Exploring Differences Between Gifted and Grade-Level Students' Use of Self-Regulatory Learning Processes with Hypermedia

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Abstract: Research comparing gifted and grade-level students has shown they display differences in their knowledge of self-regulatory strategies. However, little research exists regarding whether these students differ in their use of these strategies. This study aimed to address this question by examining think-aloud data collected from gifted and grade-level students engaging in a complex learning task while 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 than grade-level students. Grade-level students were more likely to use less effective strategies that do not promote the encoding of knowledge. Recommendations for future intervention studies are based upon these findings.

Special educational programs for gifted students exist because these students seem to learn more successfully than their grade-level peers. However, the question as to why these students are 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; Azevedo, 2005; Boekaerts & Corno, 2005; Pintrich, 2000; Winne, 1995). Recent research examining how students learn complex and challenging tasks has suggested that successful students deploy key self-regulatory strategies and processes (Azevedo & Cromley, 2004; Azevedo, Cromley, & Seibert, 2004; Azevedo, Cromley, Winters, Moos, & Greene., 2005). These studies have focused on actual learning tasks and utilized more objective data-collection techniques such as think-aloud protocols. In this study, we aim to determine whether gifted students deploy SRL more effectively than their grade-level peers by using think-aloud protocols and a pretest-posttest design to analyze students' learning of a complex and challenging task with a hypermedia environment. If gifted students do perform more successfully, we assert that their use of SRL may be one reason why gifted students outperform their grade-level peers. If true, then this suggests specific interventions for helping grade-level students learn complex and challenging tasks.

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 (Carr, Alexander, & Schwanenflugel, 1996; Alexander, Carr & Schwanenflugel, 1995). This elaborate understanding and use of more complex strategies may be what causes gifted students to be more likely to transfer these strategies to other domains (Carr et al., 1996). 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 actual 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 strategies than grade-level students but not actually deploy them differentially. However, 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 student self-report data, as opposed to more reliable methods such as think-alouds (Azevedo & Cromley, 2004; Azevedo et al., 2005). 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 does not support this claim. We hypothesize that the utilization of actual learning tasks, coupled with the collection of think-aloud data, would reveal differences in both performance and use of SRL strategies and processes between gifted and grade-level students.

Contributions of Current Study

This study contributes to the literature on gifted and grade level students by gathering both *product* and *process* data regarding students' learning of a complex and complicated task such as learning about the circulatory system. The use of a pretest-posttest design allows for the analysis of knowledge gains for each group to determine whether the gifted students truly are learning more as expected. In addition, the collection of think-aloud data allows us a more objective tool for collecting data regarding student use of SRL processes. We believe that our research design, including 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) Gifted students will be more likely to display a more sophisticated mental model of the circulatory system at posttest than grade-level students.
(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.

Method

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 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 school 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 had had little exposure to the circulatory system in science class, and the pretest confirmed that all participants had average or little knowledge of the circulatory system.

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 (in press, 2005, 2004). 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.

The pretest and posttest were constructed in consultation with a science teacher and nurse practitioner. 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); and, (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); (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.

Hypermedia Learning Environment

The participants used Microsoft Encarta's Reference Suite™ (2003) hypermedia environment installed on a laptop to learn about the circulatory system. During the training phase, learners 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.

Procedure

After the parental consent form was collected, participants were pulled out of their regular class and tested individually. 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-minute learning time 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.

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.

Mental models

Our analyses focused on participants' mental models at pretest and posttest. We followed Azevedo and colleagues' method (Azevedo & Cromley, 2004; Azevedo, Cromley, & Seibert, 2004; Azevedo, Guthrie, & Seibert, 2004; Azevedo et al., 2005) for analyzing the participants' mental models, which is based on Chi and colleagues' research (Chi et al., 1994, 2000, 2005). 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 consists of 3 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 understood 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 qualitative nature of the mental models used to measure learners' understanding of the circulatory system (for pretest and posttest), we examined whether there was a statistically significant relation between group and the distribution of participants' mental models at pretest and posttest. Our hypotheses were that there would be no such relation at pretest, given that the students had little to no prior knowledge of the circulatory system, but that the posttest would reveal differences.

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).

Students' verbalizations

The raw data collected from this study consisted of 3,920 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. Two students' audio tapes were not transcribed due to poor audio quality. During the first phase of data analysis, a graduate student transcribed the audio tapes and created a text file for each participant.

Learners' regulatory behavior

Azevedo and colleagues' (Azevedo & Cromley, 2004; Azevedo, Cromley, & Seibert, 2004; Azevedo, Guthrie, & Seibert, 2004) 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., selecting a new informational source).

We used Azevedo and colleagues' SRL model to re-segment the data from the previous data analysis phase. This phase of the data analysis yielded 5,930 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.

Inter-rater agreement

Inter-rater agreement was established by training two graduate students to use the description of the mental models developed by Azevedo and colleagues (Azevedo & Cromley, 2004; Azevedo, Cromley, & Seibert, 2004; Azevedo, Guthrie, & Seibert, 2004). 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 5,930 coded protocol segments, 5,106 were independently recoded (86%). There was agreement on 5,009 out of 5,106 segments yielding an inter-rater agreement of .98. Inconsistencies were resolved through discussion among the coders.

Results

Hypothesis 1: Gifted students will be more likely to display a more sophisticated mental model of the circulatory system at posttest than grade-level students.

To analyze changes in students' conceptual understanding we examined students' mental models using two 2 X 2 (mental model by group) chi-square test. First, we examined the students' mental models on the pretest. The chi-square test revealed a non- significant difference in the frequency distribution of the students' mental model by group (χ^2 [2, N = 98] = 1.47, p > .050) This indicates that the distribution of pretest mental model scores was not statistically significantly different across gifted and grade-level students. We then examined the students' mental models on the posttest. The chi-square test revealed a significant difference in the frequency distribution of learners' mental model by group (χ^2 [2, N = 98] = 16.667, p < .001). The results of this test indicate that the distribution of gifted and grade-level students significantly differ on their mental model scores for the posttest. Of the 49 gifted students, 18 (37%) had a high mental model on their posttest, 16 (33%) had an intermediate mental model on their posttest, and 15 (31%) had a low mental model on their posttest score. On the other hand, of the 49 grade-level students, only 6 (12%) had a high mental model on their posttest and 8 (16%) had an intermediate mental model on their posttest, while 35 (71%) had a low mental model on their posttest score.

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 (group: SRL, ERL) X 2 (time: pretest, posttest) mixed design. For these analyses, group was a between-groups factor and time was a within-subjects factor.

Matching task

Given we had a 2 X 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 1).

Labeling task

We also used a 2 X 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 1).

Flow Diagram

Again, a 2 X 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 1). Thus, in each of the declarative measure tasks, the gifted students performed better on the posttest, after adjusting for pretest scores.

Table 1: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)

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 5 of the 16 strategies, chi-square analyses revealed significant differences in the number of participants who used those strategies above the median proportion across the two groups. A larger number 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 2). 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.

Table 2: Number of coded verbalizations and proportion of gifted and grade-level students using self-regulated learning variables above the median proportion.[1]

Variable	Gifted (n = 49)	Grade-Level (n = 47)	χ^2	*p*
Strategy Use				
Summarization	**35 (71%)**[a]	12 (26%)	20.222	<.001
Selecting New Informational Source	**31 (63%)**[a]	17 (36%)	7.045	.008
Coordinating Informational Sources	**21 (43%)**[a]	11 (23%)	4.085	.043
Find Location in Environment	5 (10%)	19 (40%)[b]	11.686	.001
Taking Notes	17 (37%)	**31 (66%)**[b]	9.379	.002

Note: Degrees of freedom = 1 and n = 96 for all analyses.
Note. The **bold** type indicates the variable was used above the median frequency by more than 50% of learners.
[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.
[1]This table represents the 5 SRL processes from the strategy category that had significant chi-square analyses. Chi-squares analyses for the remaining 27 SRL processes from the categories of planning, strategy, monitoring, handling task difficulties and demands, and motivation were non-significant.

Conclusions

These results highlight key differences between gifted and grade-level students. Not only do these students perform more successfully on both declarative knowledge measures and measures of their mental model, but they also differentially utilize key SRL processes. Specifically, gifted students use more sophisticated strategies such as coordinating informational sources and summarizing, a strategy that requires encoding of information. In contrast, grade-level students spend more time orienting themselves to the environment and taking notes verbatim from the environment. This suggests that gifted students spend less time orienting themselves to the environment and more time engaging in the learning. This allows the gifted student more cognitive energy to focus on higher level SRL strategies, perhaps explaining the differential performance. Thus, this study adds to the literature on gifted students by demonstrating that they actually *use* higher-level strategies more often than grade-level students. This differential use of high-level strategies by gifted students, coupled with their more successful learning performance, suggests possible interventions for grade-level students. These results suggest that grade-level students may benefit from being explicitly taught declarative, procedural, and conditional knowledge regarding the utilization of high-level SRL strategies such as the coordination of information sources and summarization. Future research should systematically test the influence of targeted interventions aimed toward fostering this kind of high-level SRL strategy use amongst grade-level students when engaging in complex learning. If differential use of SRL strategies accounted for a significant amount of the variance between these two groups, then interventions may truly make a profound difference in student performance.

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