
Volume 50, issue 3, April 2008
ISSN 0360-1315
ELSEVIER
Computers & Education
An International Journal
Editors:
Rachelle S. Heller
Jean D.M. Underwood
Available online at
ScienceDirect
www.sciencedirect.com

Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Computers & Education 50 (2008) 1069–1083
COMPUTERS & EDUCATION
www.elsevier.com/locate/compedu

Exploring differences between gifted and grade-level students' use of self-regulatory learning processes with hypermedia

Jeffrey A. Greene [a,*], Daniel C. Moos [a], Roger Azevedo [b], Fielding I. Winters [a]

[a] *Human Development Department, University of Maryland, College Park, 3304 Benjamin Building, College Park, MD 20742, United States*
[b] *Department of Psychology and Institute for Intelligent Systems, University of Memphis, 3693 Norriswood Ave., Memphis, TN 38152, United States*

Received 31 March 2006; received in revised form 14 October 2006; accepted 16 October 2006

Abstract

Research involving gifted and grade-level students has shown that they display differences in their knowledge of self-regulatory strategies. However, little research exists regarding whether these students differ in their actual use of these strategies. This study aimed to address this question by examining think-aloud data collected from 98 gifted and grade-level students engaging in a complex learning task: utilizing a hypermedia environment to learn about the circulatory system. We also examined both declarative knowledge and mental model measures of learning to determine whether these groups differed in their actual performance. Our results show that gifted students did outperform grade-level students in all outcome measures. In addition, gifted students more often utilized more sophisticated self-regulatory strategies (e.g. coordinating informational sources) than grade-level students. Grade-level students were more likely to use less effective strategies that are less likely to promote the acquisition of knowledge (e.g. mnemonics). Recommendations for future intervention studies are based upon these findings.

Keywords: Multimedia/hypermedia systems; Teaching/learning strategies; Ability levels; Science

1. Introduction

Special educational programs for gifted students exist because these students seem to learn differently than their grade-level peers. However, the question as to why gifted students tend to be more successful remains somewhat of a mystery. Numerous authors have suggested that students in general are more successful when they engage in self-regulated learning (SRL; Boekaerts & Corno, 2005; Greene & Azevedo, in press; Pintrich, 2000; Winne, 1995; Zimmerman, 2000, 2001). Recent research examining how students learn complex and

* Corresponding author. Tel.: +1 301 405 4333; fax: +1 301 405 2891.
E-mail address: jgreene@umd.edu (J.A. Greene).

0360-1315/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.compedu.2006.10.004

challenging tasks has suggested that successful students deploy key self-regulatory strategies and processes (Azevedo & Cromley, 2004; Azevedo, Cromley, & Seibert, 2004a; Azevedo, Cromley, Winters, Moos, & Greene, 2005; Azevedo, Moos, Greene, Winters, & Cromley, in press). These studies have focused on actual learning tasks and utilized more objective SRL behavior data-collection techniques such as think-aloud protocols (Ericsson & Simon, 1993), rather than self-report measures. In this study, by using think-aloud protocols and a pretest–posttest design to analyze students' learning of a complex and challenging task with a hypermedia environment, we aim to determine if gifted students do outperform grade-level students when learning with a hypermedia environment, and whether gifted students utilize more effective SRL processes than their grade-level peers. If gifted students do perform more successfully, we assert that their use of more effective SRL processes may be one reason why these students outperform their grade-level peers. If true, these findings would suggest that specific SRL-based interventions may be effective for helping grade-level students learn complex and challenging tasks. Specifically, these interventions may be embedded in hypermedia learning environments to facilitate the SRL processes associated with learning outcomes.

1.1. Theoretical perspective: self-regulated learning

SRL is a conceptual framework for describing how students engage in the learning process. This framework is used to understand students' cognition, motivation, behavior and context as they plan, monitor, control, and reflect on those aspects of their own learning (Pintrich, 2000; Winne, 2001; Zimmerman and Schunk, 2001). When students are effective regulators of their learning, they are able to achieve academic goals (Pintrich & Zusho, 2002).

Pintrich (2000) presents a model of SRL that is defined by four assumptions: first, all learners are active, in that they make decisions and initiate behavior to further their knowledge or understanding; second, all students have the potential to regulate their learning; third, students are aware of some goal or criterion to which they should compare their progress as they learn; and fourth, the SRL activities of a student mediate the relations between the context and the individual, and the eventual achievement for that individual. Within the context of these four assumptions, the model designates four areas that students can regulate when they are learning: their *cognition* (e.g., goal-setting, employing and monitoring of cognitive strategies); their *motivation* (e.g., self-efficacy beliefs, values for the task, interest); their *behavior* (e.g., help-seeking, maintenance and monitoring of effort, time use); and the learning *context* (e.g., evaluation and monitoring of changing task conditions). It is assumed that students will cycle through phases of *planning*, *monitoring*, *controlling*, and *reflecting* in these four areas while they learn, though the degree to which this occurs depends on the learning context (Pintrich, 2000). For example, in learning about the circulatory system with a hypermedia learning environment, successful students most likely need to coordinate the multiple representations of information; including text, diagrams, and video (Azevedo et al., 2005).

In practice, however, students are not always effective at regulating their learning (Paris & Paris, 2001). Students can fail to use self-regulatory skills for many reasons. For example, they may not have prior content knowledge or know when to enact certain strategies to help them reach their goal (Azevedo, Winters, & Moos, 2004); they may not have the motivation, nor the control of their motivation to persist at a difficult task when they lose interest (Moos & Azevedo, 2006; Wolters, 2003); they may not plan appropriately to reach their goals (Vye et al., 1998); they may not monitor their progress towards those goals within changing task contexts (White, Shimoda, & Frederiksen, 2000); or they may not know when to seek help (Newman, 2002). Therefore, students' regulatory behavior, or lack thereof, will have an impact upon their learning, and students who regulate their learning effectively are more likely to be successful (Boekaerts & Corno, 2005; Butler & Winne, 1995; Pintrich, 2000; Winne, 1995). It would seem intuitive that gifted students would be better regulators of their learning than grade-level students, but the research is not conclusive (see below). The question remains as to whether the differences in performance between gifted and grade-level students are at all attributable in part to their use of SRL behaviors.

1.2. Gifted versus grade-level students

Definitions of gifted students have focused upon the interaction of creativity, task commitment, and above-average ability (Renzulli, 2002). More recently, however, researchers have been examining differences in the use of metacognition between gifted and grade-level students. For example, research has found gifted students possess more declarative knowledge regarding metacognitive strategies, and more complex strategies in general (Alexander, Carr, & Schwanenflugel, 1995; Carr, Alexander, & Schwanenflugel, 1996). Carr and colleagues (1996) speculated that this elaborate understanding and use of more complex strategies may be what makes gifted students more likely to transfer these strategies to other domains. Based upon these studies, gifted students clearly possess more metacognitive skills, but the question remains as to how this influences their learning.

Surprisingly, while these studies have found a difference in students' understanding of metacognitive monitoring strategies, they have not found significant differences between gifted and grade-level students in terms of their reported use of metacognitive skills and monitoring processes (Carr et al., 1996; Zimmerman & Martinez-Ponz, 1990). It is counter-intuitive that gifted students would possess more knowledge of SRL skills than grade-level students but not actually deploy them differentially. The lack of conclusive evidence may be due to the fact that much of the research in this area has been correlational, focusing on surveys rather than learning tasks or objective measures of learning. In addition, many studies of SRL have relied upon questionable student self-report data regarding SRL behaviors (see Winne & Jamieson-Noel, 2002), as opposed to more reliable and objective methods such as think-alouds (see Azevedo, 2005; Azevedo & Cromley, 2004). Therefore, while theory would suggest that one possible explanation for the greater success of gifted students is their understanding of metacognitive skills and processes, the current research has not effectively investigated this claim. We hypothesize that studying students engaged in challenging learning tasks, coupled with the collection of think-aloud data, will reveal differences in both the performance and use of SRL strategies and processes between gifted and grade-level students. One way to capture students' SRL use during challenging learning tasks is through studying how they learn with hypermedia.

1.3. Learning with hypermedia

Hypermedia is a computer-based learning environment in which the basic unit of information is represented as nodes (Jonassen & Reeves, 1996). Consisting of a video clip, sound bite, graphic, page of text, or even an entire document, the node is the unit of information storage in hypermedia. The structure of nodes in a hypermedia environment typically creates a dynamic knowledge base where students can access any node in varying sequences, depending on students' interests and goals. Because students can access information of their choosing through the non-sequential format of the information, they can pursue personal goals when learning with hypermedia. However, though these attributes should foster students' active participation in the construction of knowledge (Williams, 1996), empirical research has produced mixed results on the effectiveness of these learning environments. With greater freedom to explore the environment comes greater responsibility for doing so in a productive manner. Research suggests that while hypermedia fosters conceptual change in some students (Jacobson & Archodidou, 2000), other students have difficulty using these learning environments to even develop conceptual knowledge (Azevedo et al., 2005, in press; Azevedo et al., 2004; Greene & Azevedo, 2006).

Recent research has begun to examine how the effectiveness of hypermedia environments varies depending upon students' classification as grade-level, gifted, or in need of special assistance. For example, Liu (2004) explored how a hypermedia problem-based learning environment (PBL) can support the learning of 155 sixth graders. This sample was divided into ability groups through a formal nomination. Of the 155 students in this sample, 26 came from Talented and Gifted (TAG) classes and 114 came from regular education (RegEd) classes. The other 15 students were identified as students that needed additional help, beyond that of the students in either the TAG or RegEd classes. These students, who either had a learning disability or spoke English as a second language, comprised this third ability group (ESL/LD). It should be noted that while students who either have a learning disability or speak English as a second language are different types of students, this classification system was the one used by the school district from which the sample was taken. As such, Liu (2004) relied on the school's classification system to differentiate students' into three groups: TAG, RegED, and ESL/LD. These students used a PBL hypermedia program, *Alien Rescue*, during a 3-week period in their science class. In essence, *Alien Rescue* presents an ill-structured problem for the students to solve in which the students, acting as scientists, must determine the most suitable location for different alien species. A set of 13 cognitive tools is provided in the hypermedia environment, and these tools are designed to act as scaffolds (e.g. concept database, expert modeling) in order to assist the students in the problem solving activity.

Liu (2004) gathered different types of data, including both quantitative data (e.g. a 25-item multiple-choice test designed to assess students' understanding of the scientific concepts introduced in this PBL) and qualitative data (e.g. multiple interviews with both the students and teachers that concentrated on several aspects including the science concepts the students learned in *Alien Rescue*). Results from both the quantitative and qualitative data suggest students from all three ability groups (TAG, ESL/LD, and RegEd) demonstrated a significant gain in their understanding of science concepts from pretest to posttest. Furthermore, data from the qualitative data sources suggest that students from these groups could articulate what they had learned. However, while these results provide promising implications for the use of hypermedia as an educational tool for different groups of students, it is important to note that this specific hypermedia environment included cognitive tools that served as scaffolds during learning. As such, while students from differing ability groups may be able to effectively learn with hypermedia when they are provided scaffolds, it is presently unclear whether students from different ability levels will have similar success learning with a hypermedia environment that does not provide some type of scaffold.

Some research has suggested that students have difficulty learning with hypermedia when they are not provided with scaffolds (Azevedo & Hadwin, 2005; Jacobson & Azevedo, in press). For example, Azevedo and colleagues (2005) found that while some students are able to develop conceptual knowledge of the circulatory system when using a hypermedia environment without scaffolds, other students have difficulty learning with these environments. This line of research has suggested that students may need to self-regulate their learning (e.g., activating prior domain knowledge and engaging in metacognitive monitoring) in order to develop conceptual knowledge with hypermedia, and that some students have difficulty using key SRL processes during learning with a hypermedia environment. As such, the next step in this line of research is to explore whether students from different ability groups differentially use self-regulatory processes during learning in the absence of scaffolds. The goal of this current study is to address this issue by exploring how students of different ability levels (gifted and grade-level) self-regulate their learning with a hypermedia environment that does not provide scaffolds.

1.4. Contributions of current study

This study contributes to the literature on hypermedia learning environments as well as work on gifted and grade-level students by gathering both *product* and *process* data regarding students' engagement in a complex and complicated task, learning about the circulatory system. The use of a pretest–posttest design with an actual learning outcome allows for the analysis of knowledge gains for each group to determine whether the gifted students truly are performing at a higher level, as expected. These knowledge gains include both improvement on declarative measures such as matching items, as well as a better mental model, or conceptual understanding, of the circulatory system. In addition, the collection of think-aloud data provides a more objective measure than students' self-reports for collecting data regarding student use of SRL processes (Azevedo, 2005; Winne & Jamieson-Noel, 2002; Winne & Perry, 2000). We believe that our research design, which includes an actual learning task with pretest and posttest measures coupled with think-aloud data collection procedures, will demonstrate that one key difference between gifted and grade-level students is their use of SRL strategies and processes.

The hypotheses of this study are as follows:

(1) Lower mental model pretest scores and classification as a grade-level student will decrease the odds of being in a higher mental model posttest score group.
(2) Gifted students' posttest scores on measures of declarative knowledge will be statistically significantly higher than those of grade-level students, after controlling for pretest scores.
(3) Gifted students will utilize key SRL strategies and processes more frequently than grade-level students, after controlling for variations in the total number of SRL strategies and processes used by each student.

2. Method

2.1. Participants

Ninety-eight ($N = 98$) middle-school (7th grade) students from a secondary school located in the mid-Atlantic region received community service credit for participating in this study during the Spring of 2004 and 2005. Forty-nine of the students attended regular, grade-level instruction classes. The mean age of these students was 12.2 years (28 girls and 21 boys).

The other 49 students were in a gifted program that provides highly able middle school students an interdisciplinary educational program that goes beyond the local schools' gifted and talented programs. The mean age of the 7th grade gifted students was 12.2 years (17 girls and 32 boys). The students in both programs were tested several months before they covered the body systems in the science classes, and the pretest confirmed that all participants had average or little knowledge of the circulatory system.

2.2. Measures

The paper-and-pencil materials consisted of a parental consent form, a participant questionnaire, a pretest, and a posttest. All of the paper-and-pencil materials were identical to the ones previously used by Azevedo and colleagues (2004a, 2004b, 2005). The parental consent form had been signed prior to students' participation in the study. The participant questionnaire solicited information concerning age, gender, number of science classes taken, and if the circulatory system was covered in those classes.

Azevedo and colleagues have used the pretest and posttest with hundreds of students in previous studies (Azevedo et al., 2004a, 2004b; Azevedo et al., 2005). There were four parts to the pretest: (a) a sheet on which students were asked to match 13 words with their corresponding definitions related to the circulatory system (matching); (b) a color picture of the heart on which students were asked to label 14 components (labeling); (c) a sheet which contained the instruction, *Please write down everything you can about the circulatory system. Be sure to include all the parts and their purpose, explain how they work both individually and together, and also explain how they contribute to the healthy functioning of the body* (mental model essay); and, (d) an outline of the human body on which the students were asked to list in order eight structures (a list of terms was provided) related to the circulatory system to represent the flow of blood through the body (flow diagram). The posttest was identical to the pretest.

2.3. Hypermedia learning environment

The participants used Microsoft's Encarta Reference Suite™ (2003) hypermedia environment installed on a laptop to learn about the circulatory system. During the training phase, participants were shown the three most relevant articles in the environment (i.e., circulatory system, blood, and heart), which contained multiple sources of information, including text, static diagrams, photographs, and a digitized animation depicting the structure, behavior, and functioning of the circulatory system. Together these three articles comprised 16,900 words, 18 sections, 107 hyperlinks, and 35 illustrations. During learning, participants were allowed to use all of the features incorporated in Encarta such as the search functions, hyperlinks, and multiple sources of information, and were allowed to navigate freely within the environment.

2.4. Procedure

After the parental consent form was collected, participants were pulled out of their regular class and tested individually by the experimenters. First, the participants filled out the questionnaire. Second, the pretest was handed out, and participants were given 20 minutes to complete it without access to any instructional materials. After the pretest, an experimenter gave each participant a short introduction to using and navigating within Encarta. Finally, the experimenter read the following instructions for the learning task to the participants, and provided it to them in writing: *You are being presented with a hypermedia encyclopedia,* *which contains textual information, static diagrams, and a digitized video clip of the circulatory system. We are trying to learn more about how students use hypermedia environments to learn about the circulatory system. Your task is to learn all you can about the circulatory system in 40 minutes. Make sure you learn about the different parts and their purpose, how they work both individually and together, and how they support the human body. We ask you to 'think aloud' continuously while you use the hypermedia environment to learn about the circulatory system. I'll be here in case anything goes wrong with the computer or the equipment. Please remember that it is very important to say everything that you are thinking while you are working on this task.*

Participants then began the learning session, and an experimenter remained nearby to remind them to keep verbalizing when they were silent for more than three seconds (e.g., *Say what you are thinking*). All participants were given a 40-minutes to use the hypermedia environment, and they had access to the instructions during the learning session. Participants were allowed to takes notes and draw during the learning session, although not all chose to do so. After the learning session, all participants were given 20 minutes to complete the posttest without their notes or any other instructional materials.

2.5. Coding and scoring

In this section we describe the coding of the students' mental models, the students' answers for the matching task, the labeling of the heart diagram and the flow diagram, the segmentation of the students' verbalizations while they were learning about the circulatory system, the coding scheme we used to analyze the students' regulatory behavior, and inter-rater agreement.

2.6. Mental models

Our analyses focused on participants' mental models at pretest and posttest. We followed Azevedo and colleagues' method (Azevedo & Cromley, 2004; Azevedo et al., 2004a, 2004b, 2005, in press) for analyzing the participants' mental models, which is based on Chi and colleagues' research methods for measuring students' conceptual understanding about the circulatory system (Chi, 2000, 2005, Chi, de Leeuw, Chiu, & LaVancher, 1994). A student's initial and final mental models of how the circulatory system works were derived from their statements on the pretest and posttest essays, respectively. The coding scheme (see Table 1) consists of twelve individual ratings grouped into three mental model categories which represent the progression from a low level of understanding to a high level of understanding. The model categories were designed to capture qualitative, not quantitative changes in participants' understanding of the circulatory system. A participant was placed in the "low" mental model category if he or she did not demonstrate an understanding above a single-loop path of the circulatory system, with no mention of the lungs. A participant with an "intermediate" understanding of the circulatory system demonstrated he or she believed that the circulatory system was a single loop with lungs. Finally, a participant placed in the "high" mental model category demonstrated he or she understood the double-loop concept of the circulatory system.

Due to the ordinal nature of the mental models rubric we used to measure learners' understanding of the circulatory system (for pretest and posttest), we utilized ordinal regression to predict posttest scores. Our hypotheses were that lower mental model pretest scores and classification as a grade-level student would decrease the odds of that student being in a higher mental model posttest group.

2.7. Matching task, labeling of the heart diagram, and blood flow diagram

The matching task was scored by giving each student either a 1 (for a correct match between a concept and its corresponding definition) or a 0 (for an incorrect match between a concept and definition) on his/her pretest and posttest (range 0–13). Similarly, the heart diagram was scored by giving each student either a 1 (for each correctly labeled component of the heart) or a 0 (for each incorrect label) (range 0–14). The flow diagram was scored by giving each student a 1 (for correct placement of a provided term) or a 0 (for incorrect placement of a provided term) (range 0–8).

Table 1
Necessary features for each type of mental model (from Azevedo and Cromley, 2004)

Low mental model

1. No understanding
2. Basic Global Concepts
   - Blood circulates

3. Global Concepts with Purpose
   - Blood circulates
   - Describes "purpose" – oxygen/nutrient transport

4. Single loop – basic
   - Blood circulates
   - Heart as pump
   - Vessels (arteries/veins) transport

5. Single Loop with Purpose
   - Blood circulates
   - Heart as pump
   - Vessels (arteries/veins) transport
   - Describe "purpose" – oxygen/nutrient transport

6. Single loop – advanced
   - Blood circulates
   - Heart as pump
   - Vessels (arteries/veins) transport
   - Describe "purpose" – oxygen/nutrient transport
   - Mentions one of the following: electrical system, transport functions of blood, details of blood cells

Intermediate mental model

7. Single loop with lungs
   - Blood circulates
   - Heart as pump
   - Vessels (arteries/veins) transport
   - Mentions lungs as a "stop" along the way
   - Describe "purpose" – oxygen/nutrient transport

8. Single loop with lungs – advanced
   - Blood circulates
   - Heart as pump
   - Vessels (arteries/veins) transport
   - Mentions Lungs as a "stop" along the way
   - Describe "purpose" – oxygen/nutrient transport
   - Mentions one of the following: electrical system, transport functions of blood, details of blood cells

High mental model

9. Double loop concept
   - Blood circulates
   - Heart as pump
   - Vessels (arteries/veins) transport
   - Describes "purpose" – oxygen/nutrient transport
   - Mentions separate pulmonary and systemic systems
   - Mentions importance of lungs

10. Double loop – basic
    - Blood circulates
    - Heart as pump
    - Vessels (arteries/veins) transport
    - Describe "purpose" – oxygen/nutrient transport
    - Describes loop: heart–body–heart–lungs–heart

(*continued on next page*)

Table 1 (*continued*)

11. Double loop – detailed • Blood circulates • Heart as pump • Vessels (arteries/veins) transport • Describe "purpose" – oxygen/nutrient transport • Describes loop: heart–body–heart–lungs–heart • Structural details described: names vessels, describes flow through valves
12. Double loop – advanced • Blood circulates • Heart as pump • Vessels (arteries/veins) transport • Describe "purpose" – oxygen/nutrient transport • Describes loop: heart–body–heart–lungs–heart • Structural details described: names vessels, describes flow through valves • Mentions one of the following: electrical system, transport functions of blood, details of blood cell

2.8. Learners' regulatory behavior

The raw data collected from this study consisted of 3920 minutes (65 hours) of audio and video tape recordings from 96 of the participants, who gave extensive verbalizations while they learned about the circulatory system. During the first phase of data analysis, a graduate student transcribed the audio tapes and created a text file for each participant. There were 1188 single-spaced pages of text ($M = 12.64$ pages per participant) with a total of 329,488 words ($M = 3505.20$ words per participant).

Azevedo and colleagues' (Azevedo & Cromley, 2004; Azevedo et al., 2004a, 2004b, 2005, in press) model of SRL was used to analyze the learners' regulatory behavior. Their model is based on several recent models of SRL (Pintrich, 2000; Winne, 2001; Winne & Hadwin, 1998; Winne & Perry, 2000; Zimmerman, 2000, 2001). It includes key elements of these models (i.e., Winne's (2001) and Pintrich's (2000) formulation of self-regulation as a four-phase process), and extends these key elements to capture the major phases of self-regulation. These are (a) planning and goal setting, activation of perceptions and knowledge of the task and context, and the self in relationship to the task; (b) monitoring processes that represent metacognitive awareness of different aspects of the self, task, and 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. Azevedo and colleagues' model also includes SRL variables derived from students' self-regulatory behavior that are specific to learning with a hypermedia environment (e.g., coordinating informational sources).

We used Azevedo and colleagues' SRL model to re-segment the data from the previous data analysis phase. We conducted a series of chi-square tests to examine how students' use of self-regulatory variables differed across conditions. We first converted the raw counts to percentages for each participant's use of each strategy. We then conducted a median split across both groups for the proportion of use for each variable. We were then able to identify, for each variable, which participants used that variable at a proportion above or below the median. We then conducted a 2×2 chi-square analysis for each self-regulatory variable to determine whether the distribution of participants above and below the median across gifted and grade-level students was significantly different from the null. This phase of the data analysis yielded 5930 segments ($M = 61.77$ per participant) with corresponding SRL variables. A graduate student was trained to use the coding scheme and coded all of the transcriptions by assigning each coded segment with one of the SRL variables. Two transcripts from the grade-level students could not be coded due to poor audio quality. Thus, the analyses for students' regulatory behavior were based on 96 students.

2.9. Inter-rater agreement

Inter-rater agreement was established by training the second and fourth authors to use the description of the mental models developed by Azevedo and colleagues (Azevedo & Cromley, 2004; Azevedo et al., 2004a, 2004b, 2005, in press). For a complete description of the mental model coding rubric see Azevedo and Cromley (2004, Appendix B, pp. 534–535). They independently coded all selected protocols (pre- and posttest essays of the circulatory system from each participant). There was agreement on 188 out of a total of 196 student descriptions, yielding an inter-rater agreement of .96. Inter-rater agreement was also established for the coding of the learners' regulatory behavior by comparing the individual coding of the two coders. Of the 5930 coded protocol segments, 5106 were independently recoded (86%). There was agreement on 5009 out of 5106 segments yielding an inter-rater agreement of .98. Inconsistencies were resolved through discussion among the coders.

3. Results

3.1. Hypothesis 1: lower mental model pretest scores and classification as a grade-level student will decrease the odds of being in a higher mental model posttest score group

Given the ordinal nature of the mental model scoring rubric (low, intermediate, high), we utilized an ordinal regression with cumulative logits (DeMaris, 2004; Hosmer & Lemeshow, 2000) to determine the influence of both mental model pretest score as well as grade-level versus gifted classification upon students' posttest mental model. This analysis produced two prediction equations, one predicting the odds of being in the low mental model posttest score group versus being in a higher group, and one predicting the odds of being in the medium or low mental model posttest groups as opposed to being in the high group. Thus, in our analyses, the high mental model posttest group was the reference.

We ran a model with mental model pretest score and gifted/grade-level classification as predictors. This model produced a statistically significant improvement in fit over an intercept only model ($\chi^2[3, 98] = 39.479$, $p < .001$), with a Nagelkerke Pseudo R^2 of .380. The assumption of parallel lines was met. Thus, this model did explain both a statistically and practically significant amount of the variance in mental model posttest group.

In addition, both predictors, mental model pretest score group and student classification, were statistically significant in the model. As can be seen in Table 2, the regression coefficient for low mental model pretest score group was statistically significant and resulted in a 96% reduction in the odds of being in a higher mental model posttest score group ($e^{-3.147} = .04$ so the odds were reduced by 96%). Likewise, having a mental model pretest score in the intermediate group also resulted in a reduction of the odds of being in a higher mental model posttest score group ($e^{-1.490} = .23$ so the odds were reduced by 77%). Of note, while this regression

Table 2
Ordinal regression predicting posttest mental model score group

	Final model		
	b	SE (b)	e^b
Dependent measure			
Low	−1.434[a]	.736	.24
Medium	.067	.715	1.07
Independent measure			
Low mental model pretest score group	−3.147[b]	.816	.04
Medium mental model pretest score group	−1.490	.863	.23
Gifted[c]	2.072[b]	.478	7.94
Model fit			
Final −2 Log likelihood	34.59		
Model chi-square/df	39.479/3[b]		
Nagelkerke Pseudo R^2	.380		

[a] $p < .051$.
[b] $p < .001$.
[c] Gifted students were coded as 1, grade-level as 0.

coefficient is not statistically significant, in ordinal regression with dummy coded variables, if one variable is significant (as the coefficient for low mental model pretest score group is) all associated dummy coded variables are included in the model. Finally, for the student classification variable, being in a gifted program was coded as a one, and being in a grade-level program was coded as a zero. Thus, the statistically significant regression coefficient for this variable indicates that being in a gifted program increased the odds of being in a higher mental model posttest score group by a factor of 8 ($e^{2.072} = 7.94$ so the odds were increased by 794%). These results indicate that having a higher mental model pretest score increased the odds of a student having a higher mental model posttest score, as did being a gifted student.

3.2. *Hypothesis 2: gifted students' posttest scores on measures of declarative knowledge will be statistically significantly higher than those of grade-level students, after controlling for pretest scores*

To analyze changes in scores on the matching, labeling tasks, and flow diagram tasks, we used a 2 (condition: SRL, ERL) × 2 (time: pretest, posttest) mixed design. For these analyses, condition was a between-groups factor and time was a within-subjects factor.

3.2.1. *Matching task*

Given we had a 2 × 2 mixed design with equal sample sizes and that we could retain the hypothesis of sphericity, we performed a repeated measures ANOVA on the pretest and posttest data. The results showed a significant main effect of time ($F[1, 96] = 153.11$, MSE = 250.64, $p < .001$, $\eta^2 = .62$), and a significant interaction between group and time ($F[1, 96] = 46.92$, MSE = 250.664, $p < .001$, $\eta^2 = .33$), and a significant main effect of group ($F[1, 96] = 11.363$, MSE = 1075.661, $p = .001$, $\eta^2 = .11$). These results indicate that the gifted students had statistically significantly higher posttest mean than the grade-level students, taking into account each group's pretest scores (see Table 3).

3.2.2. *Labeling task*

We also used a 2 × 2 repeated measures ANOVA on the pretest and posttest data for the labeling task. Results showed a significant main effect of time ($F[1, 96] = 162.72$, MSE = 217.02, $p < .001$, $\eta^2 = .63$), and a significant interaction between group and time ($F[1, 96] = 23.41$, MSE = 217.02, $p < .001$, $\eta^2 = .20$), and a significant main effect of group ($F[1,96] = 5.306$, MSE = 487.978, $p = .023$, $\eta^2 = .05$) These results mirror the matching task results, showing the gifted students had statistically significantly higher posttest mean than the grade-level students, taking into account each group's pretest (see Table 3).

3.2.3. *Flow diagram*

Again, a 2 × 2 repeated measures ANOVA on the pretest and posttest data was used for the flow diagram task. The results showed a significant main effect of time ($F[1, 96] = 45.99$, MSE = 3.282, $p < .001$, $\eta^2 = .32$), and a significant interaction between group and time ($F[1, 96] = 10.97$, MSE = 3.282, $p = .001$, $\eta^2 = .10$), and a non-significant main effect of group ($p > .050$) These results are consistent with the results for both the matching and labeling tasks (see Table 3). Thus, in each of the declarative measure tasks, the gifted students performed better on the posttest, after adjusting for pretest scores.

Table 3
Means and standard deviations for the pretest and posttest learning measures by group

	Gifted ($n = 49$)		Grade-level ($n = 49$)	
	Pretest M (SD)	Posttest M (SD)	Pretest M (SD)	Posttest M (SD)
Matching task	36.268 (19.922)	79.748 (22.683)	35.967 (29.334)	48.461 (29.688)
Labeling task	3.060 (12.449)	40.088 (23.771)	5.974 (12.143)	22.636 (23.120)
Flow diagram	0.820 (13.800)	34.300 (30.890)	14.300 (18.480)	23.330 (25.280)

3.3. Hypothesis 3: gifted students will utilize key SRL strategies and processes more frequently than grade-level students, after controlling for variations in the total number of SRL strategies and processes used by each student

In this section, we present the results of a series of chi-square analyses that were performed to determine whether there were significant differences in the distribution of gifted and grade-level students' use of SRL variables (for a complete description of the coding and analysis plan, see Azevedo & Cromley, 2004, p. 528). We examined how participants regulated their learning of the circulatory system by calculating how often they used each of the variables related to the four main SRL categories of *strategy use, planning, monitoring*, and *handling task difficult and demands*.

For five of the 33 strategies, chi-square analyses revealed significant differences in the number of participants who used those strategies above the median proportion across the two conditions. A larger number

Table 4
Number and [percentage] of gifted and grade-level students using self-regulated learning processes above the median proportion[1]

Variable	Gifted students ($n=49$)	Grade-level students ($n=47$)	χ^2	p
Planning				
Prior knowledge activation	**28 (57%)**	20 (43%)	2.043	0.153
Planning	9 (18%)	7 (15%)	0.208	0.648
Sub-goals	**25 (51%)**	23 (49%)	0.042	0.838
Recycle goal in working memory	10 (20%)	10 (21%)	0.011	0.917
Monitoring				
Content evaluation	**29 (59%)**	19 (40%)	3.376	0.066
Identify adequacy of information	**27 (55%)**	21 (45%)	1.042	0.307
Self-questioning	22 (45%)	18 (38%)	0.430	0.512
Judgment of learning	23 (47%)	**25 (53%)**	0.375	0.540
Feeling of knowing	**25 (51%)**	23 (49%)	0.042	0.838
Monitor use of strategies	9 (18%)	9 (19%)	0.010	0.922
Monitoring progress toward goals	16 (33%)	15 (32%)	0.006	0.938
Strategy use				
Summarization	**35 (71%)**[a]	12 (26%)	20.222	0.000
Selecting new informational source	**31 (63%)**[a]	17 (36%)	7.045	0.008
Coordinating informational sources	21 (43%)[a]	11 (23%)	4.085	0.043
Find location in environment	5 (10%)	19 (40%)[b]	11.686	0.001
Taking notes	17 (35%)	**31 (66%)**[b]	9.379	0.000
Mnemonics	6 (12%)	1 (2%)	3.632	0.057
Hypothesizing	9 (18%)	3 (6%)	3.150	0.076
Memorization	13 (27%)	8 (17%)	1.269	0.260
Inferences	**27 (55%)**	21 (45%)	1.042	0.307
Read new paragraph	3 (6%)	5 (11%)	0.640	0.424
Draw	9 (18%)	11 (23%)	0.369	0.544
Goal-directed search	14 (29%)	11 (23%)	0.332	0.564
Knowledge elaboration	22 (45%)	19 (40%)	0.196	0.658
Free search	12 (24%)	10 (21%)	0.140	0.708
Read notes	16 (33%)	14 (30%)	0.092	0.762
Re-reading	24 (49%)	**24 (51%)**	0.042	0.838
Task difficulty and demands				
Help seeking behavior	6 (12%)	12 (26%)	2.780	0.095
Task difficulty	14 (29%)	20 (43%)	2.050	0.152
Expect adequacy of information	**25 (51%)**	21 (45%)	0.534	0.386
Time and effort planning	22 (45%)	19 (40%)	0.196	0.658
Control of context	24 (49%)	**24 (51%)**	0.042	0.838
Interest				
Interest statement	24 (49%)	18 (38%)	1.112	0.292

Note: Degrees of freedom = 1 and $n = 96$ for all analyses; $\alpha = .05$.
Note: The *bold* type indicates the variable was used above the median frequency by more than 50% of participants.
[a] Gifted students made the greatest contribution to chi-square for this variable.
[b] Grade-level students made the greatest contribution to chi-square for this variable.

of gifted students used *summarizing, selecting new informational sources*, and *coordinating of information sources* to learn about the circulatory system. In contrast, a larger number of grade-level students learned by *taking notes* and *finding location in environment* (see Table 4). However, chi-square analyses revealed no significant differences in the distribution of planning, monitoring, task difficulty or interest processes used above and below the median by gifted and grade-level students. Thus, gifted and grade-level students only differed in their use of strategies. However, we posit that these strategies are a key reason as to why gifted students outperformed grade-level students on the mental model and declarative knowledge measures.

4. Discussion

The literature suggests that one key difference between more and less successful learners is their use of SRL processes (Azevedo et al., 2005; Boekaerts & Corno, 2005; Greene & Azevedo, in press; Pintrich, 2000; Winne, 1995). Seeing as gifted students tend to perform differently than their grade-level peers (Winner, 2000), it would seem reasonable to assume their use of SRL processes might be one explanation. Yet, previous research examining gifted and grade-level students found differences in their knowledge of metacognitive strategies, but not in their use (Alexander et al., 1995; Carr et al., 1996; Zimmerman & Martinez-Ponz, 1990). This counterintuitive finding can possibly be explained by the fact that these studies depended upon surveys and students' self-report data, rather than actually monitoring these students' *use* of SRL processes during an actual learning task. Since self-report data is notoriously inaccurate (Winne & Jamieson-Noel, 2002), we believed there was a need for research directly investigating gifted and grade-level students *use* of SRL processes. Our study contributes to the literature by utilizing product and process data to demonstrate both differential performance on a learning task as well as differential use of SRL processes. We believe this differential use of SRL processes may be a key reason as to why gifted students are more successful using a hypermedia environment without any scaffolds.

To investigate students' use of SRL processes, we needed a task challenging enough to discriminate between the groups. We focused on a complex but typical task for middle school students, learning about the circulatory system, and we evaluated conceptual learning in two ways. Specifically, in terms of mental model change, our first hypothesis was supported. At post-test, gifted students were more likely to display a more advanced mental model of the circulatory system than grade-level students, after controlling for their pretest mental model. Our second hypothesis regarding the declarative knowledge measures was also supported: controlling for pretest knowledge, gifted students' posttest scores were statistically significantly higher than the grade-level students'. These results illustrate that there were differences in performance between the groups, and that the grade-level group did have difficulty developing conceptual knowledge, most likely due to the challenging nature of the topic studied (Azevedo et al., 2005; Azevedo et al., 2004; Liu, 2004).

Thus, having shown there was a difference in performance, we then illustrated how students' use of certain SRL processes differed by group. Specifically, in support of our third hypothesis, the gifted students more frequently utilized sophisticated SRL processes that have been previously associated with learning (Azevedo et al., 2005; Azevedo, Cromley, Winters, Moos, & Greene, 2006). Gifted students more frequently summarized the information in their own words. They also more often coordinated the text and the diagrams, a process essential to gaining an advanced understanding of the flow of blood through the heart and the rest of the circulatory system when learning with hypermedia (Cromley, Azevedo, & Olson, 2005). Grade-level students, on the other hand, more frequently copied down notes from the hypermedia environment, rather than constructing their own interpretations. This has been shown to be a less effective strategy. Therefore, we have shown that gifted students outperformed grade-level students, and that this performance was associated with increased use of higher-level SRL processes. This finding is congruent with past research on SRL (Azevedo et al., 2005; Boekaerts & Corno, 2005; Pintrich, 2000; Winne, 1995), and suggests that one way by which grade-level students might improve their performance would be to learn to enact these higher-level SRL processes.

4.1. Limitations

The major limitation of this study is that a causal relation between SRL process use and performance cannot be demonstrated without the use of an experimental design. The conclusions drawn from this study are limited by the participants' age, low prior knowledge, and the nature of the hypermedia environment. It is possible that same-aged students with a certain amount of prior knowledge of the topics may have benefited more from the hypermedia environments. It should be noted that the commercially-based software used in this study did not include all of the representations of information ideally needed to learn about the topic. For example, adding an animation illustrating pulmonary circulation may have helped facilitate students' understanding of the role of the lungs. An understanding of the role of the lungs has been associated with higher posttest mental models.

4.2. Supporting students' self-regulated learning with hypermedia: design implications

Our results have implications for the design of scaffolds used to foster both gifted and grade-level students' self-regulated learning with hypermedia. As such, we propose certain scaffolds that could be designed to foster students' self-regulated learning of complex science topics such as the circulatory system. The design guidelines are based on the results presented on Table 4. The focus of this section is twofold – to provide general implications for SRL processes and to outline specific recommendations for supporting the use of strategies.

It should be noted that neither group deployed key planning and monitoring processes significantly more than the other. This is an astounding finding given the key role of these processes during learning with hypermedia (e.g., Azevedo, 2005). The complex nature of learning with hypermedia necessitates the use of these self-regulatory processes in order to learn challenging material. As such, a general design implication is for instructional designers to build scaffolds to facilitate students' planning activities (e.g., prior knowledge activation, creating goals) and monitoring activities (e.g., determining whether the information sources are relevant to the current learning goal, assessing whether they are understanding the content and how it relates to their prior knowledge, monitoring their progress towards goals). Recent advances in artificial intelligence, computer science, and computational linguistics (e.g., Bunt & Conati, 2003; Conati, Gertner, & VanLehn, 2002; Graesser et al., 2004) make these design features possible and worthy of empirical testing.

As for strategies, several of them could be scaffolded in a hypermedia environment, including summarizing, selecting new informational sources, coordinating informational sources, taking notes, and finding location in environment. While all of these could be easily embedded in a hypermedia environment, it may prove difficult for a hypermedia learning environment to determine the quality of a student's strategy. However, it is worth testing new computational approaches to assessing students' summaries based on recent advances in computational linguistics and other data tracing approaches (e.g., Graesser et al., 2005; Graesser, McNamara, Louwerse, & Cai, 2004; McNamara, Levinstein, & Boonthum, 2004). Similar computational approaches could be used to assess the quality of students' notes. Ideally, an adaptive hypermedia environment should be able to detect, trace, and model effective strategies, while also detecting and tracing uses of ineffective strategies (or lack of the use of effective strategies). More realistically, prompts and feedback could be designed to encourage effective strategies and discourage students from using ineffective strategies. In sum, these scaffolds could lead to a new generation of adaptive hypermedia system design to detect, trace, model, and foster students' self-regulated learning about complex and challenging topics.

Acknowledgements

This research was supported by grants from the National Science Foundation (Early Career Grant REC#0133346, REC#063391) awarded to the third author. The authors thank Evan Olson for assisting with the data collection. We thank the anonymous reviewers for their feedback.

References

Alexander, J. M., Carr, M., & Schwanenflugel, P. J. (1995). Development of metacognition in gifted children: directions for future research. *Developmental Review, 15*(1), 1–37.

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

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

Azevedo, R., Cromley, J. G., & Seibert, D. (2004a). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia? *Contemporary Educational Psychology, 29*, 344–370.

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

Azevedo, R., Cromley, J. G., Winters, F. I., Moos, D. C., & Greene, J. A. (2005). Adaptive human scaffolding facilitates adolescents' self-regulated learning with hypermedia. *Instructional Science, 33*, 367–379.

Azevedo, R., Cromley, J. G., Winters, F. I., Moos, D. C., & Greene, J. A. (2006). Using computers as metacognitive tools to foster students' self-regulated learning. *Technology, Instruction, Cognition, and Learning Journal, 3*, 97–104.

Azevedo, R., & Hadwin, A. F. (2005). Scaffolding self-regulated learning and metacognition: implications for the design of computer-based scaffolds. *Instructional Science, 33*, 367–379.

Azevedo, R., Moos, D. C., Greene, J. A., Winters, F. I., & Cromley, J. C. (in press). Why is externally-regulated learning more effective than self-regulated learning with hypermedia? Educational Technology Research and Development.

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

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

Bunt, A., & Conati, C. (2003). Probabilistic student modeling to improve exploratory behavior. *User Modeling and User-Adapted Interaction, 13*, 269–309.

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

Carr, M., Alexander, J. M., & Schwanenflugel, P. J. (1996). Where gifted children do and do not excel on metacognitive tasks. *Roeper Review, 16*, 198–204.

Chi, M. T. H. (2000). Self-explaining: the dual processes of generating inference and repairing mental models. In R. Glaser (Ed.). *Advances in instructional psychology: Educational design and cognitive science* (Vol. 5, pp. 161–238). Mahwah, NJ: Erlbaum.

Chi, M. T. H. (2005). Commonsense conceptions of emergent processes: why some misconceptions are robust. *Journal of Learning Sciences, 14*(2), 161–199.

Chi, M. T. H., de Leeuw, N., Chiu, M.-H., & LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science, 18*, 439–477.

Conati, C., Gertner, A., & VanLehn, K. (2002). Using Bayesian networks to manage uncertainty in student modeling. *User Modeling and User-Adapted Interaction, 12*, 371–417.

Cromley, J. G., Azevedo, R., & Olson, E. (2005). Self-regulation of learning with multiple representations in hypermedia. In C.-K. Looi, G. McCalla, B. Bredeweg, & J. Breuker (Eds.), *Artificial intelligence in education: Supporting learning through intelligent and socially informed technology* (pp. 184–191). Amsterdam, The Netherlands: IOS Press.

DeMaris, A. (2004). *Regression with social data: modeling continuous and limited response variables*. Hoboken, New Jersey: John Wiley & Sons.

Encarta. (2003). Microsoft Electronic Encyclopedia [Computer software]. Redmond, WA: Microsoft Corporation.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: verbal reports as data* (2nd ed.). Cambridge, MA: MIT Press.

Graesser, A., Lu, S., Jackson, G., Mitchell, H., Ventura, M., Olney, A., et al. (2004). AutoTutor: a tutor with dialogue in natural language. *Behavior Research Methods, Instruments, & Computers, 36*(2), 180–192.

Graesser, A., Lu, S., Jackson, G., Olde, B., Cooper-Pye, E., & Whitten, S. (2005). Question asking and eye tracking during cognitive disequilibrium: comprehension illustrated texts on devices when the devices break down. *Memory & Cognition, 33*(7), 1235–1247.

Graesser, A., McNamara, D., Louwerse, M., & Cai, Z. (2004). Coh-Metrix: analysis of text on cohesion and language. *Behavior Research Methods, Instruments, & Computers, 36*(2), 193–202.

Greene, J. A., & Azevedo, R. (2006). Adolescents' use of self-regulatory processes and their relation to qualitative mental model shifts while using hypermedia. In S. Barab, K. Hay, & D. Hickey (Eds.), *Proceedings of the seventh international conference of the learning sciences* (pp. 203–209). Mahwah, NJ: Erlbaum.

Greene, J. A., & Azevedo, R. (in press). A theoretical review of Winne and Hadwin's model of self-regulated learning: new perspectives and directions. Review of Educational Research.

Hosmer, D. W., & Lemeshow, S. (2000). *Applied logistic regression* (2nd ed.). New York: John Wiley & Sons, Inc..

Jacobson, M., & Archodidou, A. (2000). The design of hypermedia tools for learning: fostering conceptual change and transfer of complex scientific knowledge. *Journal of the Learning Sciences, 9*(2), 149–199.

Jacobson, M. J., & Azevedo, R. (in press). Scaffolding learning with hypertext and hypermedia: theoretical, empirical, and design issues. Educational Technology Research and Development.

Jonassen, D., & Reeves, T. (1996). Learning with technology: using computers as cognitive tools. In D. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 694–719). NY: Macmillan.

Liu, M. (2004). Examining the performance and attitudes of sixth graders during their use of a problem-based hypermedia learning environment. *Computers in Human Behavior, 20*(3), 357–379.

McNamara, D., Levinstein, I., & Boonthum, C. (2004). iSTART: interactive strategy training for active reading and thinking. *Behavior Research Methods, Instruments, & Computers, 36*(2), 222–233.

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

Newman, R. S. (2002). What do I need to do to succeed...when I don't understand what I'm doing!?: developmental influences on students' adaptive help seeking. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 285–306). San Diego, CA: Academic Press.

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

Pintrich, P. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 452–502). San Diego, CA: Academic Press.

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

Renzulli, J. S. (2002). Emerging conceptions of giftedness: building a bridge to the new century. *Exceptionality, 10*(2), 67–75.

Vye, N., Schwartz, D., Bransford, J., Barron, B., Zech, L., & CTGV (1998). SMART environments that support monitoring, reflection, and revision. In D. Hacker, J. Dunlosky, & A. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 305–346). Mahwah, NJ: Erlbaum.

White, B., Shimoda, T., & Frederiksen, J. (2000). Facilitating students' inquiry learning and metacognitive development through modifiable software advisors. In S. Lajoie (Ed.), *Computers as cognitive tools: No more walls* (pp. 97–132). Mahwah, NJ: Erlbaum.

Williams, M. (1996). Learner control and instructional technologies. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology* (pp. 957–983). NY: Scholastic.

Winne, P. (1995). Inherent details in self-regulated learning. *Educational Psychologist, 30*, 173–188.

Winne, P. H. (2001). Self-regulated learning viewed from models of information processing. In B. Zimmerman & D. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (pp. 153–189). Mahwah, NJ: Erlbaum.

Winne, P. H., & Hadwin, A. F. (1998). Studying self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Hillsdale, NJ: Erlbaum.

Zimmerman, B., & Schunk, D. (2001a). *Self-regulated learning and academic achievement*. Mahwah, NJ: Lawrence Erlbaum Associates.

Winne, P. H., & Jamieson-Noel, D. (2002). Exploring students' calibration of self reports about study tactics and achievement. *Contemporary Educational Psychology, 27*(4), 551–572.

Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 531–566). San Diego, CA: Academic Press.

Winner, E. (2000). The origins and ends of giftedness. *American Psychologist, 55*, 159–169.

Wolters, C. A. (2003). Regulation of motivation: evaluating an underemphasized aspect of self-regulated learning. *Educational Psychologist, 38*(4), 189–205.

Zimmerman, B. J. (2000). Attaining self-regulation: a social cognitive perspective. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). San Diego, CA: Academic Press.

Zimmerman, B. J. (2001). Theories of self-regulated learning and academic achievement: an overview and analysis (2nd ed). In B. J. Zimmerman & D. H. Schunk (Eds.). *Self-regulated learning and academic achievement: Theoretical perspectives* (pp. 1–37). San Diego, CA: Academic Press.

Zimmerman, B. J., & Martinez-Ponz, M. (1990). Student difference in self-regulated learning: relating Grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology, 82*, 51–59.

Zimmerman, B. J., & Schunk, D. (2001). *Self-regulated learning and academic achievement* (2nd ed.). Mahwah, NJ: Erlbaum.