phases are not necessarily linear nor are they static. Within these individual phases, Pintrich (2000) proposes four different areas in which self-regulation can occur. Based on different psychological functioning (see Snow, Corno, & Jackson, 1996), the first three areas for regulation are *cognition*, *motivation/affect*, and *behavior*. The last area of context reflects contextual features, such as evaluation features and task characteristics, which can impede or facilitate an individual's attempt to self-regulate their learning. Given the complexity of this 4 x 4 account of SRL, elaborating each area (cognition, motivation, behavior, context) by phase (planning, monitoring, control, and reflection) will provide the necessary detail to adequately explain its utility in examining the richness of SRL.

In the first phase and area, cognitive planning, there are three assumed behaviors. First, target goals are set that allow learners to monitor their learning (Harackiewicz, Barron, & Elliot, 1998). While goal-setting can occur anytime because of the dynamic nature of SRL, it is assumed to occur most often at the onset of a learning task (Pintrich, 2000). During the learning task, the learner uses the goal as a criterion to monitor, assess, and guide cognition. Activation of relevant prior knowledge is the second aspect of cognitive planning and activation. It has been shown that students who are more self-regulatory when learning actively search their memory for relevant prior knowledge (Pintrich, 2000). Lastly, activation of cognitive strategies and tasks comprise the third aspect of cognitive planning and activation. Activation of these cognitive strategies is the means by which goals are thought to be attainable by the learner.

In the next phase of cognition, cognitive monitoring, the learner exhibits what is typically viewed as metacognition (Koriat & Goldsmith, 1996). That is, learners are involved in a dynamic process of monitoring their cognition. For example, two typical metacognitve monitoring activities are *judgment of learning* (JOLs) and *feeling of knowing* (FOKs). The JOLs occur when the learner becomes aware that they do not know or understand something they just read, while FOKs occur when the learner feels as though they know something but cannot recall the information when the task asks them to do so.

The third phase of cognition, cognitive control and regulation, is defined when the learner selects and uses cognitive strategies for thinking, problem solving, and learning. The use of strategies such as mnemonics, memorizing, and summarizing are behaviors that would be placed in this cell. The last phase of cognition, cognitive reaction and reflection, includes student's reflection on performance on the task. Studies have demonstrated that self-regulators learners are differentiated from other learners in this area and phase of cognitive regulation because they tend to evaluate their performance (Zimmerman & Schunk, 2001).

In addition to having the capacity to self-regulate their cognition in the four phases of cognition, learners can also self-regulate their motivation and affect in all of the phases. In the first phase of planning and activation of motivation and affect, it has been demonstrated that task value beliefs can influence learners' effort, persistence, and ultimately their learning and performance (Wigfield, 1994). For example, if a student believes that the task is relevant to near or future goals, they may be more likely to engage in the task and persist in the face of difficulty (Wigfield, 1994). Furthermore, it has been demonstrated that interest can be sparked by contextual and task features (Wigfield, 1994), and that learners can try to control and regulate this interest (Sansone, Weir, Harpster, & Morgan, 1992). In addition to the contextual and task features sparking interest, these variables may also produce negative affects such as fear and anxiety which can promote maladaptive strategies (Wigfield & Eccles, 1989).

The second phase of self-regulating motivation, motivational monitoring, has not received the same attention from researchers as motivational planning and activation. It is assumed, however, that monitoring of motivation is a crucial prelude to regulation of motivation (Pintrich, 2000). In order for learners to control their efficacy, interest, and anxiety, it is necessary to be first aware of these beliefs and affect. Some research has examined this directionality. For example, Bandura (1997) researched self-efficacy by focusing on the outcomes of individuals who became more aware of their efficacy and then adapted their efficacy levels to make their beliefs more realistic. The third phase of self-regulating motivation, motivational control and regulation, has received more attention from researchers. Researchers such as Boekaerts (1993) and Corno (1993) have examined the numerous strategies individuals can use to control their motivation and affect. For example, strategies include positive self-talk to control self-efficacy (see Bandura, 1997). In addition, self-affirmation strategy has been shown to protect self-worth by decreasing the value of the task (Garcia & Pintrich, 1994). The final phase of self-regulating motivation, motivational reaction, occurs when the learner has an emotional reaction to the outcome and then reflects on how the outcome came to be. Emotions such as pride or shame can stem from these reflections. From a self-regulation standpoint, the quality of these emotions has implications for the self-regulation process because intentional strategies used to protect self-worth for future learning tasks may be a product of these emotions.

The third area of self-regulation, regulation of behavior, occurs when the learner intentionally attempts to control his/her behavior. Behavioral forethought, planning, and activation comprise the first phase of this area. Behaviors such as time management or time and effort planning are placed in this cell. Studies have demonstrated that self-regulated learners plan how they will allocate their effort and time (Zimmerman & Martinez-Ponz, 1986). In addition, studies have also demonstrated that self-regulated learners use self-observational techniques to modify their own behavior (Zimmerman, 2000). In order for this modification to occur, planning and intention to implement the adaptation must occur. Thus, self-observational techniques also aid with the second phase of behavior regulation. In this phase, behavioral monitoring and awareness, the learner monitors their time and effort and/or time management, and then attempts to adapt their effort to meet the learning task. For example, when asked to learn about the circulatory system, a learner may decide to spend fifteen minutes memorizing the components of the heart, but later realize that the complexity of the material requires more time. The monitoring of behavior, as exhibited by a self-regulated learner, should lead to some modification of effort if the monitoring indicates a discrepancy between the effort and desired goal.

This modification defines the third phase of behavior regulation, behavioral control. Continuing with the previous example, if the learner realizes that learning the components of the circulatory system will require more than the initially planned time, the learner should modify his/her behavior. An additional strategy that has been demonstrated to be helpful in regulating behavior is help-seeking (Ryan & Pintrich, 1997). Knowing when, how, and from whom to seek help is a defining characteristic of good self-regulators (Karabenick & Sharma, 1994). It should be noted that help-seeking can be either adaptive or maladaptive. Dependent help-seeking, where the learner is consistently dependent on this form of support and desires to finish a task quickly, is generally considered maladaptive. On the other hand, help-seeking where the learner seeks help only to overcome specific parts of a problem is generally considered adaptive (Karabenick & Sharma, 1994). Lastly, the fourth phase of behavior regulation, behavioral reaction and reflection, is comprised of an individual's choice of behavior, a result of reaction to past behavior.

Finally, the last area to which self-regulation can be applied is context. The first phase of this area is comprised of contextual forethought, planning, and activation. In this phase, individuals focus on contextual regulation and direct their attention towards the task and context. Thus, the cell of this phase and area is comprised of activation of knowledge pertaining to the context, in the form of general knowledge about the classroom and task. It is important to note that perception of classroom norms can affect individual's knowledge about general norms. For example, if a learner is presented with a learning task and perceives that he/she does not have much autonomy, then their approach to learning may alter because of this perception (Boekaerts, Pintrich, & Zeidner, 2000). However, learning tasks are rarely static and contextual conditions are apt to change. Thus, a learner needs to not only perceive the classroom norms, but also monitor changing contextual conditions and tasks. Phase two, contextual monitoring, captures this important aspect of self-regulated learning. The monitoring process is closely linked to control and regulation. Contextual regulation and control, as defined in the fourth phase, may be difficult to regulate due to the nature of the context. That is, while cognition, motivation, and behavior are under the direct control of the individual, contextual control may be under external influence, such as an authority figure. From a SRL perspective, strategies to control the context and optimize learning include shaping or restructuring the learning environment (Zimmerman, 1998a). Lastly, in the contextual reaction phase, learners reflect about the task and/or classroom environment and these reflections can feed back into the first phase of contextual regulation, contextual forethought, planning, and activation.

Methods Used to Measure SRL

Because these four areas and phases, as proposed by Pintrich (2000), offer a detailed look at what should be examined in the field of SRL, this framework was used as the foundation of this study. However, when designing a methodology to study these four areas and phases, it is necessary to account for the properties of SRL. That is, Winne (1997) proposed that SRL can be viewed as having two properties, *aptitude* and *event*. An aptitude is a relatively enduring trait of an individual which can be used to predict future behavior. When viewing SRL as an aptitude, contextual variables and domain are not considered dynamic forces affecting self-regulation in learning (Boekaerts, Pintrich, & Zeidner, 2000). For example, if a student indicates that he/she uses summarizing strategies when learning about science topics, then it is assumed that this student exhibits this behavior regardless of domain (e.g. science versus social studies topics). When SRL is considered an event, on the other hand, then contextual variables assume a much different role. Self-regulation as an event suggests that SRL unfolds within particular contexts (Boekaerts, Pintrich, & Zeidner, 2000). For example, a student may use a summarizing strategy to learn about the circulatory system in science class but, due to contextual variables associated in his/her math class, choose not to use the same summarizing strategy for math homework. Because viewing SRL as an aptitude or an event carries distinct assumptions about the properties of SRL, different methodologies are associated with these two properties. Thus, when addressing the research questions in this study, it is necessary to first indicate whether SRL will be viewed as an event or aptitude because this decision will determine the protocol used in the methodology. The following section will briefly outline strengths and weaknesses of the most frequently used protocols when measuring SRL as either an aptitude or an event.

When SRL is considered an aptitude, it is assumed that a single measurement aggregates a quality of SRL based on multiple events because an aptitude is relatively stable (Winne & Perry, 1999). Based on this assumption, obtaining an individual's interpretation of their metacognitive and cognitive processes allows for the understanding of how an individual will self-regulate in the future. Thus, student's self -perceptions of their self-regulation may be captured to determine their self-regulation when learning. These perceptions often are derived from responses to questionnaires, with self-report questionnaires being the most frequently used protocol for measuring SRL as an aptitude (Winne & Perry, 2000). Relatively easy to design, administer, and score, self-report protocols are an efficient tool to capture an individual's self-perception of their actions. There are several self-report questionnaires that are most frequently used, including the *Learning and Study Strategies Inventory* (LASSI) (Weinstein, 1987). Composed of 77 items, including declarations and conditional relations, this self-report questionnaire was “designed to measure use of learning and study strategies” (Weinstein, 1987, p.2) by undergraduate students. The *Motivated Strategies for Learning Questionnaire* (MSLQ) also includes declarations and conditional relations, but was developed to additionally assess “college students’ motivational orientations and their use of different learning strategies for a college course” (Pintrich etal., 1991; p. 3). Another protocol, structured interviews, allows for individuals to provide verbal descriptions. Lastly, teacher judgments have been used to measure SRL as an aptitude (Perry, 1998). Though teacher judgments have been used relatively infrequently, teachers are in the position to uniquely examine students’ SRL.

While protocols that measure SRL as an aptitude attempt to capture stable behavior, protocols that measure SRL as an event are designed to capture the dynamic nature of SRL. For example, *error detection tasks* are designed to measure learners’ monitoring and control in a specific context by introducing errors into material. Inducing errors allows the researcher to observe when and whether the learner (a) detects the error and (b) what the learner does once the error is detected. Monitoring in these tasks has been measured by both asking the students to mark the errors (e.g. by underlining) or through eye fixations (Boekaerts, Pintrich, & Zeidner, 2000). When students underline, it is considered an observable indicator of their cognition and researchers have labeled such indicators as *traces* (Winne, 1982). In these trace methodologies, it is assumed that when a learner marks the text (such as underlining), they are discriminating that content from the surrounding content. In addition to examining the learner and his/her immediate learning task, protocols measuring and capturing SRL as an event have begun to account for relationships between the learners’ behavior and context. These protocols stress the influence of contextual variables on SRL variables, including evaluation standards and classroom climate (Turner, 1995).

Lastly, the *think aloud* methodology offers a powerful online, process methodology when examining SRL. In this protocol, the learner thinks aloud while engaged in a learning activity. While the think aloud protocol has been most popular in reading (Pressly & Afflerbach, 1995), it has been shown as an excellent tool to gather verbal accounts of SRL and map out the use of self-regulatory skills (Boekaerts, Pintrich, & Zeidner, 2000). The think aloud, considered a trace methodology, has an extensive history in cognitive psychology and cognitive science (see Newell & Simon, 1972, Ericsson & Simon, 1993 for an extensive review). For example, Azevedo, Guthrie, and Seibert (2004) used the think aloud methodology to examine the role of SRL in fostering students' conceptual understanding of complex systems while using hypermedia. This study is not isolated in demonstrating the utility of the think-aloud methodology to measure the dynamic phenomena of SRL. Other studies have supported the effectiveness of the think-aloud, including Azevedo, Winters, and Moos (in press). In this study, the think-aloud methodology was used to examine the dynamics of self- and other-regulatory processes in students' collaboration while learning about the circulatory system with hypermedia. The proven capacity of the think-aloud to capture what learners actually do in a dynamic learning situation provides support for the use of this tool to measure SRL (Winne & Perry, 2000). In addition, a common criticism of methodologies measuring SRL as an aptitude, such as self-report questionnaires, is that they measure learners' self-perceptions of their SRL, and thus assume that a learner can accurately recall their self-regulatory behavior in a dynamic learning situation. While self-report questionnaires are an efficient tool to gather data on self-regulatory behavior, the current design of these tools may not be able to capture the dynamic nature of SRL because students may not always be able to accurately recall their SRL. Thus, given the strengths of the think-aloud, and weaknesses of other protocols, the think-aloud was used in this study.

However, while studies have supported the think-aloud as a powerful tool to capture the dynamic nature of SRL, there are some potentialweaknesses that should be addressed. As highlightedby Ericsson and Simon (1993), a potential exists that thinking aloud while engaged in performing a task alters the sequence of thoughts. However, as noted by Ericsson and Simon (1993), the sequence of thoughts is less likely to change when participants are instructed to verbalize only the information they attend to while performing a task. That is, the participants are instructed to verbalize, but not describe, their thoughts while engaged in a task. Thus, in order to address this potential weakness, the think-aloud methodology should instruct participants to simply verbalize the information they attend to, but not describe or explain what they are doing, while engaged in performing a task. Another potentialweakness is the variability that can exist in the participants' ability to verbalize their thoughts while engaged in a task. This variability exists due to individuals' varying levels of access in describing what they are doing. For example, an individual may be able to perform an action very well, but not have the conscious access to describe this action. If this were the case, then the think-aloud may underestimate the use of SRL variables in individuals that do not have the conscious access to describe their thoughts while engaged in a task. However, this variability can be adequately controlled in the data analysis and will be addressed in this section of the paper.

Next Steps in SRL Research

By focusing on common assumptions and methodologies, the preceding discussion of theoretical and methodological issues gives the false impression that the field of SRL is more unified and distilled than it is. In reality, there are a number of perspectives utilizing different constructs and distinct methodologies. Moreover, even within coherent and systematic lines of research, there are more questions than answers. Hence, the field of SRL has a number of issues that need to be resolved in future research. While a handful of major philosophical, theoretical, conceptual, and methodological issues have been identified (see Boekaerts, Pintrich, & Zeidner, 2000; Zimmerman & Schunk, 2001), there are two gaps in our current knowledge that are particularly salient to the field of SRL. First, there is a need to integrate individual differences into the study of SRL as many of theories do not directly assess individual differences. For example, the SRL theorists examining SRL from a constructivist lens usually address developmental issues in the acquisition of SRL, but do not typically measure individual traits with the exception of age (Paris, Brynes, & Paris, 2001). The Information-processing theory of SRL (Winne, 2001; Wiine & Hadwin, 1998), on the other hand, usually focuses on one point in time, but does not speculate about developmental trends or individual differences in the acquisition of SRL. Assessing how individual characteristics influence self-regulated learning would greatly add to the field of SRL (Boekaerts, Pintrich, & Zeidner, 2000). Individual characteristics such as task value, extrinsic motivation, and intrinsic value have been shown to affect learning and thus may have a mediating effect on SRL (Boekaerts, Pintrich, & Zeidner, 2000). Fortunately, a measure has already been developed that measures these individual characteristics. The *MSLQ*, a self-report questionnaire, is an assessment of these attributes and is an efficient and easy tool to administer.

In addition to individual characteristics, the field of SRL can benefit from incorporating the findings from the field of goal orientation. As previously mentioned, one of the underlying assumptions found in most SRL theoretical perspectives is that behavior is goal-orientated and that goals serve as a criterion in which the learner can gauge and modify behavior. Because of this underlying foundation, the field of SRL is inherently linked to the field of goal orientation and a bridge between the two fields would greatly add to the literature. Specifically, research should examine the relationships between the goal structure of a learning task, an individual's goal orientation, and their self-regulatory behavior. As highlighted in the introduction, contextual variables, such as the goal structure of a learning task, may influence how students learn through its relationship with the student's goal orientation and their learning strategies. Whereas a few studies have examined how goal orientation affects the extent of self-regulatory behavior, this research has viewed SRL primarily as an aptitude. For example, Bouffard, Boisvert, Vezeau, and Larouche (1995) examined the impact of goal orientation on self-regulation and performance among college students. However, while the researchers found a relation between goal orientation and SRL, their use of self-report questionnaires to measure SRL indirectly implies that SRL is an aptitude. Given the recent trend to view SRL as an event, using the think aloud methodology in this study to examine how the goal structure affects the extent of self-regulatory behavior may shed more insight into student learning.

In addition to incorporating findings from the field of goal structure and orientation, the field of SRL would also benefit from developing research that examines whether students use the same proportion of SRL in different domains. Though there is research on students' SRL in one learning task focusing on one specific domain, researchers, to my knowledge, are presently unclear on whether students use the same proportion of SRL variables in two different domains. Furthermore, it is unclear what contextual variables are related to students' use of the same self-regulatory skills in different domains (see Boekaerts, Pintrich, & Zeidner, 2000). Researchers who give questionnaires presume that people are self-regulated across contexts, but little experimental work has shown cross-situational use of self-regulatory variables. This paper addresses this issue, and the following section provides a brief literature review on field of goal orientation.

Literature Review of Goal Orientation

Introducing Goal Orientation

Research on the goal structure of a learning environment and individuals' goal orientations has been the focus of recent research in the field of motivation and self-regulated learning (Maehr & Pintrich, 1991). As proposed by Ames (1992; p. 261), an individual's goal orientation represents a pattern of beliefs that leads to "different ways of approaching, engaging in, and responding to achievement situations." Achievement motivation theorists explain the different ways that individuals approach, engage in, and respond to achievement situations through focusing on behaviors involving competence. Specifically, individuals may either strive to avoid incompetence or aspire to attain competence in achievement situations (Elliot & Harackiewicz, 1996). This approach-avoidance dichotomy was evident in the earliest achievement motivation approaches to goal orientation. As early as 1944, Lewin and his colleagues identified these two motivational orientations as critical components of goal orientation in learning environments. This theory became refined in the late 1970s when researchers coined the term *achievement goal* (see Nicholls, 1979, 1984). In the mid 1980s, three goals were differentiated that presented a more complete picture of the spectrum of motivational orientations in goal orientations (see Dweck & Elliot, 1983, Nicholls, 1984). These goals comprised of two types of approach orientation (e.g. to master material and to gain approval) and an avoidance orientation (to avoid unfavorable judgments from peers and/or teachers).

However, this approach-avoidance distinction received very little empirical support in the mid 1980s and was soon abandoned (Elliot & Harackiewicz, 1994). Collapsing these three goal orientations into two categories, achievement motivation researchers began to suggest that there are two general orientations an individual can adopt: an ability/performance orientation in which the student is concerned with demonstrating his/her ability in relation to his/her peers, or a learning goal orientation in which the student is more concerned with mastering the material (Wolters, Yu, & Pintrich, 1996). Since this convergence, contemporary achievement theorists have offered several revised models of the achievement goal frameworks. For example, while Deci and Ryan (1985) distinguish between mastery and competitive goals, Ames (1984) distinguished between mastery and ability goals, and Roberts (1992) differentiated between mastery and competitive goals. While researchers have focused on differing goal frameworks, Elliot and Harackiewicz (1996) suggested that these theories are conceptually similar and all of them either implicitly or explicitly characterize both performance and mastery goals as approach forms of motivation. Despite this trend in converging goal orientations into a dichotomy, some researchers have advocated a trichotomous approach to goal orientation, as originally suggested by achievement goal theorists in the mid 1970s and late 1980s. For example, Elliot & Harackiewicz (1996) have called for a reconsideration of goal theory consisting of a mastery goal and two performance goals. More specifically, they suggested that the two performance goals should encompass a goal orientation aimed at avoiding the demonstration of failure or incompetence and a goal orientation that is directed at demonstrating competence. Elliot & Harackiewicz (1996) advocated that a framework including three goal orientations, *mastery, performance-approach*, and *performance-avoidance,* better captures the spectrum of motivation in goal orientation and offers orientations grounded in self-regulation according to the outcomes of the goal orientation. In fact, these researchers found that the three goal orientations distinctly affected self-regulating learning (see Elliot & Harackiewicz, 1996). Because these findings provide empirical evidence supporting the differential effect of the three goal orientations on SRL, the methodology of this study includes a trichotomous approach to goal orientation.

Goal Orientation and Learning

There has been ample research examining the role of goal orientation on learning outcomes. For example, a substantial amount of research has linked mastery-goal orientation to a wide range of motivational variables (Nicholls et al. 1985). These variables, in turn, are conducive to positive achievement activity, which are necessary mediators to self-regulated learning (Ames & Archer, 1988). In particular, when mastery goals are adopted, guilt is associated with inadequate effort (Wentzel, 1991a; Wentzel 1991b), and satisfaction and pride are associated with successful effort (Jagacinski & Nicholls, 1987). In addition, a mastery goal adoption has been associated with active engagement in learning. Active engagement, as proposed by Elliot & Harackiewicz (1996), is defined when an individual demonstrates the use of effective problem-solving strategies, the belief that adaptation of a strategy can overcome failure, and that effort leads to success. Thus, the findings linking mastery goal orientations to learning suggest that this orientation promotes high-quality involvement in learning.

Research on performance-orientated goals, on the other hand, has been more muddled. The earlier goal theory, in which performance-approach was not distinguished from performance-avoidance, found negative relations between cognitive, motivational, and behavioral outcomes and performance goals (Pintrich & Schunk, 1996). However, more recent research discriminating between performance-avoidant and performance-approach goals has demonstrated some differential relations between these two goals and learning outcomes. In particular, more positive aspects can be associated with a performance-approach orientation than with a performance-avoidance orientation. That is, according to Harackiewicz et al. (1998), students with a performance-approach orientation may use certain strategies or goals because they desire to attain favorable judgments. These strategies may lead them to be more involved in the learning task than those who are trying to avoid certain goals (performance-avoidance), which in turn could lead to increased learning outcomes. Those have adopted a performance-avoidance orientation may try to avoid certain goals and may become more withdrawn and less engaged in the task (Higgins, 1997). The outcome of this lack of involvement may lead to decreased learning outcomes.

Goal Orientation and Self-Regulated Learning

In addition to examining the relation between goal orientation and learning, recent research has begun to examine the relation between goal orientation and SRL. For example, in terms of the four phases and four areas as proposed by Pintrich (2000), much of the research on cognitive self-regulation has focused on monitoring and control (Boekaerts, Pintrich, & Zeidner, 2000). Methodologies using mostly self-report data from correlational studies have found a positive relation between monitoring and self-regulation. Specifically, students who adopt a mastery goal orientation are more likely to exhibit behaviors such checking for understanding and comprehension monitoring (Wolters et al., 1996). This behavior is characterized as cognitive monitoring and differentiates students who endorse a mastery goal relative to those who adopt a performance goal. In addition to literature on cognitive monitoring, research has also found a positive relation between cognitive control (in the form of cognitive strategies) and mastery goals. For example, a positive correlation has been found between the deeper cognitive processing strategies, such as elaboration strategies in the form on summarizing, and mastery goals (Pintrich et al. 1993). In addition, superficial processing strategies, such as rehearsal, have been found to be negatively related to the adoption of mastery goals (Anderman & Young, 1994).

Given the positive relations found between the adoption of mastery goals and cognitive self-regulation, it is not surprising that researchers have found similar relations between mastery goals and motivational regulation. Many of the findings were derived from correlational data that indicated a strong positive relation between motivational components such as interest, task value, and mastery goals (Boekaerts, Pintrich, & Zeidner, 2000). In addition, other research has generally demonstrated that adoption of mastery goals is positively correlated with a student's belief that effort will lead to success, while failure can be attributed to a poor strategy selection or low effort (Pintrich & Schunk, 1996). This approach is considered an adaptive pattern of attribution which allows a student's affect to remain positive and future expectancies to remain constant when that student is faced with a difficult task (Weiner, 1986).

Though the research examining the relation between mastery goals and behavioral and contextual regulation is not as substantial, there have been some findings suggesting a positive relation. For example, Pintrich et al. (1993) presented findings that suggest time and effort management is more positively related to undergraduate's adoption of mastery goals. In addition, adaptive help seeking, a crucial aspect of behavioral self-regulation, has been found to be positively associated with a mastery goal adoption (Ryan & Pintrich, 1997). All of these findings on the relation between the adoption of a mastery goal and self-regulation suggest that mastery goals are generally related to the use of effective self-regulatory skills.

Though there has also been research on the relation between performance goals and self-regulated learning, the findings are slightly more muddled due to the convergence and later distinction of performance-approach and performance-avoidance framework. Research that did not distinguish between these two performance orientated goals suggested a negative correlation between performance goals and deeper cognitive strategies (Bouffard et al., 1995). Given the nature of performance goals, these findings are not surprising. If a student adopts a performance goal and is most interested in besting others and/or demonstrating their ability to their peers, then this student may be less willing to show others that they lack ability. As a result, this student may be less likely to use behavior that could expose them as incompetent, such as exerting the necessary effort to use deeper cognitive strategies. However, recent research advocating a distinction between performance-approach and avoidance goals suggests that this distinction yields different relations with SRL. Wolters et al. (1996) suggested that having an external criterion may actually lead to the use of deeper cognitive strategies. For example, when students are presented with learning tasks that do not capture their interest or challenge, focusing on besting others may make the learning task less boring and, as a result, could lead the student to use more self-regulatory skills. However, it is generally concluded that while the adoption of a performance-approach goal may lead to the use of similar self-regulatory behavior relative to the adoption of mastery goals, it is generally agreed that the adoption of a performance-avoidance goal is related to the use of more superficial cognitive regulation (Boekaerts, Pintrich, & Zeidner, 2000).

As suggested by Dweck's original work, a student's self-efficacy (a belief in their competence to complete a task) plays a mediating role between performance goals and achievement, motivational, and cognitive outcomes (Dweck & Leggett, 1988). This complexity is especially salient when examining the relation between performance goals and motivational regulation. Dweck & Leggett (1988) suggest that performance goals are not detrimental to achievement, motivational, and cognitive outcome if a student has a high self-efficacy level. In fact, if a student has both a high self-efficacy and a performance goal orientation, it has been suggested that they would demonstrate a similar pattern of self-regulated behavior as a student who adopts a mastery goal orientation (Boekaerts, Pintrich, & Zeidner, 2000). However, Dweck and Leggett (1988) found this similarity with the mastery goal orientation only with the performance-approach goal orientation. That is, those students who demonstrated that they desired to avoid looking incompetent (performance-avoidance) exhibited maladaptive patterns of behavior, cognition, and motivation.

Finally, some research has examined the relation between performance goals and behavioral and contextual regulation. In this phase of self-regulation, knowing when and how to appropriately seek help is a crucial component of self-regulation (Byrnes, 1998; Newman, 1994). Thus, it is not surprising that studies examining the relation between performance goals and behavioral and contextual regulation have found a negative correlation. Students that focus on avoiding looking incompetent, or concerned with besting others, are less likely to seek help (Ryan & Pintrich, 1997). The behavior of seeking help may be seen as a public display that reflects poorly on ability, and thus those students with either a performance-avoidance or performance-approach goal may be less likely to engage in this type of behavior. In sum, findings have suggested that in certain contexts performance-approach goals, but not performance-avoidance goals, may elicit deeper motivational regulation similar to the regulation associated with mastery goals.

In addition to considering what previous literature has found on the relation between goal orientations and self-regulated learning, this study must also address the issue of the relationship between an individual's goal orientation and the goal structure of a learning environment (such as a hypermedia environment). Wolters, Yu, and Pintrich (1996) have suggested that an individual's goal orientation is more global than task-specific goals. Furthermore, Pintrich & Schunk (1996) have asserted that goal orientations may be a stable trait that reflects relatively stable individual differences. These assertions suggest that it is difficult, if not impossible, to experimentally induce a goal orientation through the goal structure of a learning task because an individual's goal orientation is stable across domains. Thus, if individuals do indeed have pre-existing goal orientations, the effects of experimentally inducing goal orientations in this study may be muted. Furthermore, some research suggests that goal orientations may not be exclusive to one another (e.g. an individual with a mastery goal orientation exclusively seeking mastery in all contexts), and that individuals can maintain several goal orientations simultaneously. For example, research suggests that social goal are not linked to broader goal orientations (Wentzel,1991a). Thus, this research indicates that it may be more appropriate to suggest that learning contexts have reward structures, as opposed to goal structures, which either do or do not align with a person's goal orientation but do not directly influence an individual's goal orientation.

However, it has also been suggested that a classroom environment can influence an individual's adoption of a goal orientation (Ames, 1992). Ames (1992) suggests that there are salient structures in the classroom and the way in which students experience these structures can affect their goal orientation. For example, she suggests that the design of learning activities and tasks are a central element of the classroom, and that the perception of these tasks can influence the students' willingness to apply strategies, their feelings of satisfaction, and how they approach learning. More specifically, she suggests that tasks which are focused on developing the understanding of the content of the activity are much more likely to promote learning that is consistent with a mastery goal orientation. On the other hand, she indicates, if the evaluation in the task includes a normative reference of recognition, then students are more likely to shift their goal orientation to a performance-orientation. The role of the task structure in learning, as highlighted by Ames (1992), has been corroborated by several studies.

For example, Elliot and Harackiewicz (1994) designed an experimental learning task in which they experimentally induced individual goal orientations of the participants. In this study, the participants were placed in one of three conditions that were differentiated by one of three goal-orientations: *mastery, performance-ability,* and *performance- approach.* The performance-approach and performance-avoidance goal orientations were experimentally induced by giving directions to the participants that differentially highlighted potential achievement outcomes and established a normative for evaluation of the participants' performance. The mastery goal orientation was induced by providing directions that focused the participants' attention on the task itself and downplayed a normative evaluation of their performance. The findings suggested that only the performance-avoidance goal condition, and not the performance-approach condition, produced negative effects on learning relative to the mastery goal orientation. In addition to this study, Elliot and Harackiewicz (1994) conducted a pilot study to ensure that the goal orientation manipulations did indeed induce their respective goal orientation in the participants. The findings from this pilot study suggest that the manipulations prompt differential goal orientations that correspond to the manipulation.

In summary, some recent research in the field of goal orientation has advocated the inclusion of three goal orientations and has examined the relations between these goals and self-regulated learning. Generally, a mastery goal orientation is related to deeper cognitive processes in self-regulated learning, while performance goals are related to the more superficial processes. However, as some recent research has highlighted, a performance-approach, but not performance-avoidance, goal orientation may lead to deeper cognitive processes if the individual benefits from an external criterion in the specific context and learning task. Research has examined these relations with both self-report questionnaires, such as the *MSLQ*, and methodologies that experimentally induced goal orientations. Based on these previous findings, this study used a modified version of Elliot and Harackiewicz (1994) methodology of inducing goals. That is, the participants in this study were placed in one of three conditions that were differentiated by one of three goal structures: *mastery, performance-ability,* and *performance approach.* The performance-approach and performance-avoidance goal structure was designed to experimentally induce performance-approach and performance-avoidance goal orientations, respectively, by giving directions to the participants that differentially highlighted potential achievement outcomes and establish a normative for evaluation of the participants' performance. The mastery goal structure was designed to experimentally induce a mastery goal structure by giving directions to the participants that focused the participants' attention on the task itself and downplayed a normative evaluation of their performance. However, it should be noted that while the results of this study will be examined through the theoretical framework that supports the three distinct goal orientations, the discussion will also address the results in the light of other goal orientation theories that do not support this approach.

Literature Review of Hypermedia Environments and Complex Systems

Cognitive tools are defined as tools that are developed with the aim of enhancing the cognitive capabilities of humans during problem solving, thinking, and learning (Derry & Lajoie, 1993; Jonassen & Reeves, 1996; Lajoie, 2000). Computer-based learning environments (CBLEs) have begun to assume the role of cognitive tools. The classic model of computers as cognitive tools in education has suggested the "tutor, tool, and tutee" approach (see Taylor, 1980). That is, earlier technologies as cognitive tools were designed to encode information in predefined boundaries and transmit the knowledge to the learner. However, more recent trends in using computers as cognitive tools deviate from this approach by providing the learner with an environment in which the learner can pursue personal goals and solve challenging problems (Jonassen & Reeves, 1996). Thus, the boundaries are not predefined as they were in earlier technologies.

However, in order to build a CBLE that is an effective cognitive tool, an underlying learning theory must drive the design (Lajoie, 2000). While the instructivist learning theory has been the traditional framework, the constructivist approach has begun to gain similar attention and respect (Duffy & Jonassen, 1992). The instructivist approach advocates that educational communications transmit standardized interpretations of the world to the learner, and feedback and reinforcement aid learners to mirror the accepted views of reality (Jonassen & Reeves, 1996). On the other hand, the constructivist learning theory suggests that the learner constructs knowledge according to his or her own knowledge, experiences, and beliefs and that acquisition of knowledge comes from learners' participation and interaction with the surrounding environment (Jonassen &

Reeves, 1996). Thus, cognitive tools that are based on a constructivist learning theory embrace the learners' goals, tasks, culture, and resources so that they may engage in active reflection and interpretation. Furthermore, Jonassen and Reeves (1996) suggest that technology can be an effective cognitive tool, but its greatest effect will occur when technological advances are embedded in a constructivist learning environment.

This support for technology as a cognitive tool has led to recent technological inclusions in our educational system, such as hypermedia environments. Hypermedia is a close cousin to its earlier form of hypertext in which text is displayed in a nonsequential and nonlinear method (Jonassen, 1989). Based on a constructivist approach, this design allows for information to be displayed in a manner that is more meaningful to the learner than to the designer of the hypertext program (Nelson, 1980). That is, the nonlinear and non-sequential attribute of the hypertext environment allows the learner to access information that they see fit, and not in a predetermined and constrained format as determined by the designer. Hypermedia is an extension of hypertext in which audio, video, animation, and/or graphics are integrated with the text.

The basic unit of hypermedia environments is nodes, which consist of fragments of media or text (Jonassen & Reeves, 1996). Consisting of a video clip, sound bite, graphic, page of text, or even an entire document, the node is the information storage of the hypermedia. The structure of nodes in a hypermedia environment typically creates a dynamic knowledge base because the learner can access any node and in multiple sequences, depending on his/her interests and motivations. The access of these nodes is flexible because of the links between the different nodes. Typically interconnecting and associative in nature, these links enable the learner to flexibly progress through the nodes.

Nodes are generally highlighted by hot spots on the screen and are activated by either clicking on the hot spot or pressing an associated keyboard key. Once the hot spot or associated key is clicked, the learner will be linked to another node of information. In sum, the nodes comprise the information base of hypermedia environments, and the links allow the learner to freely navigate the network of nodes.

The ability to navigate freely through hypermedia environments define this cognitive tool as “learner controlled instruction” because this instructional context gives the learner some degree of freedom with the respect to the “path,” “flow”, or “events” of instruction (Williams, 1996). Consistent with the constructivist approach mentioned earlier, Hartley (1985) advocates that a learner’s participation in the construction of mental structures, such as afforded by the learner-controlled instruction in hypermedia environments, facilitates the learning of complex knowledge structures. However, though there has been ample research on the interaction between learner-controlled instruction and learning, empirical research has produced mixed results on the effectiveness of such an instructional context. Most of this research has compared learner-controlled and program-controlled treatment conditions (Williams, 1996). For example, while researchers such as Morrison, Ross and Baldwin (1992) found that program-controlled treatments were superior to learner-controlled treatments with respect to posttest achievements, other researchers such as Ellermann and Free (1990) found that learner-controlled instructional contexts fostered higher levels of learning. Researchers begun to question why these mixed results exist and why some learners can effectively use a learner-controlled learning environment whereas others have difficulty using these cognitive tools to learn.

Williams (1996) suggests that there are some possible explanations to this variability, including rational-cognitive and emotional-motivational aspects of choice and learning. For example, several researchers (e.g. Milheim & Martin, 1991) have suggested that two kinds of cognitive traits, ability and prior knowledge, may explain how students use learner-controlled environments. According to Williams (1996), individuals may make appropriate choices in how they use hypermedia environments, but these choices reflect their own perceptions of the learning task and not necessarily the optimal choice as determined by an external source. As such, the learner's prior knowledge and ability will dictate whether their choice coincides with the optimal choice. In terms of emotional-motivational aspects of choices in hypermedia environments, Williams (1996) suggests that it is necessary to understand the motivations for the learner's particular choices. Understanding certain individual variables may allow for a better understanding of why some individuals effectively use a learner-controlled environment where others cannot. Such variables as extrinsic and intrinsic motivation, as well as task value, may play a role in an individual's motivation when using a hypermedia environment.

Despite these mixed results on the effectiveness of learner-controlled instruction, hypermedia environments have been used as educational tools, especially with complex systems. According to Hmelo-Silver & Pfeffer (2003), understanding complex systems is difficult because it requires abstract thought and can challenge an individual's current beliefs regarding the phenomena. Furthermore, complex systems are comprised of multiple levels of organization that depend on local interactions not necessarily intuitively apparent (Ferrari & Chi, 1998; Wilenski & Resnick, 1999). For example, in the circulatory system, transportation of blood occurs at the organ system level as well as at a cellular level. An understanding of this interdependent and dynamic relationship may present a substantial hurdle to the acquisition of deep conceptual knowledge of complex systems such as the circulatory system (Feltovich, Coulsen, Spiro, & Dawson – Saunders, 1992; Chi, 2000). Narayanan and Hegarty (1999) suggest that a possible reason for this hurdle is that the working memory assumes an enormous load with the processing of these interdependent and dynamic relationships. Furthermore, the nonlinear, intermediate steps that characterize these relationships may place an additional load on a learner's working memory (Perkins & Grotzer, 2000). Perkins and Grotzer (2000) have also demonstrated that learners typically do not focus on the underlying function, but rather concentrate on the structure of systems. This approach to learning does not allow for deep conceptual understanding of complex systems. In order to effectively learn complex systems, students must be presented with cognitive tools that allow them to learn about the dynamic network of concepts that define the system. As highlighted earlier, technological advances such as hypermedia environments, present learners with a cognitive tool that incorporates a variety of presentations, including text, audio, and video clips which may be effective in teaching complex concepts.

Recent research has begun to examine how students use hypermedia environments to learn complex systems. For example, Azevedo, Guthrie, & Seibert (2004) demonstrated that learners can effectively use hypermedia environments to learn about complex systems such as the circulatory system. Using the think-aloud methodology to capture SRL at a fine-level of analysis, research such as this has been able to identify specific SRL variables that are related to the learning of the circulatory system with a hypermedia environment. Additional research has also demonstrated that in order to effectively use hypermedia environments to learn about complex science topics, it may be necessary to deploy certain SRL variables. For example, Azevedo, Winters, and Moos (2004) found that low-achieving students may have difficulty learning about science-related topics with a hypermedia environment due to their limited use of specific SRL variables while using a hypermedia environment. However, while research such as this has provided insight into *what* SRL skills are related to learning of complex systems with hypermedia environments, research, to the best of my knowledge, has not directly examined *why* students use specific SRL skills while learning about complex systems with a hypermedia environment. By combining process and product data into one study, these two issues may be addressed.

Self-Regulation, Goal Orientation, and Hypermedia Environments: Knowns and Unknowns

The preceding sections suggest that there may be links between the fields of SRL, goal structure and orientation, and learning with hypermedia environments. All of these fields have examined the phenomenon of student learning and have focused on student and contextual factors. However, to the best of my knowledge, a study has not been conducted that integrates the findings from these fields while using product and process data.

Research Question and Hypotheses

In summary, the findings presented in the literature review of the SRL, goal orientation, and learning with hypermedia environments are the theoretical and empirical foundations for the research questions and hypotheses of this thesis. The three specific research questions of this study are:

1) Is the goal structure of the two learning task related to the proportion of SRL variables in the two learning tasks?

2) Is the goal structure of a learning task related to the learning outcome, as measured by a posttest?

3) Is the goal structure of the learning task related to intrinsic motivation, extrinsic motivation, and/or task value?

Based on previous research in the three fields, three hypotheses are proposed:

1) When the proportions of SRL variables in the two learning tasks are examined within each condition and learning task, it is hypothesized that the participants in the mastery and performance-approach condition will use similar proportion (i.e. non-significant difference) of SRL variables in the two learning tasks. However, it is hypothesized that the participants in the performance-avoidance condition will use a significantly different proportion of SRL variables in the two learning tasks.
2) Because it is hypothesized that the participants in the mastery and performance-approach will use a similar proportion of SRL variables in the two learning tasks, it is hypothesized that the participants in these two conditions will have similar (i.e. non-significant difference) scores in the two posttests. However, because it is hypothesized that participants in the performance-avoidance condition will use a significantly different proportion of SRL variables in the two learning tasks, it is hypothesized that participants in this condition will have different scores on the two posttests.

3) It is hypothesized that the participants' task value, extrinsic motivation, and intrinsic motivation will be differentially related to the three different conditions.

Chapter III: Method, Procedure, and Data Analysis

Method

Participants

Participants were 64 undergraduate students recruited from undergraduate classes at the University of Maryland, College Park. The participants received extra credit in their classes for participating in this study. Their mean age was 21.00 (*SD* = 3.75); there were 47 women (63%) and 17 men (27%). These students reported minimal prior knowledge of the circulatory and respiratory system on the participant questionnaire.

Research Design

A 3 (condition: mastery goal orientation [A], performance-approach orientation [B], performance-avoidance orientation [C]) x 2 (learning task: learning task 1, learning task 2) with repeated measures design was utilized. The participants were randomly assigned to one of three conditions. In addition to posttests at the end of each learning task, verbal data was collected using a think-aloud protocol methodology (Ericsson & Simon, 1993).

Measures and Materials

Prior to the start of the study, participants read and signed the consent form (see Appendix A), adapted from Dr. Roger Azevedo's previous work on self-regulated learning in hypermedia environments. In addition to the consent form, participants completed a participant questionnaire (see Appendix B), which solicited the participants' age, gender, current GPA, class, academic major, previous biology classes taken, and any previous related work experience (in the field of health and/or medicine). The participants also completed three measures from the MSLQ before both learning tasks

(Pintrich et al., 1991; see Appendix C for complete MSLQ and Appendix D for the three MSLQ measures used in this study). The complete MSLQ questionnaire consists of 81 items answered on a 7 point Likert scale (1=not at all true of me, 7=very true of me), and these 81 items fall into nine scales. This study used three of the nine scales [intrinsic motivation, extrinsic motivation, and task value]. The intrinsic motivation and extrinsic motivation scales include 4 items each, and the task value scale includes 6 items. The participants also completed two posttests, one after each learning task. Both of the posttests (one on the circulatory system and one on the respiratory system) were constructed in consultation with a former science teacher who is also familiar with the content presented in the hypermedia environment. Each posttest had 12 multiple-choice declarative knowledge questions and was designed by the researcher and the former science teacher to reflect the material presented in the hypermedia environment (see Appendix E for circulatory system posttest and Appendix F for the respiratory system posttest). In addition, every participant received the same four questions during each learning task that were designed to guide his or her learning throughout the task. All four learning task questions were given to the participant at the beginning of the twenty-minute learning task and were displayed on a magnetic board positioned by the computer (see Appendix G for the circulatory system learning task questions and Appendix H for the respiratory system learning task questions).

Hypermedia Environment

During the two learning tasks, participants used the Microsoft Encarta Reference Suite™ (2003) hypermedia environment. This DVD was installed onto the hard-drive of a 486 MHz laptop computer with an 11-inch color monitor and sound card. Participants were given access to the entire DVD and could freely search while learning about the circulatory or respiratory system. However, participants were not allowed to use the dictionary portion nor were they able to use the Internet to access web links during the learning task. In this hypermedia environment, the circulatory system has three particularly relevant articles (the heart, circulatory system, and blood articles), which are comprised of 16,900 words, 35 illustrations, 107 hyperlinks, and 18 sections. The respiratory system consists of two particularly relevant articles (the respiratory system and lung articles), which are comprised of 13,282 words, 14 illustrations, 68 hyperlinks, and 11 sections. See Appendix I for hypermedia screen shots of the respiratory system and circulatory system.

Experimental Conditions

As noted earlier, the 64 participants were randomly assigned to one of three goal conditions (mastery, performance-approach, or performance-avoidance) and were individually tested by the researcher. Data from 4 participants were not used due to poor audio quality and/or incomplete paper-and-pencil measures, resulting in a final sample of 60 participants and three conditions of 20 participants each. In each condition, participants were engaged in two learning tasks about science topics using the hypermedia environment. In one learning task, they learned about the circulatory system, and in the other learning task they learned about the respiratory system. The order of the science topics in the learning tasks was counterbalanced between participants.

The methodology for inducing the goal orientations through the goal structure of the learning tasks was based on previous literature (Elliot & Harackiewicz, 1998). For the first learning task, participants in all three conditions received identical directions (see

Appendix J for learning task one directions), and these directions were designed to induce a mastery goal structure. However, for the second learning task, the wording of the directions differed between conditions, with one condition receiving a mastery goal structure (See Appendix K for directions), the second condition receiving a performance-approach goal structure (see Appendix L for directions), and the third condition receiving a performance-avoidance goal structure (see Appendix M). Whereas the directions for the mastery goal structure were intended to focus the participants' attention on the task itself and downplay a normative reference for their performance, the directions for the other two conditions (i.e., performance-approach and performance-avoidance goal structure) were intended to highlight potential achievement outcomes and establish a normative reference for performance evaluation (see Table 1 for the research design).

Table 1.
Research Design

CONDITION	GOAL STRUCTURE FOR LEARNING TASK #1	GOAL STRUCTURE FOR LEARNING TASK #2
A (Mastery)	Mastery	Mastery
B (Performance-approach)	Mastery	Performance-Approach
C (Performance-avoidance)	Mastery	Performance-Avoidance

Procedure

Prior to taking part in this study, each participant read and signed the consent form. Next, participants completed the participant questionnaire and then were given a 5-minute training session of the hypermedia environment in which the most relevant articles for the first science topic (the circulatory or respiratory system) were identified. They also practiced using the navigation and search tools, and practiced accessing multiple representations (text, static diagrams, and digitized video clip). Following this training session, the participants were given the directions for learning task one. The directions were comprised of two main sections, with the first section indicating that the participant would have twenty minutes to learn about a science topic (the circulatory or respiratory system) using the hypermedia environment and that, during those 20 minutes, they would be given four questions to help guide their learning. The directions instructed the participants to "think aloud" during the learning task (see Azevedo, Guthrie, & Seibert, 2004). These directions indicated that, *"In order for me* [the researcher] *to assess how you* [the participant] *use the hypermedia environment, you are asked to "think aloud" continuously during this learning task. That is, I would like you to clearly articulate everything you are thinking and doing. For example, if you are reading, please read aloud. If you are searching for a topic, please vocalize what you are searching for and why. If you are skimming, please vocalize this behavior by stating that you are skimming and what you are skimming. If you are silent for more than a couple of seconds, I will prompt you to vocalize what you are thinking."*

After reading the directions, the participant completed the three MSLQ measures. Participants were then given 20 minutes to learn about a science topic (the circulatory or respiratory system) using the hypermedia environment, with four questions guiding their learning over the 20 minutes. All four questions were given to the participant at the beginning of each learning task, and they were displayed on a magnetic board positioned by the computer throughout the entire twenty minutes. In addition, the participant was told that he/she could answer the questions in any order of their choosing. During these twenty minutes, the participants wore a microphone so that verbal data during the learning tasks could be collected using the think-aloud protocol methodology (Ericsson &

Simon, 1993). This verbal data served as a record of their SRL variables. Additionally, the session was video-taped with the purpose of creating a back-up to the audio tape. The video-tape was positioned to capture the computer screen and the profile, but not the face, of the participant. At the end of the 20-minute learning task, participants were then given five minutes to complete the 12 question multiple-choice posttest on the science topic they had just learned about. After completing the posttest for the first learning task, the participant began the second learning task, during which he or she learned about the other science topic (either the respiratory or circulatory system). The procedure for the second learning task was identical to the procedure for the first learning task, except that the directions differed depending on the goal structure for the second task (see previous description). See Table 2 for methodological paradigm.

Table 2**.**
Methodological Paradigm

Goal Structure for Each Condition*				Goal Structure for Each Condition*			
A: Mastery	MSLQ	Learning Task #1	Posttest #1	A: Mastery	MSLQ	Learning Task #2	Posttest #2
B: Mastery	MSLQ	Learning Task #1	Posttest #1	B: Performance-Approach	MSLQ	Learning Task #2	Posttest #2
C: Mastery	MSLQ	Learning Task #1	Posttest #1	C: Performance-Avoidance	MSLQ	Learning Task #2	Posttest #2

* Note- Training phase in hypermedia environment occurs prior to instructions for both learning task

= Participants engage in think-aloud

Data Analysis

Coding and Scoring

In this section, the coding of the students' MSLQ, scoring of the two posttests, the segmentation of the students' verbalization while learning about the circulatory and respiratory system, the coding scheme of the students' regulatory behavior, and inter-rater agreement will be addressed.

Motivated Strategies for Learning Questionnaire (MSLQ)

The MSLQ questionnaire used in this study consists of 14 items answered on a 7 point Likert scale (1=not at all true of me, 7=very true of me) and the scoring of these items followed the scoring procedure as used in the scoring scheme for the complete MSLQ (see Pintrich et al., 1991). Four items relate to extrinsic motivation, four items relate to intrinsic motivation, and six items relate to task value. Each participant received one score for each of these three categories (intrinsic motivation, extrinsic motivation, task value) in each learning task. The score is calculated by dividing the sum of all the questions in each category by the number of items in each category.

Posttest

Each posttest was scored by giving each correct answer on the posttest a score of 1 and each incorrect answer on the posttest a score of 0, for a possible total of 12 on each posttest (range: 0 –12).

Student Verbalizations

The participants wore a microphone so the verbal data during the learning tasks, which served as a record of their SRL variables, could be collected using the think-aloud protocol methodology (Ericsson & Simon, 1993). In addition, the session was video-taped with the purpose of creating a back-up to the audio tape. The video-tape was positioned to capture the computer screen and the profile, but not the face, of the participant. See Appendix N for a screen shot of the video angle and participant set-up. The researcher was present throughout the entire session, and provided technical support, if necessary. In addition, the researcher provided prompts for the think-aloud during the learning task, if necessary (see Appendix O for think-aloud prompts). The raw data collected from this study consists of 2,394 minutes (39.9 hours) of audio and video recordings from 60 participants who gave extensive verbalizations while learning about the circulatory and respiratory system. During the first phase of data analysis, the audio tapes were transcribed by the researcher and a text file was created for each student. This phase of the data analysis yielded a total of 852 double-spaced pages (M = 14.2 pages per participant). This is a standard procedure used by other researchers that have utilized the think-aloud protocol (e.g. Azevedo, Winters, & Moos, 2004).

Student's Self-Regulatory Behavior (SRL)

The next phase of the data analysis comprised of coding each transcription using modified codes developed by Azevedo, Cromley, and Seibert (2004; see Appendix P for modified classes, descriptions, and examples of codes). Their model was based on several recent models of SRL (Pintrich, 2000; Winne, 2001; Winne & Hadwin, 1998; Winne & Perry, 2000; Zimmerman, 2000, 2001). This model includes key components of Pintrich's (2000) formulation of self-regulation as a four-phase process and extends these key components to capture the major phases of self-regulation. These phases include: (a) planning and goal setting, activation of perceptions and knowledge of the task an context, and the self in the relation to the task; (b) monitoring processes that represent metacognitive awareness of different aspects of the self, task and/or context; (c) efforts to control and regulate different aspects of the self, task, and context; and, (d) various kinds of reactions and reflections on the self and the task and/or context. The codes used in this study are also based on Azevedo, Cromley, & Seibert's (2004) inclusions of SRL variables derived from students' self-regulatory behavior that are specific to learning with a hypermedia environment (e.g., find location in environment). The coding scheme in this study was modified from Azevedo, Cromley, & Seibert's (2004) to adjust to the methodological paradigm of this study, and it includes 23 variables from the five SRL categories of *planning*, *monitoring*, *strategy use*, *tasks difficulty*, and *motivation*. The *planning* variables include recycling goals in working memory and activating prior knowledge. The *monitoring* variables include judgment of learning, feeling of knowing, self-questioning, content evaluation, identifying content as answer to goal, monitoring progress towards goals. The *strategy use* variables include reviewing notes, free search, goal-directed search, summarization, taking notes, drawing, re-reading, inference, hypothesizing, mnemonic devices, find location in environment, and skip. The *task difficulty* variables include time and effort planning and task difficulty. Finally, the *motivation* variable includes interest statements. The researcher coded all the transcriptions by assigning each coded segment to one of the SRL variables presented in Appendix P. In this study, this phase of data analysis yielded a total of 4,867 coded SRL segments for all participants (M = 81.1 per participant; M = 40.6 per learning task). See Appendix Q for a one-page example from a coded transcript.

Inter-rater Agreement

Inter-rater reliability was established for the coding of the undergraduate students' self-regulated behavior by comparing the individual coding of the researcher, who was trained to use an adapted version of Azevedo and colleagues' (2004) coding scheme, with that of Dr. Azevedo. Thirty percent of the transcripts (n = 18) were used for inter-rater reliability, and there was agreement on 1,380 out of 1,455 coded SRL segments, yielding a reliability coefficient of 95%. Any disagreements were resolved through discussion.

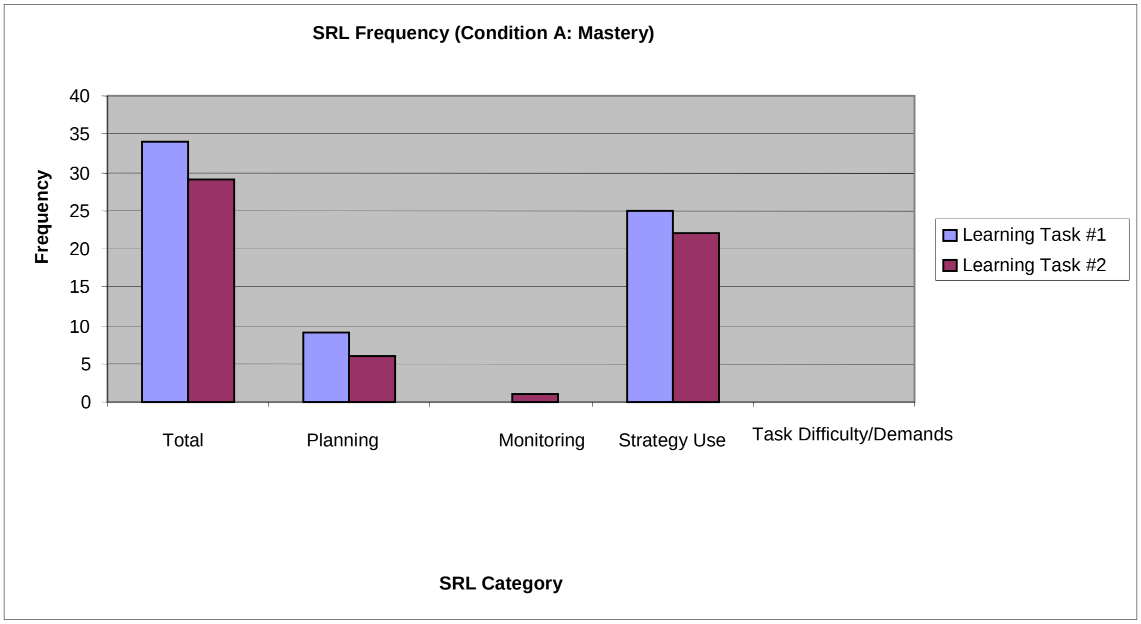
Chapter IV: Results

Results from Pilot Study

With the assistance of Dr. Roger Azevedo, a pilot study was run with three participants. One participant was randomly placed in each of the three conditions and they were run using the identical procedure as outlined in this paper, with one exception. While the main study used four questions to guide the participants' learning during both learning tasks, the pilot participants received five questions during both of the learning tasks. When interviewing each of the pilot participants after the session, they all stated that they felt as though they did not have time to adequately answer all five questions in the learning task. Thus, the methodology in this study was modified and the participants were given four guiding questions in the learning tasks. The question removed from the original five was the question that reportedly presented the pilot participants with the most difficulty. This question required a disproportionate amount of time, especially given the short learning session of twenty minutes for each learning task..

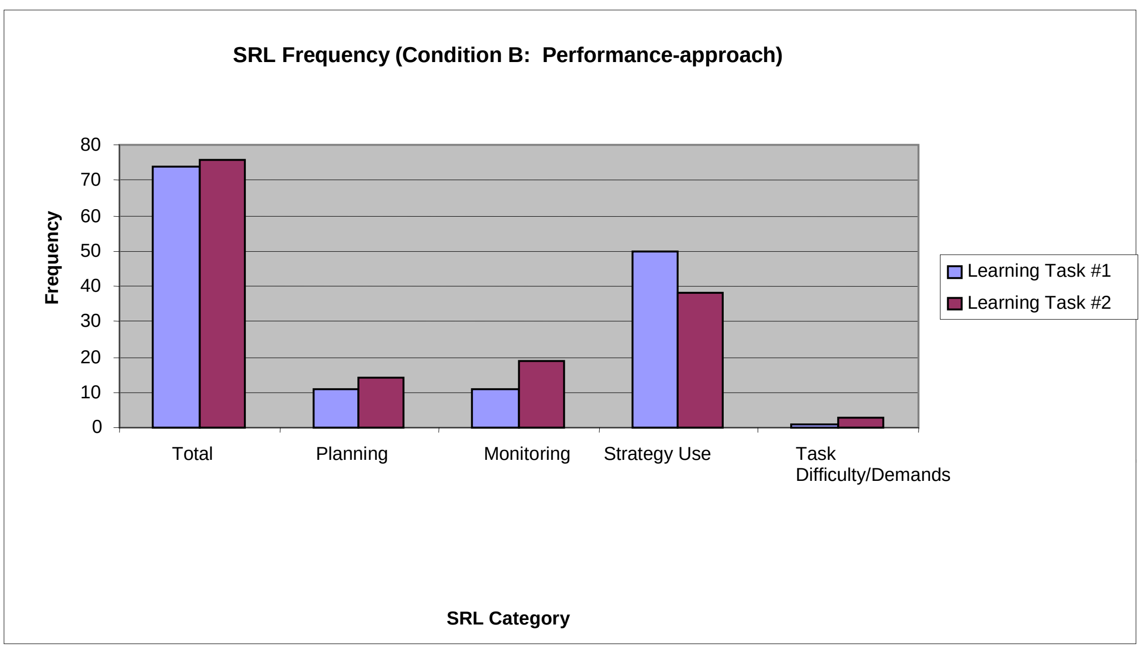
Though a statistical analysis would not be appropriate given the small number of pilot participants, there are some interesting trends worth mentioning. First, examining the SRL codes on a more global level paints an intriguing picture between the three conditions. Specifically, the participants in condition A (mastery) and condition B (performance-approach) exhibited similar frequencies of self-regulatory variables in the first learning task and in the second learning task. The participant in Condition A exhibited 34 counts of SRL in learning task one and 29 counts of SRL in learning task two (see Figure 1).

Figure 1.
SRL Frequency (Condition A: Mastery)



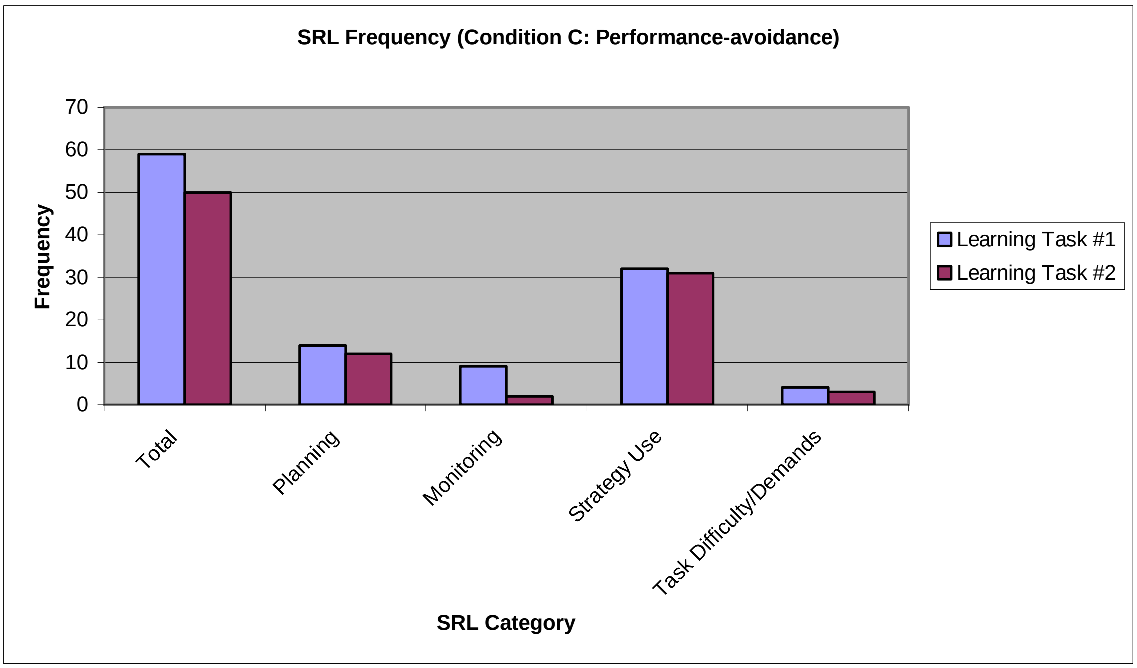
The participant in condition B exhibited 72 counts of SRL in learning task one and 74 counts of SRL in learning task two (see Figure 2).

Figure 2.
SRL Frequency (Condition B: Performance - approach)



These data would suggest that these two participants used similar self-regulatory behavior in the two learning tasks. However, the data for the participant in Condition C (performance-avoidance) presents a different story. While this participant exhibited 59 counts of SRL variables in the first learning task with the mastery goal-structure, she only exhibited 50 counts of SRL in the second learning task with the performance-avoidance goal structure (see Figure 3).

Figure 3.
SRL Frequency (Condition C: Performance - avoidance)



This discrepancy of SRL frequencies between the two learning tasks suggests that the participant in condition C did not use similar self-regulatory skills in the two learning tasks. Thus, it is plausible that the performance-avoidance goal structure of the second learning is related to this participant's disproportionate use self-regulatory variables in the two learning tasks.

A finer-grained analysis of the SRL variables provides a richer picture. Specifically, when the SRL variables are grouped into the four categories of *planning, monitoring, strategy use,* and *task difficulty and demands,* an interesting picture develops. While the two learning tasks elicited similar frequencies of *planning* and *task difficulties/demands* from all three participants in both learning tasks, there is a clear difference in *monitoring* in the two learning tasks between the three conditions. In particular, the participant in condition C exhibited 9 counts of monitoring in learning task one, but only 2 counts of monitoring in learning task two. Given this substantial discrepancy and decrease in monitoring activity, it is plausible that the performance-avoidance goal structure is related to the lower frequency of monitoring variables.

In general, however, the pilot study proved useful in refining the methodology and demonstrating the feasibility.

Results from Current Study

In this chapter, the results from several measures will be examined, including the think-aloud protocol, the MSLQ scores, and the posttest scores. The results will be presented by individually examining each of the three research questions previously mentioned. Following this section, the discussion chapter will further unpack these results by examining the results of each individual research question in relation to previous literature.

Research Question One: Is the goal structure of the two learning task related to the proportion of SRL variables verbalized in the two hypermedia learning tasks?

After tallying the raw frequencies of the 23 SRL variables for each participant in both learning tasks, these raw frequencies were then collapsed into five SRL categories, *planning, monitoring, strategy use*, *task difficulty*, and *motivation* for each learning task. Next, the raw frequencies in these SRL categories were converted into proportions of verbalizations for each participant to control for the participants' variability in the number of verbalizations. A median split was then performed on the proportion for each SRL category within the learning task and within the condition. These median splits were used to determine if the participants, within their condition, used the same proportion of SRL variables in the two learning tasks (i.e. above the median in both learning tasks or below the median in both learning tasks), or if they used a different proportion (i.e. above the median in one learning task, and below the median in another learning task).

For each SRL category, a 3 (Condition: A, B, C) x 2 (proportion stability: same proportion in each, different proportion) chi-square analysis was computed. Only the chi-square for *planning* variables was significant, χ^2 [2, N = 60] = 6.65, $p < .05$. See Table 3 for this analysis. The planning category consists of activating prior knowledge and recycling goals in working memory. A significantly larger number of participants in the performance-avoidance condition used a different proportion of planning variables in the two learning tasks. In this condition, 85 percent of the participants (n = 13) used a different proportion of planning variables in the two learning tasks (See Figure 4). On the other hand, in the performance-approach condition, only 25 percent of the participants (n = 5) used a different proportion of planning variables in the two learning tasks, and in the mastery condition, 40 percent of the participants (n = 8) used a different proportion of planning variables in the two learning tasks (See Figure 4). The Chi-square tests were non-significant for the other four SRL categories, *monitoring* ($p > .05$), *strategy use*

(*p* > .05), *task difficulty* (*p* > .05), and *motivation* (*p* > .05). See Table 3 and Figure 4 for this analysis. However, it should be noted that while there was a relatively normal distribution for the planning variable of recycling goals in working memory [kurtosis for learning task #1 = -.050; kurtosis for learning task #2 = -.167], the normal distribution for the planning variable of activating prior knowledge was not as normally distributed [kurtosis for learning task #1 = 7.124; kurtosis for learning task #2 = 2.465] (see Table 4). Thus, this lack of normal distribution for this planning variables must be taken into account when interpreting the results for research question one.

Table 3.
Number of participants who used a different proportion of SRL variables in the two learning tasks, based on median splits within condition and learning task.

SRL Category	Condition A: Mastery (n = 20)	Condition B: Performance-Approach (n = 20)	Condition C: Performance-Avoidance (n = 20)	Chi-square Value
Planning	8 (40%)	5 (25%)	13 (85%)	6.65*
Monitoring	5 (25%)	6 (30%)	3 (15%)	1.30
Strategy Use	7 (35%)	2 (10%)	7 (35%)	4.26
Task Difficulty and Demands	4 (20%)	4 (20%)	8 (40%)	2.73
Motivation	5 (25%)	7 (35%)	9 (45%)	1.76

[1] All Chi-Square analyses are based on df = 1 and N = 60
* p < .05

Figure 4.
Percent of participants who used a different proportion of SRL variables in the two learning tasks, based on median splits within condition and learning task.

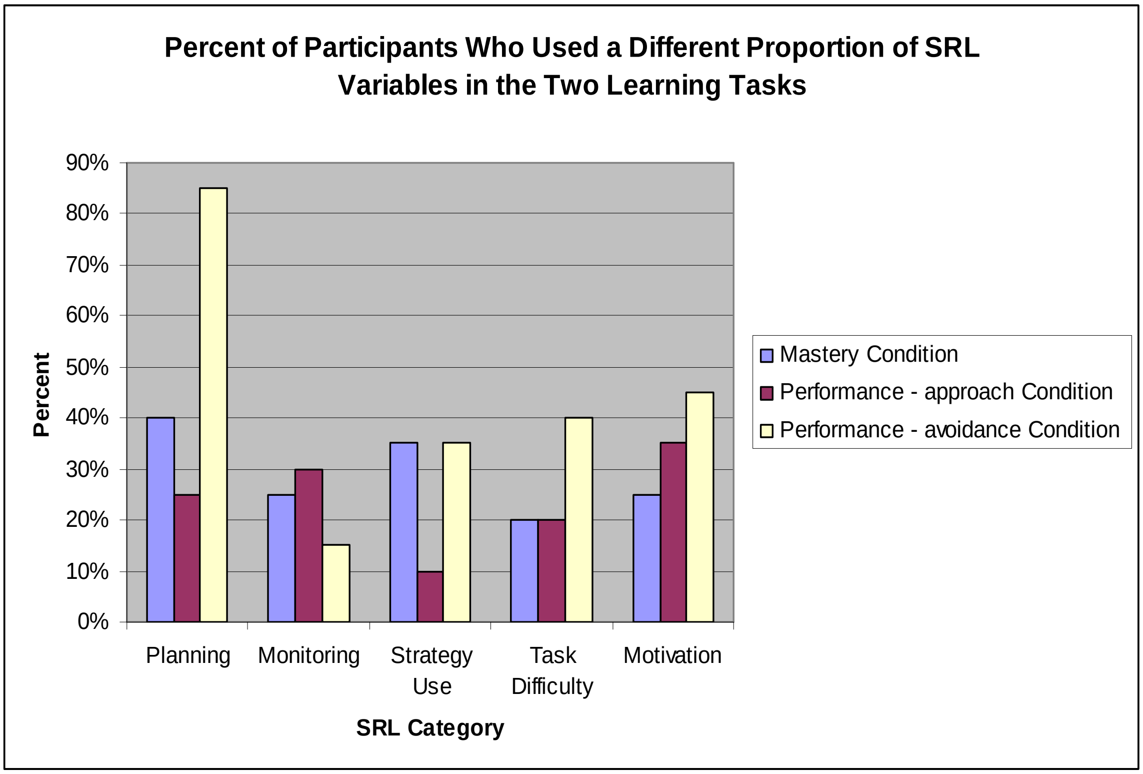


Table 4
Kurtosis of SRL Variables Used by All Participants in Each Learning Task

SRL Categories and Variables	Learning Task #1	Learning Task #2
	Kurtosis	Kurtosis
Planning		
Prior Knowledge Activation	7.124	2.465
Recycle Goal in Working Memory	-.050	-.167
Monitoring		
Content Evaluation	.869	2.751
Feeling of Knowing (FOK)	9.774	2.502
Judgment of Learning (JOL)	5.556	5.137
Monitoring Progress Toward Goals	2.528	3.436
Self-Questioning	7.368	2.464
Identifying Content as Answer to Goal	1.258	2.565
Strategy Use		
Hypothesizing	48.410	39.868
Draw	9.719	43.964
Summarization	-.369	-.419
Mnemonics	27.360	39.254
Goal-Directed Search	5.671	5.002
Taking Notes	-.700	.945
Re-Reading	30.799	22.681
Read Notes	15.617	9.411
Inferences	1.864	1.788
Find Location in Environment	9.385	13.010
Skip	6.136	27.621
Free Search	-.989	.095
Task Difficulty and Demands		
Time and Effort Planning	3.540	6.974
Task Difficulty	11.441	8.221
Interest		
Interest Statement	23.925	4.160

Research Question Two: Does the goal structure of a learning task lead to significant differences in students' learning?

A 3 (condition: mastery, performance-approach, performance-avoidance) X 2 (learning task: learning task #1, learning task #2) repeated measures ANOVA on the posttest scores showed no significant effect of learning task, F (1,58) = 1.83, $p > .05$, no significant effect of condition, F (2, 57) = .211, p > .05, and no significant interaction between condition and learning task F (2,57) = 1.41, p > .05 (See Table 5).

Table 5.
Mean score and (standard deviation) on the two posttests, by condition

	Condition A: Mastery		Condition B: Performance – Approach		Condition C: Performance – Avoidance	
	Learning Task #1	Learning Task #2	Learning Task #1	Learning Task #2	Learning Task #2	Learning Task #2
Mean Posttest Score (%) (Standard Deviation)	72.08 (14.83)	72.50 (20.07)	75.00 (16.13)	75.42 (16.42)	70.00 (23.67)	79.17 (14.67)

Research Question Three: Is the goal structure of a learning task related to students' task value, extrinsic motivation, and/or task value?

Three 3 (condition: mastery, performance-approach, performance-avoidance) X 2 (learning task: learning task #1, learning task #2) repeated measures ANOVAs were calculated for the three MSLQ scores.

For the task value, the analysis showed a significant effect of learning task, F (1,58) = 5.612, p < .05, no significant effect of condition, F (2, 57) = .351, p > .05, and no significant interaction between condition and learning task F (2,57) = .506, p > .05. Thus, participants in all conditions rated the task value of the learning task higher in the second learning task than in the first learning task, but this score was not significantly affected by the experimental condition nor was there an interaction between the condition and learning task (See Table 5).

For the extrinsic value, the analysis showed no significant effect of learning task, F (1,58) = 1.261, p > .05, no significant effect of condition, F (2, 57) = .191, p > .05, and no significant interaction between condition and learning task $F(2,57) = 1.922$, $p > .05$. Thus, participants did not demonstrate a significant difference in their extrinsic score between learning tasks, and this score was not significantly affected by the experimental condition nor was there an interaction between the condition and learning task (See Table 5).

For the intrinsic value, the analysis showed no significant effect of learning task, $F(1,58) = .896$, $p > .05$, no significant effect of condition, $F(2, 57) = .770$, $p > .05$, and no significant interaction between condition and learning task $F(2,57) = 1.45$, $p > .05$. Thus, participants did not demonstrate a significant difference in their intrinsic score between learning tasks, and this score was not significantly affected by the experimental condition nor was there an interaction between the condition and learning tasks (See Table 6).

Table 6.
MSLQ scores, by condition and learning task.

MSLQ Score, and Standard Deviation, by category	Condition A: Mastery		Condition B: Performance – Approach		Condition C: Performance – Avoidance	
	Learning Task #1	Learning Task #2	Learning Task #1	Learning Task #2	Learning Task #2	Learning Task #2
Task Value*	4.04 (1.23)	4.42 (1.27)	3.81 (1.59)	3.95 (1.63)	3.88 (1.43)	4.08 (1.31)
Extrinsic Motivation	4.61 (1.1)	4.30 (1.29)	4.32 (1.37)	4.11 (1.56)	4.39 (1.11)	4.41 (1.29)
Intrinsic Motivation	5.10 (.85)	5.00 (.65)	5.03 (1.16)	4.99 (1.03)	4.80 (.74)	4.66 (.90)

Chapter V: Discussion

Introduction

In this study, think-aloud and posttest data from 60 undergraduates were used to examine whether these students deploy a different proportion of self-regulated learning (SRL) variables in two related learning tasks while using a hypermedia environment. The goal structure of the two learning tasks was also manipulated in order to explore whether the goal structure is related to the use of SRL variables. Participants were randomly assigned to 1 of 3 conditions [mastery goal structure, performance-approach goal structure, or performance-avoidance goal structure] and participated in two 20-minute learning tasks in which they learned about the circulatory and respiratory system. The results indicate that a mastery goal structure and a performance-approach goal structure are related to undergraduates' use of similar proportions of SRL variables in two learning tasks, whereas a performance-avoidance goal structure may be related to undergraduate's use of different proportions of SRL variables, specifically *planning*, in two similar learning tasks with a hypermedia environment.

The following discussion will dissect these results by individually examining each of the three research questions, and will follow with the potential theoretical and methodological contributions to the field of educational psychology. Next, implications for the design of hypermedia will be examined, followed by the limitations of this study. Lastly, this chapter will end with concluding remarks.

Research Questions

With regard to the first research question, the results support the first part of the hypothesis that when the proportions of SRL variables in the two learning tasks are examined within each condition, the participants in the mastery and performance-approach condition will use a similar proportion (i.e. non-significant difference) of SRL variables in the two learning tasks. These findings are supported by some previous literature on goal orientation (eg. Boekaerts, Pintrich, & Zeidner, 2000). The literature that supports a theoretical framework consisting of three goal orientations (mastery, performance-approach, and performance-avoidance) suggests that a performance-approach goal orientation may lead to the use of similar self-regulatory behavior relative to that of a mastery goal orientation. For example, Wolters et al. (1996) suggested that having a positive external criterion, as in a performance-approach but not performance-avoidance goal orientation, may actually lead to the use of cognitive strategies similar to that of a mastery goal orientation. In this study, the participants in the mastery goal structure and the performance-approach structure conditions used a similar proportion of SRL variables in the two learning tasks. While this study suggests that self-regulated learning may be stable within a particular context as described in this study, I do not believe that this data provides substantial evidence that SRL should be considered an aptitude. Within this learning environment, in which the participants used the same learning environment for both learning tasks (hypermedia) and learned about two science-related topics (respiratory system and circulatory system), SRL may become more stable. However, the question remains as to whether SRL is an event or aptitude when students learn dissimilar topics and in different learning environments.

However, the results of this study only partially support the second part of the hypothesis that the participants in the performance-avoidance condition will use a significantly different proportion of SRL variables in the two learning tasks. The results suggest that the participants in the performance-avoidance condition used a different proportion of SRL variables, but only in the SRL category of *planning.* As highlighted earlier, some research supports this finding by indicating that a performance-avoidance goal orientation is related to distinct self-regulatory behavior (Boekaerts, Pintrich, & Zeidner, 2000). For example, Elliot & Harackiewicz (1998) found that participants in the performance-avoidance condition strove to avoid failure and this behavior was not evident in the other two conditions, mastery and performance-approach.

While such studies have examined the relationship between performance-avoidance goal orientation and learning, limited research has examined the relationship between goal orientation and SRL in two learning tasks, using a fine-grained level of analysis (i.e. examining SRL as 23 variables in five categories) and the think-aloud methodology. This study examines this relationship with a fine-grained level of analysis and suggests that a performance-goal orientation may be differentially related to specific SRL variables, specifically planning. Based on these findings, future research should continue to explore the relationship between goal orientation and SRL, using a fine-grained level of analysis. In particular, one intriguing question that stems from this study is: If the performance-avoidance goal orientation is in fact related to the use of *planning* variables, what is about this goal orientation that is related to undergraduates' use of a different proportion of planning variables but the same proportion of SRL variables from the other four categories? Specifically, why would students use a different proportion of the planning variables, *recycling their goals* and *activating their prior knowledge,* when faced with a performance-avoidance goal structure?

However, it should be noted that these results need to be interpreted with caution because while some researchers have experimentally induced goal orientation through the goal structure of a learning task (see Elliot & Harackiewicz, 1998), there is other research that suggests goal orientation is a stable trait and that an individual's goal orientation is more global than task-specific goals (Wolters, Yu, and Pintrich, 1996). This assertion suggests that it is difficult, if not impossible, to experimentally induce a goal orientation through the goal structure of a learning task because an individual's goal orientation is stable across domains. Thus, if individuals have pre-existing goal orientations, and/or maintain multiple goal orientations, the effects of experimentally inducing one goal orientation in this study may be muted. While discussing the results for research question one, the nature of the learning task must also be taken into account. That is, the participants were asked to answer four questions during a relatively short learning session of twenty minutes. Had the participants been asked one global guiding questions, instead of four questions, and had been given more time than twenty minutes, then it is plausible that they would have exhibited different SRL variables, such as subcategories of planning. Thus, it is possible that the questions given to the participants during the learning session, and the length of the learning session, affected the use of SRL in each category. With these considerations in mind, the results for research question one must be cautiously interpreted.

In addition to the relationship between the goal structure of a learning task and the use of SRL variables, as examined in research question one, other factors that may be related to these participants' use of a similar proportion of these SRL variables in the two learning tasks should be addressed. For example, the science topics in the two learning tasks in this study were distinct, but closely related. That is, the two science topics focused on related systems, the circulatory system and respiratory system, which share some foundational and underlying similarities. Thus, it is possible that the relatedness of the content may explain these students' use of a similar proportion of SRL variables. Thus, though these undergraduates, in all three conditions, used a similar proportion of *monitoring*, *strategy use*, *task difficulty and demand*, and *motivation* variableswhile learning about two related topics, the question arises as to whether they would use a similar proportion if they had learned about more distinct topics (e.g. a science topic and a history topic), or even related topics with different degrees of complexity (e.g. the digestive system and the circulatory system). In addition to the topics of the learning tasks, the context in which these participants learned about the related topics may also explain why they used a similar proportion of some SRL variables. Using the same hypermedia environment to learn about two different topics may influence students' use of specific SRL variables. Stability, in the sense of the undergraduates' use of similar SRL variables in two learning tasks, may provide support for incorporating self-report questionnaires like the MSLQ with think-aloud protocols when examining SRL variables in related domains and contexts, because measures such as the MSLQ implicitly assume consistency across situations. However, this study raises the question as to *why* some undergraduates may use similar SRL variables in two learning tasks. Did these undergraduates use a similar proportion of SRL variables in two learning tasks because of contextual factors (i.e. using the same hypermedia environment) and/or the domain of the two learning tasks (i.e. learning about two related topics)? Examining these questions will shed light on the role of contextual and domain factors in students' use of specific SRL variables while learning with a hypermedia environment.

With regard to the second research question, the results support the hypothesis that the participants in the mastery and performance-approach conditions will have similar (i.e. non-significant difference) scores in the two posttests. These results are supported by recent research that indicates a relationship between an individual's SRL and his/her learning of science topics with hypermedia environments (see Azevedo, Guthrie, & Seibert, 2004). Based on this research, it is not surprising that participants in this study scored similarly on the two posttests after using a similar proportion of SRL variables in the two learning tasks. However, the second part of this hypothesis, that participants in the performance-avoidance condition will have significantly different scores on the two posttests, was not supported by the results. While participants in this condition did use a different proportion of planning variables in the two learning tasks, their posttests were not significantly different. These findings pose several questions. First, future research should continue to examine SRL on a fine-grained level of analysis so that the relationship between specific SRL categories, such as planning, and learning outcomes can be more closely examined. However, while a different proportion of planning variables did not seemingly affect the posttest scores for undergraduates in the performance-avoidance condition, these results should be interpreted with care. Specifically, the nature of the posttest should be taken into consideration when examining the relationship between SRL and the learning outcomes, as measured by the posttest. In this study, the participants completed each posttest in a short time period (5 minutes), and the posttest consisted of 12 multiple choice questions testing declarative knowledge.

Thus, if a relationship exists between a specific SRL category and the acquisition of declarative *and* procedural knowledge (as noted in previous research such as Azevedo, Guthrie, & Seibert, 2004), then the effects of these conditions on learning outcomes may have been muted in this study because the posttests only tested declarative knowledge. In addition, the participants' performance on the first posttest should be taken into account. Because the participants from all three conditions scored relatively well on the first posttest (each condition had a mean score of at least 70 percent for the first posttest score), it could be argued that this moderate score on the first posttest prompted the participants to maintain similar SRL variables in the second learning task. A more difficult first posttest, in which the participants were tested on both declarative and procedural knowledge, may influence participants to use different SRL variables in the second learning task. As such, in my opinion, future research that continues to examine the relationship between SRL and more complex learning outcomes, in the form of declarative *and* procedural knowledge, and mental models (see Azevedo & Cromley, 2004; Azevedo, Winters, & Moos, in press), will allow researchers to gain amore insightful understanding of the relationship between specific categories of SRL (planning, monitoring, strategy use, task difficulty, and motivation) and learning outcomes.

With regards to the third research question, the results do not support the hypothesis that the three measures of the *MSLQ* (task value, extrinsic motivation, and intrinsic motivation) are differentially related to the three conditions. While the analysis indicated that the participants' task value score was significantly higher in the second learning task than in the first learning task, this score was not significantly affected by the experimental condition nor was there an interaction between the condition and learning task. In addition, none of the other three *MSLQ* measures were significantly different between conditions. These results are not supported by some previous research. For example, Elliot & Harackiewicz (1998) suggest that individuals in a learning task with a performance-avoidance goal structure demonstrate decreased intrinsic motivation relative to individuals in a learning task with a mastery or performance-approach goal structure. However, this decrease in intrinsic motivation for participants in the performance-avoidance condition was not found in this study. There are several possible explanations for this discrepancy between findings in this study and Elliot & Harackiewicz (1998). First, while this study used the same methodology as Elliot & Harackiewicz (1998) of inducing goal orientations through the goal structure of the learning task, the methodological paradigm of this study is distinct. The domain (science topics), context (hypermedia environment), and procedure (two learning tasks) are different from the methodological paradigm in Elliot & Harackiewicz's study (1998). These differences may offer an explanation on why there is a discrepancy between the findings in the two studies. Future research should continue to explore the relationship of goal orientation and individual factors such intrinsic motivation, extrinsic motivation, and task value by extending Elliot & Harackiewicz's findings (1998) to other domains and contexts. However, this research would only be fruitful if the three goal orientations, as suggested by Elliot & Harackiewicz (1998), exist and if there is indeed a relationship between these goal orientations and individual factors such as intrinsic motivation, extrinsic motivation, and task value. As highlighted earlier, some researchers have suggested that it is difficult, if not impossible, to experimentally induce a goal orientation through the goal structure of learning tasks because an individual's goal orientation is stable across domains (Wolters, Yu, and Pintrich, 1996). Thus, it is also necessary for the field of goal orientation to continue to explore the relationship between the goal structure of a learning task and an individual's goal orientation.

Contributions

This study provides an empirically-based and theoretically-driven analysis that potentially offers theoretical and methodological contributions to the field of SRL. From a theoretical standpoint, this study builds on existing models of SRL in learning with hypermedia (e.g. Azevedo, Guthrie, & Seibert, 2004) by examining the stability of SRL variables across two similar learning tasks with a hypermedia environment. Existing SRL models attempt to best capture the dynamic nature of SRL with theoretical frameworks that appeal to the social, behavioral, motivational, and cognitive variables in distinct instructional contexts (Winne, 2001; Winne & Hadwin, 1998). As such, research should illuminate the role of these variables to further extend the SRL framework. In my opinion, this study sheds light on several of these variables, including cognitive variables in an instructional context (i.e. hypermedia environment) and motivational variables (i.e. goal structure and orientation). Future research can build on this study by further examining the role hypermedia, as an instructional context, and the goal structure and orientation, as a motivational variable, in students' SRL.

In addition to potentially offering a theoretical contribution, this study also potentially offers a methodological contribution to the field of SRL. First, some research has utilized the think-aloud methodology to capture the dynamic nature of SRL (e.g. Azevedo et al., 2003a, 2003b). I believe that this tool has proven to be effective in capturing SRL. However, to the best of my knowledge, very few studies have used the think-aloud in combination with self-report measures to examine SRLThis study used a methodological paradigm that combined the process data from the think-aloud methodology with the data from a self-report questionnaire, the *MSLQ*. While there are limitations of both self-report questionnaires and think-aloud protocols, each possess a unique strength and, to the best of my knowledge, this study is one of the few that has combined these measures in one study. Future research should continue to integrate the strengths of these two measures by examining the correspondence between MSLQ scores and the rich data offered from the think-aloud protocol (see Winne, Jamieson-Noel, & Muis, K., 2002; Wiine & Perry, 2000 for an extensive review).

This study also potentially offers theoretical and methodological contributions to the field of goal orientation. From a theoretical standpoint, this study illuminates the need for future research to continue to examine the exact nature of goal orientations. While the results suggest a significant difference between the three conditions with respect to the proportion of planning variables in the two learning tasks, these results need to be interpreted with caution because the field of goal orientation maintains several distinct theoretical frameworks. While some theoretical frameworks postulate three goal orientations, there are other theoretical frameworks that dispute this assumption. Further research should continue to examine the exact nature of goal orientations. From a methodological standpoint, this study provides rich data that extend previous research on the role of goal structure in learning (Elliot & Harackiewicz, 1994) by using the think-aloud methodology to capture the dynamic interaction between the goal structure of two learning tasks and the use of SRL. However, because there was some discrepancy between the findings of this study and the findings of Elliot & Harackiewicz (1994), a question is raised regarding the methodology of inducing goal orientations through the goal structure of the learning task. Were these discrepancies due to the different methodological paradigms in the two studies (i.e. different contexts and domains)? Or, were the discrepancies due to the nature of the true relationship between the goal structure of a learning task and an individual's goal orientation? These are intriguing questions and this study highlights the need for future research to address these methodological issues.

Implications or the Design of Hypermedia

In addition to the potential methodological and theoretical contributions to the fields of SRL and goal orientation, this study also has implications for the design of hypermedia. As previously highlighted, hypermedia environments may help students learn about complex systems (e.g. science topics; Azevedo, Winters, & Moos, 2004). Students may potentially benefit from these environments which provide a variety of representations of information [text, audio, and video clips]. However, recent research has demonstrated that students may need to deploy certain SRL variables in order to effectively use hypermedia environments to learn about science topics (Azevedo & Cromley, in press; Azevedo et al., 2003a, 2003b). These studies have highlighted specific SRL variables that foster learning in hypermedia environments and, as a result, have made significant contributions to the design implications of hypermedia environments However, while these studies have highlighted *what* SRL skills students use to learn about complex topics with a hypermedia environment, the question remains as to *why* students deploy certain SRL skills in this learning context. Do students deploy these specific SRL variables because of individual factors (i.e. motivational factors)? Or, does the learning context of the hypermedia environment play a direct role in what SRL variables students use? While it is quite possible, and probably even likely, that there is an interaction between contextual and individual variables, the results of this study suggest that the hypermedia environment may elicit certain SRL variables. Because these participants, in all three conditions, used the same proportion of SRL variables in four out of five SRL categories in each learning task, it is plausible that there is a relationship between the hypermedia environment and the students' use of specific SRL variables. If hypermedia environments do indeed draw out specific SRL variables, the design of hypermedia environments should take this factor into account. As such, future research should continue to examine the relationship between hypermedia environments and specific SRL variables because this will better inform the design of these educational tools.

While future research should continue to examine the relationship between hypermedia environments and specific SRL variables, this study potentially offers a specific design principle for hypermedia environments. When the raw frequencies of the use of SRL variables are examined, it is clear that these undergraduates, regardless of the condition, use more strategy SRL variables than variables from the other four categories. In fact, these undergraduates, on average, used three times more strategy variables than variables from either the *planning* category or the *monitoring* category (see Table 7). However, previous studies have identified that *planning* (such as activating prior knowledge) and *monitoring* variables (such as feeling of knowing) are related to learning with hypermedia environments (see Azevedo & Cromley, 2004). Thus, if undergraduates are deploying key strategies, but are failing to use important planning and monitoring variables, then the design of a hypermedia environment should address this issue by scaffolding key planning variables, such as activating prior knowledge, and monitoring variables, such as feeling of knowing.

Table 7
Raw Frequencies of SRL Variables Used by All Participants in Each Learning Task

SRL Categories and Variables	Condition A: Mastery (n = 20)		Condition B: Performance - Approach (n = 20)		Condition C: Performance-Avoidance (n = 20)	
	Learning Task #1	Learning Task #2	Learning Task #1	Learning Task #2	Learning Task #1	Learning Task #2
Planning						
Prior Knowledge Activation	8	14	8	15	8	14
Recycle Goal in Working Memory	120	120	119	124	98	109
TOTAL	128	134	127	139	106	123
Monitoring						
Content Evaluation	50	39	39	42	51	38
Feeling of Knowing (FOK)	34	35	29	37	20	26
Judgment of Learning (JOL)	7	7	7	13	4	8
Monitoring Progress Toward Goals	31	40	25	32	33	26
Self-Questioning	8	13	17	10	12	6
Identifying Content as Answer to Goal	29	18	35	27	40	25
TOTAL	159	152	152	161	160	129
Strategy Use						
Hypothesizing	0	1	6	4	2	0
Draw	8	4	1	0	0	7
Summarization	227	233	223	273	177	226
Mnemonics	1	1	0	2	1	0
Goal-Directed Search	27	15	26	21	26	20
Taking Notes	86	99	100	104	113	117
Re-Reading	13	10	4	18	9	8
Read Notes	6	5	7	7	1	10
Inferences	21	26	8	20	15	8
Find Location in Environment	5	5	0	3	4	9
Skip	4	0	5	4	1	0
Free Search	102	69	136	68	121	112
TOTAL	500	468	516	524	470	517
Task Difficulty and Demands						
Time and Effort Planning	11	12	8	8	4	5
Task Difficulty	6	5	16	7	5	3
TOTAL	17	17	24	15	9	8
Interest						
Interest Statement	9	18	18	32	17	18

Limitations of Study

While this study potentially offers theoretical and methodological contributions to the fields of SRL and goal orientation, there are some limitations that need to be addressed. One of the issues is thatthis study does not provide evidence that undergraduates' use of SRL variables in science-related learning tasks will generalize to other domains (e.g. history-related learning tasks). Thus, the scope of these findings is relatively limited. In addition to this limitation, there are other limitations that have been previously addressed in this paper. The first is the methodology of inducing goal orientation through the goal structure. Previous literature is inconsistent in its support of the role of the goal structure in an individual's goal orientation, and this study does not provide substantial and direct evidence that the goal structure of the three conditions differentially induced goal orientations. Furthermore, this study does not identify the typical goal orientation of an undergraduate, or of the participants in this study. Identifying the participants' goal orientation before they participated in the study could have shed light on the effectiveness of inducing goal orientation through the goal structure of a learning task. That is, the effectiveness of inducing goal orientation may have been affected by the participants' goal orientation they maintained before participating in the study. However, because this study did not identify the participants' goal orientation, this interaction cannot be identified. Taking these points into consideration, the interpretation of the data needs to be made with care. Future research should continue to examine the role of goal structure in an individual's goal orientation, and identify an individual's goal orientation prior to examining this interaction.

Lastly, the limitations of the research design need to be addressed. Specifically, the cons of having an experimental posttest only design need to be identified. Pretests confirm that randomization was effective. However, because this was a posttest only design, it is possible that randomization did not occur and that this lack of randomization was not identified. Furthermore, while the posttest measured the learning outcomes of each participant, the absence of a pretest means that the participants' learning cannot be truly measured because their prior knowledge, as measured by the pretest, is not taken into account. However, because of the logistical time constraints, I believe that having an experimental posttest only design made sense for this study. The design of the study asked each participant to engage in a labor intensive session that lasted 75 minutes, and thus it made sense to exclude a pre-test which would have elongated each session.

Conclusion

While there are some limitations to this study, I believe that it provides empirically-based and theoretically-driven analyses that build on existing models of SRL in learning with hypermedia by examining whether students will use a similar proportion of SRL variables in two learning tasks about related science topics. In addition, this study also adds to the field of goal orientation by exploring factors that could potentially impact students' SRL in these two learning tasks. Providing rich data that extend previous research on the role of goal structure in learning (Elliot & Harackiewicz, 1994), this study used the think-aloud methodology to capture the dynamic interaction between the goal structure of the two learning tasks and use of SRL. Unlike previous research on the role of goal structure in learning, this study examines the interaction between goal structure and undergraduates' use of SRL variables in two hypermedia learning tasks. In addition to providing empirically-based and theoretically-driven analyses that add to the fields of SRL and goal orientation, this study provides the foundation for future research in these two fields. Lastly, based on these contributions, these findings also provide data that have implications for the design of hypermedia environments.

Appendix A: Participant Consent Form

Participant ID: _______________

USING HYPERMEDIA TO LEARN ABOUT COMPLEX SYSTEMS
STUDENT INFORMED CONSENT FORM

Identification of Project	Using hypermedia to learn about complex systems.
Statement of Age of Participant	I state that I am over 18 years of age, in good physical health, and wish to participate in a master's research study being conducted by Daniel Moos in the Department of Human Development at the University of Maryland, College Park.
Purpose	The purpose of this research is to examine the cognitive processes used by students as a result of utilizing a hypermedia environment to learn about complex biological systems.
Procedures	The procedures will involve 1 session and will last approximately 70 minutes. During the session, I will be asked to use a hypermedia environment for two learning tasks, one about the circulatory system and one about the respiratory system. After filling out the participant questionnaire, I will be asked to engage in the following for each learning task: (1) Complete a questionnaire, (2) answer questions about the biological system while using a hypermedia environment, (3) verbalize my thinking during the learning task, and (4) complete a posttest. I understand that the session will be audio and video recorded.
Confidentiality	All information collected in the study is confidential. A numeric code will be used as identification on data collection material and my name will never be used at any time. Once data are collected, this code will be used for analysis of data.
Risks	I understand that there are no known risks from this experiment.
Benefits: Freedom to Withdraw and Ask Questions	I understand that the experiment is not designed to help me personally, but the investigator hopes to learn more about the cognitive processes used by students when using hypermedia to learn about complex systems. I understand that I am free to ask questions and/or to withdraw from participation at any time and without penalty.
Contact Information of Institutional Review Board	If you have any questions about your rights as a research participant or wish to report a research-related injury, please contact: **Institutional Review Board Office, University of Maryland, College Park, Maryland, 20742; irb@deans.umd.edu; 301-405-4212**

_______________________________ _______________________________

Printed Name of Participant **Signature of Participant**

_____________________ **(Date)**

Appendix B: Participant Questionnaire

Participant ID: ________________________

PARTICIPANT QUESTIONNAIRE
(UMCP Undergraduate Students)

NAME ____

GENDER ________________

AGE ________________

ACADEMIC MAJOR ____

CLASS ________________

CURRENT GPA ________________

BIOLOGY CLASSES PREVIOUSLY (if any)

Course Title	Course Number	*Was the Circulatory System Covered? (Yes or No)* If Yes, what aspects were taught?	*Was the Respiratory System Covered? (Yes or No)* If Yes, what aspects were taught?

Relevant work experience (related to health of medicine)

____

Directions:
Please take a moment to answer the following three questions about yourself. For this assessment to be helpful, it is important that you answer all of the questions honestly. There is no right or wrong answer; these are opinions about yourself.

(1 = *Not at all true of me,* 3 = *Somewhat true of me,* 5 = *Very True of me*)

1) I like course work that really challenges me.

1 2 3 4 5

2) My class rank is important to me.

1 2 3 4 5

3) It is very important to me that I don't look unknowledgeable in my courses.

1 2 3 4 5

Appendix C: Complete MSLQ

(1 = *not at all true of me; 7 = very true of me*)

REHEARSAL

When I study for this class, I practice saying the material to myself over and over.

1 2 3 4 5 6 7

When studying for this class, I read my class notes and the course readings over and over.

1 2 3 4 5 6 7

I memorize key words to remind me of important concepts in this class**.**

1 2 3 4 5 6 7

I make lists of important terms for this course and memorize the lists.

1 2 3 4 5 6 7

ELABORATION

When I study for this class, I pull together information for different sources, such as lectures, readings, and discussions.

1 2 3 4 5 6 7

I try to relate ideas in this participant to those in other courses whenever possible

1 2 3 4 5 6 7

When reading for this class, I try to relate the material to what I already know.

1 2 3 4 5 6 7

When I study for this course, I write brief summaries of the main ideas from readings and the concepts from the lectures.

1 2 3 4 5 6 7

I try to understand the material in this class by making connections between readings and the concepts from the lectures.

1 2 3 4 5 6 7

I try to apply ideas from course readings in other class activities such as lectures and discussions.

1 2 3 4 5 6 7

ORGANIZATION

When I study the readings for this course, I outline the material to help me organize my thoughts.

1 2 3 4 5 6 7

When I study for this course, I go through the readings and my class notes and try to find the most important ideas.

1 2 3 4 5 6 7

I make simple charts, diagrams, or tables to help me organize course material.

1 2 3 4 5 6 7

When I study for this course, I go over my class notes and make an outline of important concepts.

1 2 3 4 5 6 7

CRITICAL THINKING

I often find myself questioning things I hear or read in this course to decide if I find them convincing.

1 2 3 4 5 6 7

When a theory, interpretation, or conclusion is presented in class or in readings, I try to decide if there is good supporting evidence.

1 2 3 4 5 6 7

I treat the course material as a starting point and try to develop my own ideas about it.

1 2 3 4 5 6 7

I try to play around with ideas of my own related to what I am learning in this course.

1 2 3 4 5 6 7

Whenever I read or hear an assertion or conclusion in this class, I think about possible alternatives.

1 2 3 4 5 6 7

METACOGNITION

During class time I often miss important points because I'm thinking of other things.

1 2 3 4 5 6 7

When reading for this course, I make up questions to help focus my reading.

1 2 3 4 5 6 7

When I become confused about something I'm reading for this class, I go back and try to figure it out.

1 2 3 4 5 6 7

If course materials are difficult to understand, I change the way I read the material.

1 2 3 4 5 6 7

Before I study new course material thoroughly, I often skim it to see how it is organized.

1 2 3 4 5 6 7

I ask myself questions to make sure I understand the material I have been studying in class.

1 2 3 4 5 6 7

I try to change the way I study in order to fit the course requirement and instructor's teaching style.

1 2 3 4 5 6 7

I often find that I have been reading for class but don't know what it was all about.

1 2 3 4 5 6 7

I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.

1 2 3 4 5 6 7

When studying for this course, I try to determine which concepts I don't understand well.

1 2 3 4 5 6 7

When I study for this class, I set goals for myself in order to direct my activities in each study period.

1 2 3 4 5 6 7

If I get confused taking notes in class, I make sure I sort it out afterward.

1 2 3 4 5 6 7

INTRINSIC MOTIVATION

In a class like this, I prefer course material that really challenges me so I can learn new things.

1 2 3 4 5 6 7

In a class like this, I prefer course material that arouses my curiosity, even if it difficult to learn.

1 2 3 4 5 6 7

The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.

1 2 3 4 5 6 7

When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.

1 2 3 4 5 6 7

EXTRINSIC MOTIVATION

Getting a good grade in this class is the most satisfying thing for me right now.

1 2 3 4 5 6 7

The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.

1 2 3 4 5 6 7

If I can, I want to get better grades in this class than most of the other students.

1 2 3 4 5 6 7

I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.

1 2 3 4 5 6 7

TASK VALUE

I think I will be able to use what I learn in this course in other courses.

1 2 3 4 5 6 7

It is important for me to learn the material in this class.

1 2 3 4 5 6 7

I am very interested in the content areas of this course.

1 2 3 4 5 6 7

I think the material in this class is useful for me to learn.

1 2 3 4 5 6 7

I like the participant matter of this course.

1 2 3 4 5 6 7

Understanding the participant matter of this course material is very important to me.

1 2 3 4 5 6 7

CONTROL BELIEFS

If I study in appropriate ways, then I will be to learn the material in this course.

1 2 3 4 5 6 7

It is my own fault if I don't learn the material in this course.

1 2 3 4 5 6 7

If I try hard enough, then I will understand the course material.

1 2 3 4 5 6 7

If I don't understand the course material, it is because I didn't try hard enough.

1 2 3 4 5 6 7

SELF-EFFICACY

I believe I will receive an excellent grade in this course.

1 2 3 4 5 6 7

I'm certain I can understand the most difficult material presented in the readings for this course.

1 2 3 4 5 6 7

I'm confident I can understand the basic concepts taught in this course.

1 2 3 4 5 6 7

I'm confident I can understand the most complex material presented by the instructor in this course.

1 2 3 4 5 6 7

I'm confident I can do an excellent job on the assignments and tests in this course.

1 2 3 4 5 6 7

I expect to do well in this class.

1 2 3 4 5 6 7

I'm certain I can master the skills being taught in this class.

1 2 3 4 5 6 7

Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.

1 2 3 4 5 6 7

TEST ANXIETY

When I take a test I think about how poorly I am doing compared with other students.

1 2 3 4 5 6 7

When I take a test I think about items on other parts of the test I can’t answer.

1 2 3 4 5 6 7

When I take I think of the consequences of failing.

1 2 3 4 5 6 7

I have an uneasy, upset feeling when I take an exam.

1 2 3 4 5 6 7

I feel my heart beating fast when I take an exam.

1 2 3 4 5 6 7

TIME AND STUDY ENVIRONMENT

I usually study in a place where I can concentrate on my course work.

1 2 3 4 5 6 7

I make good use of my study time for this course.

1 2 3 4 5 6 7

I find it hard to stick to a study schedule.

1 2 3 4 5 6 7

I have a regular place set aside for studying.

1 2 3 4 5 6 7

I make sure I keep up with the weekly readings and assignments for this course.

1 2 3 4 5 6 7

I attend class regularly.

1 2 3 4 5 6 7

I often find that I don’t spend very much time on this course because of other activities.

1 2 3 4 5 6 7

I rarely find time to review my notes or readings before an exam.

1 2 3 4 5 6 7

EFFORT REGULATION

I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do.

1 2 3 4 5 6 7

I work hard to do well in this class even if I don’t like what we are doing.

1 2 3 4 5 6 7

When the course work is difficult, I give up or only study the easy parts.

1 2 3 4 5 6 7

Even when course materials are dull and uninteresting, I manage to keep working until I finish.

1 2 3 4 5 6 7

PEER LEARNING

When studying for this course, I often try to explain the material to a classmate or a friend.

1 2 3 4 5 6 7

I try to work with other students from this class to complete the course assignments.

1 2 3 4 5 6 7

When studying for this course, I often set aside time to discuss the course material with a group of students from the class.

1 2 3 4 5 6 7

HELP-SEEKING

Even if I have trouble learning the material in this class, I try to do work on my own, without help from anyone.

1 2 3 4 5 6 7

I ask the instructor to clarify concepts I don’t understand well.

1 2 3 4 5 6 7

When I can’t understand the material in this course, I ask another student in this class for help.

1 2 3 4 5 6 7

I try to identify students in this class whom I can ask for help if necessary.

1 2 3 4 5 6 7

Appendix D: Three Measures from MSLQ

Participant ID#____________________ **LEARNING TASK # __________**

Questionnaire

Please take time to answer the following questions. For this questionnaire to be helpful, it is important tat you answer all of the questions honestly. These are opinions about yourself; there are no right or wrong answers.
Please answer based on the following scale:
(1 = not at all true of me … 7 = very true of me)

In this learning task, I would prefer material that really challenges me so I can learn new things.

1 2 3 4 5 6 7

In this learning task, I would prefer material that arouses my curiosity, even if it difficult to learn.

1 2 3 4 5 6 7

In this learning task, it will be satisfying for me to try and understand the content as thoroughly as possible.

1 2 3 4 5 6 7

If I have the opportunity in this learning task, I will choose material that I can learn from even if it doesn’t guarantee a good score on the posttest.

1 2 3 4 5 6 7

In this learning task, getting a good score on the learning task questions and posttest would be most satisfying.

1 2 3 4 5 6 7

The most important thing for me right now is improving my overall grade point average, so my main concern is getting the extra credit from this study.

1 2 3 4 5 6 7

If I can, I want to get a better score on the posttest than most of the other students.

1 2 3 4 5 6 7

In this learning task, I want to do well on the learning task questions and the posttest because it is important to show my ability to others.

1 2 3 4 5 6 7

I think I will be able to use what I learn in this learning task in other courses.

1 2 3 4 5 6 7

It is important for me to learn the material in this learning task.

1 2 3 4 5 6 7

I am very interested in the content areas of this learning task.

1 2 3 4 5 6 7

I think the material in this learning task is useful for me to learn.

1 2 3 4 5 6 7

I think that I will like the participant matter of this learning task.

1 2 3 4 5 6 7

Understanding the participant matter of this learning task is very important to me.

1 2 3 4 5 6 7

Appendix E: Posttest - Circulatory System

Participant ID _______________ Date ______________

Posttest

1) Which of the following is the primary function of red blood cells?

(A) Transport oxygen and remove carbon dioxide
(B) Defend body against foreign organisms and substances
(C) Generate impulses so all the muscle cells contract virtually in unison
(D) Clot blood when vessel is cut

2) Which of the following produces antibodies?

(A) Platelets
(B) Red Blood Cells
(C) Myocardium
(D) White Blood Cells

3) What is the purpose of coagulation?

(A) To capture oxygen molecules as the blood moves through the lungs
(B) To form a clot whenever a blood vessel is broken
(C) To absorb nutrients, expel wastes, and exchange gases with their environment
(D) To maintain the salt concentration in plasma

4) From the right atrium, where does deoxygenated blood travel?

(A) Left Ventricle
(B) Pulmonary Artery
(C) Left Atrium
(D) Right Ventricle

5) Where does the left ventricle send blood?

(A) Aorta (aortic valve)
(B) Left Atrium
(C) Right Atrium
(D) Right Ventricle

6) After being newly oxygenated in the lungs, blood flows into what?

(A) Tricuspid Valve
(B) Superior Vena Cava
(C) Inferior Vena Cava
(D) Pulmonary Vein

7) Where is the Tricuspid Valve located?

(A) Between the Right Atrium (also called auricle) and Left Atrium
(B) At the opening of the Aortic Valve
(C) Between the Left Atrium (also called auricle) and Left Ventricle
(D) Between the Right Atrium (also called auricle) and Right Ventricle

8) What is the primary purpose of all of the heart valves?

(A) To prevent blood from flowing backwards when the heart pumps or beats
(B) To pump oxygen-rich blood to the body
(C) To prevent oxygen-poor blood from entering the heart
(D) To dissolve oxygen and nutrients

9) Where is the Mitral (also known as the bicuspid valve) located?

(A) At the opening of the Pulmonary Vein
(B) Pulmonary Artery
(C) Between the Right Atrium (also called auricle) and Left Atrium
(D) Between the Right Atrium (also called auricle) and Right Ventricle
(E) Between the Left Atrium (also called auricle) and Left Ventricle

10) Which of the following is NOT a function of the circulatory system?

(A) Transport oxygen and nutrients
(B) Carry away wastes
(C) Regulate balance of acid and base in tissues
(D) Regulate body temperature

11) Which of the following is an important function of the circulatory system?

(A) Increases blood flow to meet energy needs during exercise
(B) Regulates acidic build-up
(C) Houses cells that detect smell
(D) Assists in production of sounds for speech

12) Which of the following is considered the engine of the circulatory system?

(A) Heart
(B) Blood
(C) Lungs
(D) Blood vessels

Appendix F: Posttest - Respiratory System

Participant ID _______________ Date ______________

Posttest

1) Which of the following connect the lungs to the heart?

(A) Bronchioles
(B) Capillaries
(C) Pulmonary Arteries
(D) Alveoli

2) Which of the following receive blood from the arteries and empties the blood into veins?

(A) Capillaries
(B) Pulmonary Arteries
(C) Bronchioles
(D) Myofibril

3) What is the correct description for the connection between the tubes in the lungs?

(A) Alveoli branch out to bronchi and the bronchi narrow down to alveolar ducts. These ducts open up to bronchioles.
(B) Alveolar ducts branch out to bronchioles and the bronchioles narrow down to bronchi. These tubes open up to alveolar ducts.
(C) Alveoli branch out to bronchioles and the bronchioles narrow down to bronchi. These ducts open up to alveolar ducts.
(D) Bronchi narrow down to bronchioles and the bronchioles divide into narrower alveolar ducts. These ducts end in a cluster of sacs called alveoli.

4) What controls the movement of the lungs (contracting and expanding)?

(A) Muscle located in inner layer of lungs
(B) Rib cage and diaphragm
(C) Electrical impulses generated by the heart
(D) Pressure of oxygen-rich blood

5) How is air forced into the lungs?

(A) Muscles that lift rib cage and lower diaphragm relax
(B) Muscles located in inner layer of lungs contract
(C) Output of electrical impulses originating from heart
(D) Partial vacuum created when rib cage contracts and chest cavity expands

6) What is the correct path of air from the nose or mouth to the lungs?

(A) Nose or mouth → bronchial tubes → trachea → larynx → lungs
(B) Nose or mouth → bronchial tubes → larynx → trachea → lungs
(C) Nose or mouth → trachea → bronchial tubes → lungs
(D) Nose or mouth → larynx → trachea → bronchial tubes → lungs

7) Which of the following is the organ where voice is produced and is located in the upper part of the windpipe?

(A) Larynx
(B) Pharynx
(C) Trachea
(D) Lungs

8) Which of the following is commonly called the windpipe?

(A) Lungs
(B) Larynx
(C) Pharynx
(D) Trachea

9) Which of the following is a muscular tube located in the neck and connects the nose and mouth with the trachea?

(A) Pharynx
(B) Trachea
(C) Lungs
(D) Aortic tube

10) What is the purpose of the respiratory system's removal of carbon dioxide?

(A) To increase the acidic level in the blood
(B) To maintain equilibrium of gases in the blood
(C) To limit diffusion from alveoli to the capillaries
(D) To prevent lethal buildup of waste products in body tissues

11) Which of the following is NOT a function of the respiratory system?

(A) Assist in production of sounds for speech
(B) Clot blood when vessels are cut
(C) Deliver oxygen to circulatory system
(D) Protect body against toxic substances inhaled with air

12) What is the purpose of the respiratory system's major function of regulating the balance of acid and base in tissues?

(A) To maintain normal functioning of cells
(B) To promote steady blood flow throughout the body
(C) To maintain alveoli's ability to diffuse oxygen to the capillaries
(D) To limit the need for white blood cells

Appendix G: Learning Task Questions – Circulatory System

Identify at least 3 major functions of the circulatory system.

Name the components of blood and briefly describe the role of each component.

Describe the path of blood as it travels through the heart.

Describe the location and function of the major valves in the heart.

Appendix H: Learning Task Questions – Respiratory System

Identify at least 3 major functions of the respiratory system.

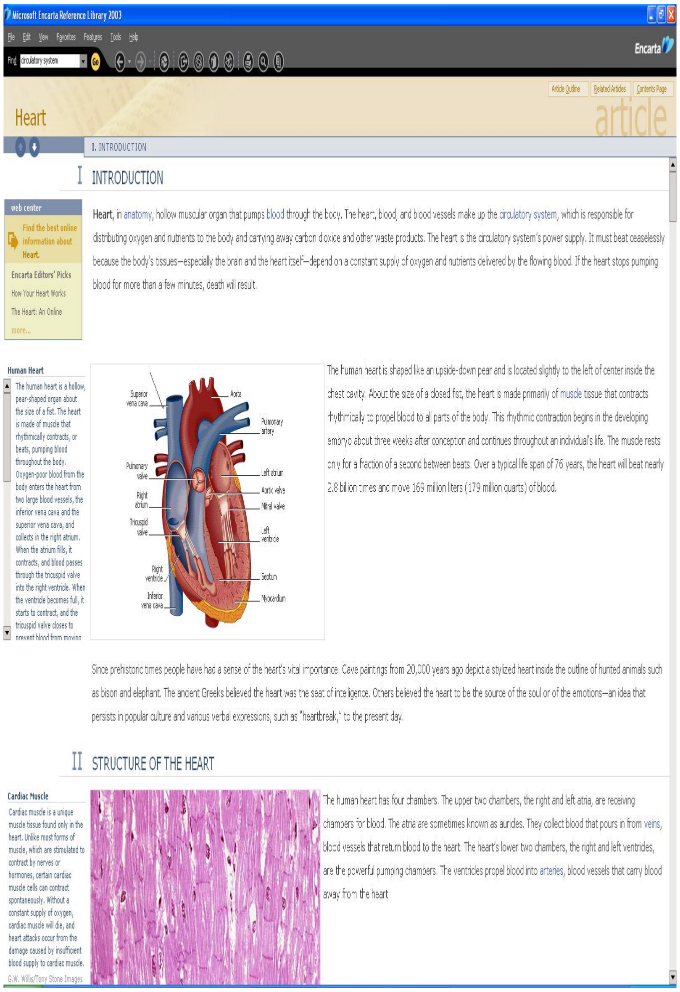
Name the tubes that branch off from the trachea and briefly describe how they are connected.

Describe the path of air in breathing from the nose to the lungs.

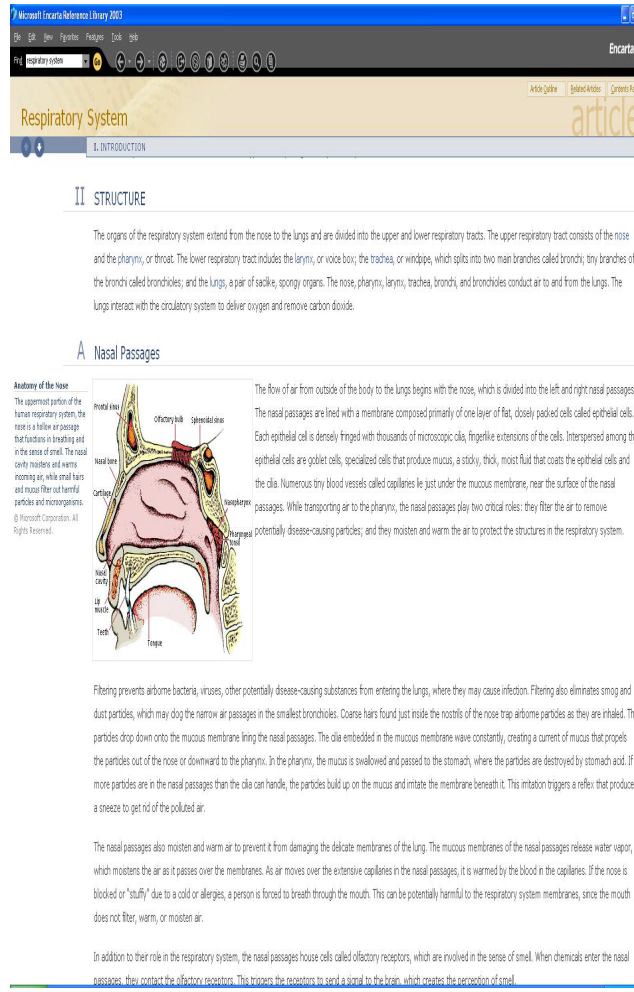
Describe the location and function of major organs in the respiratory tract.

Appendix I: Hypermedia Screen Shots

CIRCULATORY SYSTEM



RESPIRATORY SYSTEM



Appendix J: Learning Task One Directions

Directions for Learning Task #1:
In this learning task, you will be given the opportunity to study the circulatory system. After the learning task, you will be given a posttest that measures your learning. Though I will be scoring the posttest, I most interested in how you learn in this environment. You should use this time to learn as much as you can about the circulatory system.

I am studying how undergraduates learn complex topics in a hypermedia environment. In this learning task, you will be given 20 minutes to answer 4 questions about the circulatory system using a hypermedia environment. These questions will help you learn material for the posttest. In the hypermedia environment, you will have access to digitized video clips, static diagrams, and textual information. The questions will be placed on a board and you can answer them in any order. In addition, once you have begun to search for an answer, you may skip that question and move onto another question. You are allowed to return to a question at any time. As soon as you think that you have completely answered the question, please indicate that you are ready to go onto the next question. While I will not provide feedback on your answer during the learning task, I will be here if there are any problems with the computer.

In order for me to assess how you use the hypermedia environment, you are asked to "think aloud" continuously during this learning task. That is, I would like you to clearly articulate everything you are thinking and doing. For example, if you are reading, please read aloud. If you are searching for a topic, please vocalize what you are searching for and why. If you are skimming, please vocalize this behavior by stating that you are skimming and what you are skimming. If you are silent for more than a couple of seconds, I will prompt you to vocalize what you are thinking.

Appendix K: Learning Task Two Directions (Mastery)

Directions for Learning Task #2:
In this learning task, you will be given the opportunity to study the respiratory system. After the learning task, you will be given a posttest that measures your learning. Though I will be scoring the posttest, I am again most interested in how you learn in this environment. You should use this time to learn as much as you can about the respiratory system.

In this learning task, I am also examining how undergraduates learn complex topics in a hypermedia environment. You will again be given 20 minutes to answer 4 questions about the respiratory system using a hypermedia environment. These questions will help you learn material for the posttest. In this hypermedia environment, you will have access to static diagrams and textual information. As with the first learning task, the questions will be displayed on the board and you may answer them in any order. In addition, once you have begun to search for an answer, you may skip that question and move onto another question. You are allowed to return to a question at any time. As soon as you think that you have completely answered the question, please indicate that you are ready to go onto the next question. While I will not provide feedback on your answer during the learning task, I will be here if there are any problems with the computer.

In order for me to assess how you use the hypermedia environment, you are again asked to “think aloud” continuously during this learning task. Remember, I would like you to clearly articulate everything you are thinking and doing. For example, if you are reading, please read aloud. If you are searching for a topic, please vocalize what you are searching for and why. If you are skimming, please vocalize this behavior by stating that you are skimming and what you are skimming. If you are silent for more than a couple of seconds, I will prompt you to vocalize what you are thinking.

After the time has expired, you will be given a posttest that measures your learning. Though I will be scoring the posttest, I am most interested in how you learn in this environment. You should use this time to learn as much as you can about the respiratory system.

Appendix L: Learning Task Two Directions (Performance - approach)

Directions for Learning Task #2:
In this learning task, you will be given the opportunity to study the respiratory system. After the learning task, you will be given a posttest that measures your learning. While the purpose of the first learning task focused on how you as an individual learn, the purpose of this learning task is to compare the performance of undergraduate students to one another. University of Maryland undergraduates are fairly comparable in terms of how they learn. However, some students stand out because they perform quite well in this learning task and on the posttest. I will be comparing your answers on this learning task, as well as your performance on the posttest, with other University of Maryland students. In this learning task and on the posttest, you will be given an opportunity to demonstrate that you excel on the learning task questions and on the posttest.

In this learning task, I am also examining how undergraduates learn complex topics in a hypermedia environment. You will again be given 20 minutes to answer 4 questions about the respiratory system using a hypermedia environment. These questions will help you learn material for the posttest. In this hypermedia environment, you will have access to static diagrams and textual information. As with the first learning task, the questions will be displayed on the board and you may answer them in any order. In addition, once you have begun to search for an answer, you may skip that question and move onto another question. You are allowed to return to a question at any time. As soon as you think that you have completely answered the question, please indicate that you are ready to go onto the next question. While I will not provide feedback on your answer during the learning task, I will be here if there are any problems with the computer.

In order for me to assess how you use the hypermedia environment, you are again asked to "think aloud" continuously during this learning task. Remember, I would like you to clearly articulate everything you are thinking and doing. For example, if you are reading, please read aloud. If you are searching for a topic, please vocalize what you are searching for and why. If you are skimming, please vocalize this behavior by stating that you are skimming and what you are skimming. If you are silent for more than a couple of seconds, I will prompt you to vocalize what you are thinking.

After the time has expired, you will be given a posttest that measures your learning and you should use this time to learn as much as you can about the respiratory system.

Appendix M: Learning Task Two Directions (Performance - avoidance)

Directions for Learning Task #2:
In this learning task, you will be given the opportunity to study the respiratory system. After the learning task, you will be given a posttest that measures your learning. While the purpose of the first learning task focused on how you as an individual learn, the purpose of this learning task is to compare the performance of undergraduate students to one another. University of Maryland undergraduates are fairly comparable in terms of how they learn. However, some students stand out because they perform quite poorly in this learning task and on the posttest. I will be comparing your answers on this learning task, as well as your performance on the posttest, with other University of Maryland students. In this learning task and on the posttest, you will be given an opportunity to demonstrate that you do not perform poorly on the learning task questions and on the posttest.

In this learning task, I am also examining how undergraduates learn complex topics in a hypermedia environment. You will again be given 20 minutes to answer 4 questions about the respiratory system using a hypermedia environment. These questions will help you learn material for the posttest. In this hypermedia environment, you will have access to static diagrams and textual information. As with the first learning task, the questions will be displayed on the board and you may answer them in any order. In addition, once you have begun to search for an answer, you may skip that question and move onto another question. You are allowed to return to a question at any time. As soon as you think that you have completely answered the question, please indicate that you are ready to go onto the next question. While I will not provide feedback on your answer during the learning task, I will be here if there are any problems with the computer.

In order for me to assess how you use the hypermedia environment, you are again asked to “think aloud” continuously during this learning task. Remember, I would like you to clearly articulate everything you are thinking and doing. For example, if you are reading, please read aloud. If you are searching for a topic, please vocalize what you are searching for and why. If you are skimming, please vocalize this behavior by stating that you are skimming and what you are skimming. If you are silent for more than a couple of seconds, I will prompt you to vocalize what you are thinking.

After the time has expired, you will be given a posttest that measures your learning and you should use this time to learn as much as you can about the respiratory system.

Appendix N: Screen Shots of Video Angle and Participant Set-Up

Appendix O: Think-aloud Prompts

“Say what you are thinking.”

“Say what you are looking for.”

“Keep saying everything that you are learning.”

Appendix P: Modified Coding Scheme

Classes, Descriptions and Examples of Variables Used to Code Learners' Self-Regulatory Behavior (based on Azevedo, Guthrie, & Seibert, 2004)

Variable (parentheses indicates code abbreviation used in transcriptions)	Description	Example
Planning		
Prior Knowledge Activation (PKA)	Searching memory for relevant prior knowledge acquired in learning environment either before beginning performance of a task or during task performance.	**Student:** "Organs deliver oxygen to the circulatory system…" [Statement made while learning about the respiratory system and after learning about the circulatory system]
Recycle Goal in Working Memory (RG)	Restating the goals (e.g., question or parts of the question) in working memory	**Student:** "I want to name the components of blood and describe the role of each."
Monitoring		
Judgment of Learning (JOL)	Learner becomes aware that they don't know or understand everything they read, or learner indicates an understanding of the something they read.	**Student:** "That doesn't make sense." OR **Student:** "That makes sense."
Feeling of Knowing (FOK)	Learner is aware of having read or learned something in the past and having some understanding of it, or indicates an inability to recall it on demand.	**Student:** "So the larynx delivers air to the trachea, I know that." OR **Student:** "I learned that in high school, but I don't remember it."
Self-Questioning (SQ)	Posing a question in reference to improving understanding of the content.	**Student: "**So, where is the mitral valve located?"
Content Evaluation (CE)	Monitoring content relative goals, and inferring that content is inadequate and/or not useful.	**Student:** "Okay, this is not relevant to the question."
Identifying Content as Answer to Goal (ECAG)	Monitoring content relative goals, and inferring that content is adequate and/or useful for goal.	**Student:** "The introduction has the the three major functions."
Monitor Progress Towards Goals (MPTG)	Assessing whether previously-set goals has been met.	**Student:** "I have answered the first question."

Strategy Use

Review Notes (RN)	Reviewing learner's notes.	**Student:** "Okay, I am just going to review my notes quickly."
Free Search (FS)	Freely searching hypermedia environment. Free search includes skimming through the environment.	**Student:** "I am skimming right now."
Goal-Directed Search (GDS)	Searching the hypermedia environment through specifying a specific plan or goal and using the search tool afforded by the environment.	**Student:** "I am going to type in blood in the search engine."
Summarization (SUM)	Attempting to summarize what was just read, inspected, or heard in the hypermedia environment. Can include paraphrasing, but segment must represent an idea unit.	**Student:** "So, it goes to the lungs to pick up oxygen."
Taking Notes (TN)	Copying from the hypermedia environment.	**Student:** " …I am going to take brief notes here."
Draw (Draw)	Making a drawing or diagram to assist in learning.	**Student:** "I will draw a little diagram."
Re-reading (RR)	Intentionally re-reading or revisiting a section of the hypermedia environment.	**Student:** "Wait, I want to re-read that. [Re-reads] The blood, now oxygen rich, returns to the heart."
Inferences (INF)	Attempting to make an inference based on what was read, seen, or heard in the hypermedia environment. Inferences can be answered with the information available in the environment.	**Student:** "…it goes from the nasal passages to the pharynx, I guess."
Hypothesizing (HYP)	Making inferences that go beyond information available in environment.	**Student:** "That is why they do bone marrow transplants."
Mnemonic (MNEM)	Using a verbal or visual memory Technique to remember content.	**Student:** " I am going to use a mnemonic device to remember this."
Find Location in Environment (FLE)	Statement about where in environment learner had been reading.	**Student:** "Where was I?"
Skip (Skip)	Skipping learning task question to address another learning task question.	**Student:** " I am going to skip this question and move on."

Task Difficulty and Demands

Time and Effort Planning (TEP)	Attempts to intentionally control behavior as indicated by statement referencing effort and/or time	**Student:** “I only have two minutes left.”
Task Difficulty (TD)	Learner indicates that task or information in learning environment is either easy or difficult.	**Student:** “I am never going to remember any of this.”

Motivation

Interest Statement	Statement regarding level of interest in the task or in the content domain of the task	**Student:** “Cool. That’s interesting.” OR **Student:** “That is not interesting to me”

Appendix Q: One-Page Example from Coded Transcript

[redacted]

Scanning through here. FS

Reads: Numerous tiny blood vessels called capillaries lie just under the mucous membrane, near the surface of the nasal passages. While transporting air to the pharynx, the nasal passages play two critical roles: they filter the air to remove potentially disease-causing particles; and they moisten and warm the air to protect the structures in the respiratory system. Filtering prevents airborne bacteria.. Air leaves the nasal passages and flows to the pharynx, a short, funnel-shaped tube.. SUM

Transports air to the laynx.. Skimming here.. primary role is to transport air into trachea…also serves other functions..prevents food from entering the air passage..against choking [unintelligible]..help filter air…air passes from larynx into trachea..um…two tubes, left and right bronchi…okay..from the trachea to alveoli, which are in the lungs. Takes care of that question. *Describe the location and function of major organs in the respiratory tract*...inhalation.. describe the location and function of the major organs.. FS SUM MPTG RG

DM: What are you thinking?

JG: I am just looking for the diagrams right now. I am going back to contents page and.. I don't want that one..fish….[unintelligible] describe the location and function of major organs in the respiratory tract…just the pharynx..to filter..I need to go back up here. Nasal passage…so nasal passages filter and moisten and the pharynx…contains tonsils which fight disease…the larynx…transports air also, produces sound, prevents food from entering lungs..and the trachea..[unintelligible] transports air..alveoli.. and identify three major functions of the → CE RG GNC SUM

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