The Role of Goal Structure in Undergraduates' Use of Self-Regulatory Processes in Two Hypermedia Learning Tasks

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Abstract

We collected think-aloud and posttest data from 60 undergraduates to examine whether they used different proportions 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 hypermedia learning tasks in order to explore whether the goal structure of the learning task is related to the use of SRL variables. Participants were randomly assigned to one of three conditions (mastery goal structure, performance-approach goal structure, or performance-avoidance goal structure) and participated in two 20-minute learning tasks in which they used hypermedia to learn about the circulatory system in one learning task and the respiratory system in another learning task. 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 hypermedia learning tasks, whereas a performance-avoidance goal structure is related to undergraduate's use of different proportions of SRL variables, specifically *planning*, in two similar hypermedia learning tasks. Based on these results, the implications for the design of hypermedia learning environments are discussed.

The Role of Goal Structure in Undergraduates' Use of Self-Regulatory Processes in Two Hypermedia Learning Tasks

Computer-based learning environments (CBLEs) are becoming commonplace in the classroom (Alexander, Graham, & Harris, 1998). Recent CBLEs provide an environment in which students can pursue personal goals and solve challenging problems (Jonassen & Reeves, 1996; Lajoie, 2000; Lajoie & Azevedo, in press). Hypermedia, an example of a type of CBLE that allows students to pursue personal goals, presents information in a non-sequential and nonlinear manner which allows students to access information of their choosing (Jacobson & Archodidou, 2000; Jonassen, 1989).Though this learning environment should foster a student's participation in the construction of knowledge structures (Hartley, 1985), research has begun to question the effectiveness of these CBLEs (Williams, 1996; White & Frederriksen, in press).

Empirical research has produced mixed results on the effectiveness of such learning environments. Most of this research has compared student-controlled and program-controlled treatment conditions (Williams, 1996). Student-controlled CBLEs offer students the provision of choice in accessing information, whereas program-controlled CBLEs present information in a predetermined manner. For example, while researchers such as Morrison, Ross and Baldwin (1992) found that program-controlled treatments were superior to student-controlled treatments with respect to the posttest achievements of 6th graders learning about mathematical concepts, other researchers such as Ellermann and Free (1990) found that student-controlled instructional contexts fostered higher levels of learning with adults learning about phonetics. These mixed results suggest that some individuals can effectively use CBLEs such as hypermedia, whereas other students have difficulty using these CBLEs to learn.

Recent research has begun to shed light on why some students have difficulty effectively using student-controlled CBLEs, such as hypermedia environments. While these environments may offer a student the opportunity to choose which information to access, the multiple navigational choices may present the student with cognitive overload and disorientation (Müller-Kaltjoff & Möller, 2003). In order to address these potential hurdles to learning with these environments, the design of hypermedia often incorporates navigational aids such as graphical overviews (Müller-Kaltjoff & Möller, 2003) and scaffolds (Brush & Saye, 2001). However, some researchers suggest the provision of support tools does not guarantee that students will effectively use them while learning with hypermedia (Clarebout, Elen, Johnson, & Shaw, 2002). In order to better account for why some students have difficulty learning with hypermedia, other researchers have focused on individual student factors that may affect learning with hypermedia.

For example, Azevedo, Guthrie, & Seibert (2004) demonstrated that students need to regulate their learning when using a hypermedia environment in order to effectively navigate through the multiple representations and control the sequencing of non-linear information. Using self-regulated learning theory (SRL) as a theoretical framework to examine learning with a hypermedia environment, these researchers identified specific SRL variables that are related to learning complex and challenging science topics in a hypermedia environment. Students who regulate their learning by planning and monitoring tend to perform better than those students who do not deploy these self-regulatory processes while learning with hypermedia (Azevedo & Cromley, 2004).

Self-Regulated Learning: Theoretical Framework

In order to account for the complexity of learning with hypermedia, research has adopted the SRL theoretical framework (Winne, 2001; Winne & Hadwin, 1998). When using the SRL theoretical framework to examine learning with hypermedia, several theoretical and empirically-based assumptions are made (Pintrich, 2000). First, an underlying assumption is that students 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 assume that students can potentially regulate and monitor certain aspects of their cognition, behavior, and motivation. However, due to the influence of contextual variables, individual differences, and developmental constraints, individuals do not consistently monitor and control their cognition, behavior, and adoption of goals in all learning contexts. Third, most SRL models assume that all human behavior is goal-directed and that self-regulated students 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.

Self-Regulated Learning with Hypermedia

In order to effectively use hypermedia environments to learn about complex topics, it may be necessary to deploy certain SRL variables (Azevedo, Winters, & Moos, 2004). Because hypermedia is structured in a non-linear fashion, students are required to regulate their learning, including making decisions about which information to access, how much time to spend in the different representations of information, and when and how to modify strategies (Hadwin & Winne, 2001; Shapiro, 1999; Williams, 1996). Through identifying specific SRL variables that foster learning with hypermedia, recent research has begun to examine *how* students regulate their learning while using a hypermedia environment (e.g. Azevedo, Guthrie, & Seibert, 2004). However, it is also crucial to address *why* students regulate their learning.

Recent research examining how students regulate their learning while using a hypermedia environment has been primarily cognitive in nature (e.g., Azevedo & Cromley, 2004). That is, the interactions between motivational factors and the use of specific SRL variables in hypermedia environments have been largely unaddressed (Lajoie & Azevedo, in press; Lepper, Woolverton, Mumme, & Gutner 1993). However, as suggested by Lepper et al. (1993), learner characteristics such as motivational factors can distinctly affect how students regulate their learning. For example, though a student may have the capacity to engage in specific SRL activities, such as monitoring their time and effort, the student's motivation may determine if this specific SRL is used in a particular context (Lepper et. al., 1993). Thus, while it is important to understand *how* students regulate their learning while using a hypermedia environment (e.g. Azevedo, Guthrie, & Seibert, 2004), it is also crucial to examine students' motivation when using hypermedia because this line of research will help explain *why* students choose to regulate their learning with hypermedia (Corno & Mandinach, 1983, 2004).

Motivation and Hypermedia Environments

Literature examining the relationship between hypermedia and motivation suggests that students' use of hypermedia can increase their motivation toward learning (Liu & Pederson, 1998). Two theoretical camps have used different theories to explain the relationship between motivation and learning with hypermedia (Wishart, 2000). In one theoretical camp, cognitive theories suggest that hypermedia environments present intriguing intrinsic motivators (Wishart, 2000). For example, research has suggested that the most important cognitive factor in students' perception of CBLEs was their perception of control and ability to choose which information is accessed (Wishart,1990). Studies have suggested that provision of choice, as offered in hypermedia environments, is linked to increased intrinsic motivation because this aspect of the learning context increases the self-relevance of the activity (Cordova & Lepper, 1996). In the second theoretical camp, classical behaviorist theories originating from the work of Thorndike (1898) suggest that CBLEs such as hypermedia present extrinsic rewards. In these environments, students have access to multiple forms of information, including video, audio, animation and text (Jonassen, 1996), and these entertaining animations and graphics can be compelling and related to increased motivation (Wishart, 2000). For example, Wishart (2000) used structured interviews and surveys to ascertain students' motivation in learning with multimedia encyclopedias on CD-ROMs. Results from these surveys and interviews suggested that the learning environment of multimedia and hypermedia, in which graphics, video and sound are integrated, is related to high levels of student motivation.

While this line of research suggests that students' use of hypermedia is related to increased motivation towards learning, the relationship between motivation and SRL during learning with hypermedia remains largely unaddressed. In order to better understand students' regulation of their learning in hypermedia, it is crucial to address *how* (i.e. the SRL processes) and *why* (i.e. the motivation underlying these SRL processes) students regulate their learning. To begin to address both of these issues, findings that have examined the role of different goal structures on learning should be considered (Ames, 1992). This line of research has been previously used to examine the role of motivation in SRL, but has not extensively examined the role of motivation in SRL within the context of learning with hypermedia.

Goal Structure and Self-Regulated Learning

When considering how and why students self-regulate their learning in a hypermedia environment, it is important to address the influence of the hypermedia's goal structure. Goal structure has been defined as the expectation embedded in the design of learning activities

(Ames, 1992). It has been suggested that the design of learning activities can influence the motivation underlying how a student learns (Ames, 1992). Ames (1992) suggests that there are salient structures in the learning activities and that the way in which students experience these structures can affect their learning. For example, she suggests that students' perception of structures in learning activities can influence students' willingness to apply strategies, their feelings of satisfaction, and how they approach learning. More specifically, she suggests that learning activities which are focused on developing understanding of the activity's content are much more likely to promote learning that is distinct from environments that include an external criterion for performance.

Other researchers have also supported this assertion that different goal structures within a learning activity can affect learning. For example, Elliot & Harackiewicz (1996) advocated that an environment can have three goal structures, *mastery, performance-approach,* and *performance-avoidance*. In this goal structure framework, performance-avoidance goal structure refers to an environment that presents normative references with the underlying emphasis of avoiding failure or demonstration of incompetence (Wolters, 2004). Performance-approach goal structure refers to an environment that presents normative references with the underlying emphasis of demonstrating competence relative to others (Wolters, 2004). Mastery goal structure refers to an environment that downplays normative references and emphasizes mastering of material through increasing the level of competence and learning as much as possible (Wolters, 2004). Elliot & Harackiewicz (1996) examined how these three distinct goal structures differentially impacted the learning process by randomly assigning 54 undergraduate students to one of three conditions (mastery, performance-approach, or performance-avoidance). These students completed four problem-solving activities under one of these distinct goal structures.

The results of this study suggest that the three goal structures distinctly affect learning (see Elliot & Harackiewicz, 1996). Specifically, the findings suggested that a performance-avoidance goal structure undermined learning, while the performance-approach condition and mastery condition were related to increased intrinsic motivation and higher learning outcomes.

In summary, research examining learning in environments with different goal structures suggests that these contextual variables can distinctly affect *why* and *how* students learn. Generally, when a student learns in an environment with a mastery goal structure, they tend to use more effective cognitive processes, while a student learning in an environment with performance goal structures typically use more superficial processes. However, as some recent research has highlighted, a performance-approach, but not performance-avoidance, goal structure may lead to more effective cognitive processes. Research has examined these relationships with both self-report questionnaires, such as the *Motivated Strategies for Learning Questionnaire (MSLQ)*, and methodologies that experimentally created distinct goal structures in learning activities (e.g. Elliot and Harackiewicz, 1996). Despite previous literature highlighting the relationship between goal structures of learning environments and students' SRL, it is currently unclear whether this relationship holds true in learning with hypermedia.

Overview of Study and Hypotheses

The literature reviewed in the preceding sections suggests that in order to best understand learning in hypermedia environments, it is necessary to account for both *how* SRL variables are related to learning with hypermedia (e.g. Azevedo, Cromley, & Seibert, 2004) and *why* individuals deploy these SRL skills (e.g. Boekaerts et. al., 2000). This study attempts to address both of these issues regarding the role of goal structure in self-regulated learning with hypermedia by combining research from the fields of SRL, goal structure, and learning with hypermedia.

This study combines product data (i.e. posttest and MSLQ scores) and process data (i.e. the frequency of specific SRL variables used while learning with hypermedia) to address the following research questions: (1) Is the goal structure of two hypermedia learning tasks related to the use of specific SRL processes? (2) Is the goal structure of a hypermedia learning task related to students' learning, as measured by a posttest? and (3) Is the goal structure of a hypermedia learning task related to the extrinsic motivation, intrinsic motivation, and task value, as measured by the MSLQ?

Method

Participants

Participants were 64 undergraduate students pursuing education majors and were recruited from undergraduate education courses at a large Mid-Atlantic university. 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. The participants received extra credit in their classes for participating in this study. Their mean age was 21.0 ($SD = 3.75$); there were 45 women (75%) and 15 men (25%).

Research Design

A 3 (condition: mastery goal structure [A], performance-approach structure [B], performance-avoidance structure [C]) x 2 (learning task: learning task 1, learning task 2) repeated measures design was used. Participants were randomly assigned to one of the three conditions (mastery, performance-approach, or performance-avoidance). In addition to posttests at the end of each learning task, verbal data were collected using a think-aloud protocol methodology while students used a hypermedia environment (based on Ericsson & Simon, 1994).

Hypermedia Environment

During the two learning tasks, participants used the Microsoft Encarta Reference Suite™ (2003) hypermedia environment that was installed on a laptop computer. 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 tasks because this study was examining learning in a finite corpus of information. In this hypermedia environment, the circulatory system has three particularly relevant articles (the heart, circulatory system, and blood articles), which are composed 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 composed of 13,282 words, 14 illustrations, 68 hyperlinks, and 11 sections.

Measures and Materials

Participants read and signed a consent form and completed a participant questionnaire, 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 Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991). The complete MSLQ questionnaire consists of 81 items answered on a 7 point Likert scale (1 = not at all true of me to 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 each include 4 items, and the task value scale includes 6 items (see Appendix A). Participants also completed two posttests, one after each learning task.These posttests 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 researchers and the former science teacher to reflect the material presented in the hypermedia environment (see Appendix B).

Procedure

The 60 participants were randomly assigned to one of three goal conditions (mastery, performance-approach, or performance-avoidance) and were individually tested by the researcher. 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 on 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 a digitized video clip). Following this training session, the participants were given the directions for learning task one. For the first learning task, participants in all three conditions received identical directions which were designed to create a mastery goal structure for that learning task. These directions were designed based on previous research by Elliot and Harackiewicz's (1996) and were intended to focus the participants' attention on the task itself and downplay a normative reference for their performance The directions were comprised of two main sections. The first section indicated that the participant would have twenty minutes to learn about a science topic (the circulatory or respiratory system) using the hypermedia environment and they would be given four questions to help guide their learning during those 20 minutes. In the second section, the directions instructed the participants to "think aloud" during the learning task (based on Azevedo, Guthrie, & Seibert, 2004) (see Appendix C). 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 (see Appendix D). Verbal data were collected during the 20 minute learning task using the think-aloud protocol methodology (Ericsson & Simon, 1993). 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.

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 order of the science topics in the learning tasks was counterbalanced between participants. The procedure for the second learning task was identical to the procedure for the first learning task, except that each condition received directions with a different goal structure. One condition received a mastery goal structure, the second condition received a performance-approach goal structure, and the third condition received a performance-avoidance goal structure (see Appendix E). These directions were designed based on previous research by Elliot and Harackiewicz (1996). The directions for the performance-approach and performance-avoidance goal structure were intended to highlight potential achievement outcomes and establish a normative reference for performance evaluation, while the mastery goal structure was intended to intended to downplay a normative reference for their performance (see Table 1 for the methodological paradigm).

Insert Table 1 about here

Coding and Scoring

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

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 procedure used 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 was calculated by dividing the sum of the participants' responses to all of the questions in each category by the number of items in each category.

Posttest on Circulatory and Respiratory Systems

The posttests were 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). Each participant received two posttest scores, one for the circulatory systems posttest and one for the respiratory systems posttest.

Student Verbalizations

The verbal data collected during the learning tasks was used to analyze the students' SRL during learning of the two hypermedia learning tasks. 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 first author 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 procedure has been previously used by researchers investigating the role of SRL with hypermedia (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). 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 used in this study was modified from Azevedo, Cromley, & Seibert's scheme (2004) to capture the SRL behavior used by the participants in this particular study. The modified coding scheme includes 23 SRL variables from the five SRL categories of *planning, monitoring, strategy use, tasks difficulty,* and *motivation*.

- *Planning* variables include recycling goals in working memory and activating prior knowledge.
- *Monitoring* variables include judgment of learning, feeling of knowing, self-questioning, content evaluation, identifying content as answer to goal, and monitoring progress towards goals.
- *Strategy use* variables include reviewing notes, free search, goal-directed search, summarization, taking notes, drawing, re-reading, inference, hypothesizing, using mnemonics, finding location in environment, and skiping content.
- *Task difficulty* variables include time and effort planning and handling task difficulties.
- *Motivation* variable includes interest statements.

All of the transcriptions were coded by assigning one of the SRL variables (presented in Appendix F) to each coded segment. 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).

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 their number of verbalizations. A median split was then performed on this 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). Thus, these median splits were used to determine if there was proportion stability of the SRL variables used in the two learning tasks.

Inter-rater Agreement

Inter-rater agreement was established for the coding of the undergraduate students' self-regulated behavior by comparing the individual coding of the first author, who was trained to use an adapted version of Azevedo, Guthrie, and Seibert's (2004) coding scheme, with that of the second author. 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.

Results

Research Question One: Is the goal structure of two hypermedia learning tasks related to the use of specific SRL processes? For each SRL category, a 3 (Condition: Mastery, Performance-approach, Performance-avoidance) x 2 (proportion stability: above or below the median proportion in each learning task, above the median proportion in one learning task and below the median proportion in the other learning task) chi-square analysis was computed. The chi-square for *planning* variables was significant, χ^2 [2, $N = 60$] = 6.65, $p < .05$. 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 hypermedia learning tasks. In this condition, 85 percent of the participants (*n* = 13) used a different proportion of planning variables in the two hypermedia learning tasks. On the other hand, only 25 percent of the participants (*n* = 5) in the performance-approach condition used a different proportion of planning variables in the two hypermedia learning tasks, and 40 percent of the participants (*n* = 8) in the mastery condition used a different proportion of planning variables in the two hypermedia learning tasks. The Chi-square analyses were non-significant for the other four SRL categories, *monitoring* ($p > .05$), *strategy use* ($p > .05$), *task difficulty* ($p > .05$), and *motivation* ($p > .05$). These data suggest that these participants used a similar proportion of SRL variables from the categories of *monitoring, strategy use, task difficulty,* and *motivation* in the two hypermedia learning tasks (see Table 2).

Insert Table 2 about here

Research Question Two: Is the goal structure of a learning task related to 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 3).

Insert Table 3 about here

Research Question Three: Is the goal structure of a learning task related to *students' task value, extrinsic motivation, and/or task value?* Three separate 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 3).

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 3).

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 3).

Discussion

This study provides an empirically-based and theoretically-driven analysis that potentially offers theoretical contributions to the field of SRL in learning with hypermedia. From a theoretical standpoint, this study builds on existing models of SRL in learning with hypermedia (e.g. Azevedo, Cromley, & Seibert, 2004) by examining the stability of SRL variables across two hypermedia learning tasks. Stability of SRL, in the sense of the undergraduates' use of similar SRL variables in multiple hypermedia learning tasks, is an area that has been largely unaddressed and this study potentially contributes to our understanding of this issue. The results from this study 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 hypermedia learning tasks. These findings are supported by previous literature on goal structure (eg. Boekaerts et. al., 2000). The literature that supports a theoretical framework consisting of three distinct goal structures (mastery, performance-approach, and performance-avoidance) suggests that learning contexts with a performance-approach goal or a mastery goal structure may elicit the use similar SRL processes. For example, Wolters et al. (1996) suggested that having a positive external criterion, as in a performance-approach but not performance-avoidance goal structure, may actually lead to the use of cognitive strategies similar to that of a mastery goal structure. However, while this study suggests that the goal structure of a hypermedia environment may be related to the stability of students' SRL use, the role of the hypermedia context must also be considered. Why did participants from all three conditions use a similar proportion of SRL processes from 4 of the 5 SRL categories (monitoring, strategy use, task difficulty and demand, and motivation) in two hypermedia learning tasks? It is possible that the learning context of hypermedia may elicit the use of specific SRL processes from students, regardless of what is being learned in hypermedia. Previous research has suggested that students may be required to use a set of specific skills in order to effectively learn with hypertext and hypermedia (Shapiro, & Niederhauser, 2004). That is, when a student is learning with hypermedia, the student is required to regulate their learning, including making decisions about which information to access, how much time to spend in the different representations of information, and when and how to modify strategies (Azevedo, Cromley, & Seibert, 2004; Hadwin & Winne, 2001; Shapiro, 1999; Williams, 1996). Thus, it is plausible to suggest that the context of hypermedia elicits specific SRL processes when a student is learning about similar topics. Because undergraduates used similar SRL variables in two hypermedia learning tasks, this study provides some support that the learning context of hypermedia may elicit specific SRL variables. Future research should continue to examine the influence of this learning environment, and mediating roles of other contextual variables such as the goal structure, on students' use of SRL variables when learning with hypermedia.

While this study suggests that a mastery goal structure and performance-approach goal structure may be related to undergraduates' use of similar SRL processes in two hypermedia learning tasks, the results of this study also suggest that a performance-avoidance goal structure may affect students' use of SRL processes. Participants in the performance-avoidance condition used a different proportion of SRL variables in the two learning tasks, specifically in the SRL category of *planning*. As highlighted earlier, some previous research supports this finding by indicating that a performance-avoidance goal structure is related to students' use of distinct self-regulatory behavior (Boekaerts et. al., 2000). For example, Elliot & Harackiewicz (1994) found that participants learning in an environment with a performance-avoidance goal structure strove to avoid the demonstration of failure and this behavior was not evident in students learning in an environment with a mastery or performance-approach goal structure. While previous research has examined the relationship between performance-avoidance goal structure and SRL (Maehr & Pintrich, 1991), limited research has examined the relationship between goal structure and SRL in two hypermedia learning tasks on a fine-grained level of analysis (i.e. examining SRL as 23 variables in five categories) using the think-aloud methodology. This study's use of a fine-grained analysis raises an intriguing question: Why is a performance-avoidance goal structure related to undergraduates' use of a different proportion of planning variables in two hypermedia learning tasks? One plausible explanation is that the planning category includes the SRL variable of *recycling goal in working memory*. When a student recycles a goal in their working memory, this student is verbally restating that a goal that has not been met. Continually restating that a goal has not been met may be construed as a failure to achieve that goal. Thus, students learning in an environment with a performance-avoidance goal structure may strive to avoid this planning activity because this goal structure emphasizes the avoidance of failure.

In addition to demonstrating how the goal structure of hypermedia environments may potentially impact both *how* and *why* students regulate their learning, the results from this study also examine how the goal structure of hypermedia environments may potentially impact *what* the students learn. Participants in the mastery and performance-approach conditions scored similarly on the two posttests and their use of SRL in the two hypermedia learning task may explain this similarity. Recent research suggests that there is a positive relationship between a students' SRL and his/her learning of science topics with hypermedia (see Azevedo, Guthrie, & Seibert, 2004). Based on this research, it is not surprising that participants in the mastery and performance-approach conditions scored similarly on the two posttests after using a similar proportion of SRL variables in the two learning tasks. Interestingly, however, the participants in the performance-avoidance condition also scored similarly on the two posttests despite the fact that they planned differently in the two learning tasks. This finding raises an intriguing question about the relative importance of using different SRL categories while learning with hypermedia. While previous research has demonstrated the importance of using specific SRL variables in learning with hypermedia, limited research has examined the relative importance of different SRL variables in learning with hypermedia. This study suggests that not using critical planning variables, such as prior knowledge activation, may be compensated for by relying on key SRL variables from other categories, such as strategy use. That is, participants in the performance-avoidance condition used key strategies in two hypermedia learning tasks, and this may have compensated for their use of different planning variables in the two tasks. Future research should continue to examine SRL on a fine-grained level of analysis so that the relative importance of specific SRL categories and learning outcomes when using a hypermedia environment can be more closely examined.

Lastly, this study suggests that different goal structures of hypermedia learning tasks are not distinctly related to three measures from the *MSLQ* (task value, extrinsic motivation, and intrinsic motivation). 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, neither extrinsic motivation nor intrinsic motivation was significantly different between conditions. These results are not supported by previous research. For example, Elliot & Harackiewicz (1996) 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 (1996). First, while this study used the same methodology as Elliot & Harackiewicz (1996) of creating different goal structures for the learning tasks, 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 (1996). These differences may offer an explanation on why there is a discrepancy between the findings in the two studies.

Implications for the Design of Hypermedia

Understanding how students learn from hypermedia environments necessitates a new direction of research (Brusilovsky, 2001), and this research has implications for the design of hypermedia. As previously highlighted, hypermedia may help students learn about complex and challenging topics (Azevedo, Winters, & Moos, 2004) by providing a variety of representations of information (text, audio, and video clips). However, recent research has demonstrated that students may need to deploy certain SRL processes in order to effectively use hypermedia environments to learn about science topics (Azevedo & Cromley, 2004; Azevedo et al., 2004). This study furthers existing research by highlighting the need for the design of hypermedia to support the use of specific SRL variables. When the raw frequencies of the use of SRL processes are examined, it is clear that these undergraduates, regardless of the condition, use more SRL processes from the *strategy* category than from the other four categories. In fact, these undergraduates, on average, used at least three times more *strategy* variables than variables from either the *planning* category or the *monitoring* category (see Table 4).

Insert Table 4 about here

It is important to note that previous studies have identified that *planning* (such as activating prior knowledge) and *monitoring* variables (such as feeling of knowing) are critical 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, as suggested by this study, then the design of a hypermedia environment should address this issue by focusing on scaffolding key planning variables, such as activating prior knowledge, and monitoring variables, such as feeling of knowing.

Limitations

While this study potentially offers theoretical contributions to research examining the role of SRL in learning with hypermedia, there are some limitations that need to be addressed. First, this study provides results that may only apply to undergraduates' use of SRL variables when learning about similar science topics with a hypermedia environment, and does not provide evidence that undergraduates would use similar SRL variables when learning about unrelated topics with hypermedia. Second, this study does not identify the individual goal orientation of the participants in this study. Identifying the participants' goal orientation before they participated in this study could have shed light on any interactions between an individual's goal orientation and the effectiveness of providing different goal structures for the two learning tasks. Taking both of these points into consideration, the interpretation of the data needs to be made with care. Lastly, the limitations of the research design should be addressed. Though the participants were randomly assigned to one of three conditions, the absence of a pretest does not allow the participants' learning to be truly measured because their prior knowledge, as measured by a pretest, cannot be taken into account.

Conclusion

This study provides analyses that build on existing models of SRL in learning with hypermedia by examining whether undergraduates use similar SRL variables in two hypermedia learning tasks about related science topics. Providing rich data that extend previous research on *how* students regulate their learning with hypermedia (e.g. Azevedo & Cromley, 2004) and *why* students regulate their learning (e.g. Elliot & Harackiewicz, 1994), this study explores factors that could substantially impact students' learning with hypermedia. Results indicate that undergraduates who use a hypermedia environment with a mastery goal structure or a performance-approach goal structure use similar proportions of SRL processes in two learning tasks, whereas undergraduates who use a hypermedia environment with a performance-avoidance goal structure use different proportions of SRL processes, specifically *planning*, in two learning tasks. In addition to providing empirically-based and theoretically-driven analyses that shed light on how and why students regulate their learning in a hypermedia environment, this study also provides data that have implications for the design of hypermedia environments.

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Table 1
Methodological Paradigm

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

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

= Participants engage in think-aloud

= Progression through experimental procedure

Table 2
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 $N = 60$
* $p < .05$

Table 3
Mean posttest score (%) and mean MSLQ rating, by condition and learning task

	Condition A: Mastery		Condition B: Performance – Approach		Condition C: Performance – Avoidance	
	Learning Task #1 Mean (SD)	Learning Task #2 Mean (SD)	Learning Task #1 Mean (SD)	Learning Task #2 Mean (SD)	Learning Task #1 Mean (SD)	Learning Task #2 Mean (SD)
Posttest Score	72.08 (14.83)	72.50 (20.07)	75.00 (16.13)	75.42 (16.42)	70.00 (23.67)	79.17 (14.67)
MSLQ: 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)
MSLQ: 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)
MSLQ: Intrinsic Motivation	5.10 (.85)	5.00 (.65)	5.03 (1.16)	4.99 (1.03)	4.80 (.74)	4.66 (.90)

Table 4
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)	
Planning	Learning Task #1	Learning Task #2	Learning Task #1	Learning Task #2	Learning Task #1	Learning Task #2
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
GRAND TOTAL	*813*	*789*	*837*	*871*	*762*	*795*

Appendix A
Three MSLQ Measures (Pintrich, Smith, Garcia, & McKeachie, 1991)

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)[1]

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.

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

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.

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

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.

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

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.

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

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

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

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

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

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

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[1] In the study, the participants was given the 7 point Likert Scale for each question

Appendix B
Two Posttests

Posttest: Circulatory System

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) Increase blood flow to meet energy needs during exercise
- (B) Regulate acidic build-up
- (C) House cells that detect smell
- (D) Assist 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

Posttest: Respiratory System

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) Increase the acidic level in the blood
- (B) Maintain equilibrium of gases in the blood
- (C) Limit diffusion from alveoli to the capillaries
- (D) 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) Maintain normal functioning of cells
- (B) Promote steady blood flow throughout the body
- (C) Maintain alveoli's ability to diffuse oxygen to the capillaries
- (D) Limit the need for white blood cells

Appendix C
Directions for Learning Task One

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 D
Guiding Questions

Circulatory System

1) Identify at least 3 major functions of the circulatory system.

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

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

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

Respiratory System

1) Identify at least 3 major functions of the respiratory system.

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

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

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

Appendix E
Directions for Learning Task Two (Mastery Goal Structure)

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.

Directions for Learning Task Two (Performance – Approach Goal Structure)

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.

Directions for Learning Task Two (Performance – Avoidance Goal Structure)

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 F
Coding Scheme

Classes, Descriptions and Examples of Variables Used to Code Students' Self-Regulatory Behavior (based on Azevedo, Cromley, & 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)	Student becomes aware that they don't know or understand everything they read, or student indicates an understanding of the something they read.	**Student:** "That doesn't make sense." OR **Student:** "That makes sense."
Feeling of Knowing (FOK)	Student 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 recall it."
Self-Questioning (SQ)	Posing a question to improve understanding of the content.	**Student: "**So, where is the mitral valve located?"
Content Evaluation (CE)	Monitoring content relative to 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 to 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 have been met.	**Student:** "I have answered the first question."

Strategy Use

Review Notes (RN)	Reviewing student'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 aorta 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 student 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)	Student 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.”