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Middle school children's strategic behavior: Classification and relation to academic achievement and mathematical problem solving

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Abstract. Theories of problem solving (e.g., Verschaffel et al., 2000) hold strategic behavior central to processing mathematical word problems. The present study explores 80 sixth- and seventh-grade students' self-reported use of 14 categories of strategies (Zimmerman & Martinez-Pons, 1986) and the relationship of strategy use to academic achievement, problem-solving behaviors, and problem-solving success. High and low achievement groups differed in the number of different strategies and categories of strategies reported but not in overall number of strategies, confidence in using strategies, or frequency of strategy use. Students whose behaviors evidenced elaboration of the word problem's text reported more self-evaluation; organizing and transforming; and goal setting and monitoring behavior. Implications for instructional practices that support active stances toward problem solving are discussed.

Keywords: achievement, mathematics, problem solving (mathematics), self-regulated learning, strategic behavior

Introduction

Theories of mathematical problem solving (e.g., English, 1997; Mayer, 1992; Schoenfeld 1985, 1992; Verschaffel et al., 2000) hold strategic behavior as central to the cognitive processing necessary to solve mathematical word problems. Expert and successful problem solvers transform the problem text to form a mental model or a cognitive representation of the problem that corresponds to the problem elements and their relationships. Problem solvers may evoke internal representations for the problem or they may use concrete or semi-concrete (i.e., pictures) external representations to facilitate this constructive process. Based on the model developed for the problem, the problem solver begins a solution path. Less successful problem solvers may not form this mental model. Rather, they often directly translate the problem elements to a solution without an image of the problem to facilitate their solution processes (Hegarty et al., 1995; Pape, in press, in review;

Verschaffel et al., 2000). Transforming the text to a situational model, and the situational model to a mathematical model (English, 1997) requires a great deal of strategic behavior and monitoring skill.

The purpose of this study is to examine middle school students' self-reported strategies. Students were asked to report the strategies they used to accomplish typical school-related tasks and to talk aloud as they were videotaped solving mathematical word problems. A constant-comparative approach is used to examine and fully describe 14 categories of self-regulated behaviors (Zimmerman & Martinez-Pons, 1986, 1988) within this middle school population, and problem-solving behavior is coded using a classification scheme developed in prior research (Hegarty et al., 1995; Pape, in press). The relative frequency of students' use of each category of strategic behavior is examined. Total number of strategies, number of different strategies, number of categories of strategies, frequency of strategy use, and confidence ratings for using strategies are investigated in relation to academic achievement, problem-solving behavior, and problem-solving success rates, and differences between high and low achievement group students are explored. Finally, implications for instructional practices that support active stances toward problem solving are discussed.

Strategic behavior and academic achievement

Self-regulated learners are defined as active participants in their own learning. They select from a repertoire of strategies, implement these strategies in goal-directed activities, and monitor their progress using these strategies. Self-regulation involves the control of cognitive and metacognitive processes as well as volitional and emotional control (Zimmerman, 1994, 2000). Based on structured interviews (Zimmerman & Martinez-Pons, 1986, 1988, 1990) and self-report questionnaires (e.g., the Motivated Strategies for Learning Questionnaire, Pintrich & De Groot, 1990; Pintrich et al., 1993) self-regulated learning (SRL) strategy use has been shown to be related to and predictive of academic achievement and giftedness. Of six components of academic behavior (i.e., motivation, methods of learning, use of time, physical environment, social environment, and performance) identified as significant contributors to academic outcomes (Dembo & Eaton, 2000; Zimmerman & Risemberg, 1997) strategic behavior for interacting with academic tasks is one area teachers may influence through instruction. This area is particularly crucial for middle school children and their teachers because the middle grades represent a crossroads in children's academic careers.

Zimmerman and Martinez-Pons (1986) used a structured interview to assess 40 high achieving and 40 low achieving high school students' strategy use. For the purposes of the study academic track placement, determined by

the school district based on multiple measures, was used to assign students to achievement group. Students reported the strategies they employed and frequency of strategy use for six learning contexts, each portraying a typical school-related situation. Fourteen categories of self-regulated behavior were identified (see Appendix A). Cognitive strategies included organizing and transforming; seeking information; and rehearsing and memorizing. Monitoring strategies included self-evaluating; goal setting and planning; keeping records and monitoring; and reviewing records such as tests, notes, and texts. Environmental structuring included strategies such as working in a quiet setting, and self-consequences involved providing rewards for progress. Finally, students reported many types of help seeking strategies from peers, teachers, or other adults.

Three variables were generated for each of the 14 categories of strategies: *strategy use*, a dichotomous variable indicative of strategy category use; *strategy frequency*, the number of times a strategy category was mentioned; and *strategy consistency*, the frequency participants reported using each category of strategy (Zimmerman & Martinez-Pons, 1986). Discriminant function analysis revealed significant relationships between these three variables and achievement group (i.e., low vs. high). Strategy consistency, however, was the most reliable predictor of group assignment. Seeking information, keeping records and monitoring, and organizing and transforming were the three strongest strategy category predictors of achievement group followed by seeking teacher assistance, seeking peer assistance, and seeking adult assistance. In addition, high and low achievement groups differed in their use of all categories of strategies except self-evaluation.

To further validate their strategy model of self-regulated behavior, Zimmerman and Martinez-Pons (1988) interviewed 80 tenth-grade students and compared their strategies with teacher ratings of student SRL behavior and achievement test scores. Student reports of self-regulated strategy use were positively and significantly related to teacher ratings of student SRL behavior and were distinct from verbal expressiveness and achievement. Two categories, rehearsing and memorizing, and organizing and transforming, were most strongly associated with teacher ratings of behavior. Finally, Zimmerman and Martinez-Pons (1990) investigated student responses on this same measure, and verbal and mathematics self-efficacy in relation to grade level (5th, 8th, and 11th grade), sex, and giftedness. Older students and gifted students were found to surpass younger children and students not in gifted programs on three measures of self-regulation. In addition, self-efficacy beliefs, predictive of academic achievement (Zimmerman, 1998), were found to be associated with SRL behaviors.

Subsequently, Purdie and Hattie (1996) and Purdie et al. (1996) investigated cross-cultural differences in students' use of strategic behavior by adapting Zimmerman and Martinez-Pons' (1986, 1988, 1990) structured interview protocol questions as an open-ended questionnaire format. Both of these studies compared Japanese and Australian high school students' views of learning and SRL strategies and found differences in the beliefs and strategy use of these groups of students. While structuring the study environment and checking work were most important to each of these groups of students, Japanese students reported memorizing as more important than the Australian students. Each of these studies provides detailed descriptions of upper secondary students' strategic behaviors. The present study therefore sought to examine strategic behavior among middle school students.

Mathematical problem-solving behavior

Problem solving begins when the solver reads the problem's text. This reading stimulates the activation of various knowledge structures, which help the problem solver represent the problem. Although stated in different ways, problem representation is the first stage of problem solving (English, 1997; Mayer, 1992; Verschaffel et al., 2000). Young children may begin by forming an object-based model with concrete objects. This first step may lead to the development of a more complex mental model, which may also be referred to as a situational model. An accurate model, which serves as the framework for the solution process leading to success or failure, is constructed through active transformation of the text base, activation of schemas for particular types of problems, and integration of the problem elements within these schemas. The representation process relies on both reading comprehension and mathematical problem-solving strategies (Pape, in review).

Verbal protocol analyses of accurate and inaccurate or of novice and expert problem solvers' behaviors have provided insight into the problem-solving process. Schoenfeld (1987) examined behaviors of both expert problem solvers and mathematics students. These behaviors, later formulated into a framework for analyzing processes of successful and unsuccessful groups of problem solvers (Artzt, 1996; Artzt & Armour-Thomas, 1992), include reading, understanding, exploring, analyzing, planning, implementing, verifying, and watching and listening. While expert problem solvers begin with reading and analyzing the problem, they move toward solution using various other cognitive processes, altering their behavior based on whether they judge their solution path to be adequate. For expert problem solvers, developing a mental representation for the problem is an ongoing process involving many transformative behaviors. Novice problem solvers, however, begin ineffectual

solution paths, based predominantly on exploration, and continue these paths although they may not lead toward a solution.

Hegarty et al. (1992) examined undergraduate students' problem-solving behaviors using compare word problems, mathematical word "problems [that concern] a static numerical relation between two variables" (Lewis & Mayer, 1987: 363; for a complete discussion of these problems see also Pape, in press; Riley & Greeno, 1988). These problems include three statements: an introduction of the known quantity, a statement of the relationship between known and unknown quantities, and a question. The relational sentence may be presented in either consistent language (CL) or inconsistent language (IL) formats. Since the subject of the relational sentence in CL problems refers to the unknown variable, the relational term is consistent with or matches the arithmetic operation necessary to solve the problem. An example of a CL problem follows: *Joe runs 6 miles a week. Ken runs three times as many miles. How many miles does Ken run in four weeks?* (Lewis & Mayer, 1987: 366). In IL problems, the subject of the relational sentence refers to the known quantity. Therefore, since the relational term is provided in terms of the known quantity, it is inconsistent with the mathematical operation needed to determine the unknown quantity. For example: *Joe runs 6 miles a week. He runs 1/3 as many miles a week as Ken does. How many miles does Ken run in four weeks?* (Lewis & Mayer, 1987: 366). For this problem, the necessary operation is multiplication rather than division.

Eye-fixation data collection techniques were used to examine each line of the problem the student looked at and the words in that line on which the individual fixated, resulting in three patterns (Hegarty et al., 1992). The funnel effect describes an individual's tendency to concentrate on progressively smaller proportions of words on successive rereadings. According to the selection effect, problem solvers refer to numbers more than other words on successive rereadings. The consistency effect refers to the tendency to examine words other than numbers (i.e., relational terms) more on IL than CL problems.

Protocols of one high-accuracy student were presented (Hegarty et al., 1992). On less difficult problems, the problem solver focused mainly on the numbers. This pattern exemplifies the funnel and selection effects. In contrast, on more difficult problems, the high-accuracy student exhibited readings that focused more on the variable names and relational terms. In a follow-up study, Hegarty et al. (1995) examined differences in successful and unsuccessful problem solvers' behaviors. Selecting the numbers and relational terms from the problem and directly translating these elements into arithmetic operations exemplifies a *direct translation approach*, similar to the high-accuracy problem-solver's performance on the low-difficulty problem

described above. In doing so, the problem solver is likely bypassing or short-circuiting the formation of a mental model for these propositions, a prevalent behavior among problem solvers (Verschaffel et al., 2000). Alternatively, an individual using a *meaningful approach* formulates an object-based or mental model of the problem relationships, similar to the high-accuracy students' behavior on more difficult problems described above. These different patterns of behavior result in differences in the accuracy of the representation formed and subsequent success or failure. Unsuccessful students focused on the numbers and relational terms more than successful problem solvers. All students, however, fixated on numbers and relational terms more than variable names.

These patterns of behaviors differ in the degree to which students transform the elements of the word problem into a mental or other model to support their problem-solving endeavor. The present study investigates middle school problem solvers' behaviors coded from videotaped problem-solving episodes in relation to their self-reported strategies for similar school-related tasks.

Method

Participants

Eighty sixth- and seventh-grade students from a public intermediate school in New York City were randomly selected from a total of 95 participants. Students who were Limited English Proficient, received special education services, or returned incomplete consent forms were excluded from participation. Equal numbers of sixth- and seventh-grade students were included with 29 male (36%) and 51 female (64%) students whose mean age was 11.89 years old ($SD = 0.65$). The participants' self-identified ethnicity included 50% Caucasian, 20% Italian-American, 14% Hispanic, 8% Eastern-European, 5% Asian, 1% African American, and 2% other. Approximately 35–40% of students in the school were eligible for free lunch.

Measures

The Strategy Questionnaire, adapted from Zimmerman and Martinez-Pons (1986), presented five typical academic scenarios that middle school students might encounter (see Appendix B). Two contexts (i.e., reading and mathematical problem solving) were included because both reading-related strategic behavior and mathematical problem-solving strategic behavior are considered important to successful problem solving. Scenarios two, three, and five were based on mathematical problem-solving activities (i.e., classroom discussion of problem solving; problem-solving homework; and understanding and

solving a mathematical word problem), and scenarios one and four were reading-related tasks (i.e., reading a novel for class discussion; writing a book report). Students were asked to report strategies they employ to accomplish the task and the strategies they would use when experiencing difficulty accomplishing the task. Scenario five incorporated four parts including strategies students use to understand and to solve mathematical word problems and strategies they use when having difficulty understanding and solving problems. Responses to an additional open-ended question about students' views of learning will not be analyzed in this article. Students reported the frequency they use each strategy ranging from 1 for "not very often" to 4 for "most of the time." After the students completed all of the scenarios, they were asked to reread the strategies and record their confidence in using each strategy. Confidence ratings ranged from 1 for "not confident" to 4 for "very confident."

The *Think-Aloud Stimulus* consisted of 16 mathematics word problems including 12 target compare word problems discussed above (see also Pape, in press) and four filler problems not examined in this study. Two protocol forms were developed by first counterbalancing order of appearance of problem type. The second form was developed from the first by holding constant the order of CL and IL problems while interchanging addition for multiplication and subtraction for division problems. ANOVA analyses revealed no significant differences due to form. Thus, the data were collapsed across forms.

Procedure

Participants completed the measures on two separate days at their school. On the first day, students were individually videotaped completing the Think Aloud Stimulus in the librarian's office. Students were asked to "think aloud" or "say whatever comes to [their] minds" as they read and solved the problems. Each student practiced "thinking-aloud" using two sample word problems. If they were silent, the researcher posed a probing question (i.e., What are you doing right now?). The students identified their behavior and were reminded to perform the self-identified behavior out loud using the same words. If the students' behaviors indicated inability to solve the problem by not actively seeking to solve the problem, they were reminded to explain the difficulty they were having and move on to the next problem. In addition, the students were informed that the researcher could not answer questions related to their solution. No time limits were imposed on students' solution. Following completion of each problem, the students turned the problem over and recalled the problem sentences out loud.

During the second session, students completed the Strategy Questionnaire. For each scenario, students recorded their strategies and frequency ratings for each of these strategies. When students completed recording their strategies and frequency ratings, they were asked to review each strategy and record a confidence rating. When the students completed the measures, they identified the primary language spoken at home, other languages spoken, and ethnicity and were thanked for their participation. Finally, the researcher examined school records to collect norm curve equivalent standardized achievement scores. Students were divided into high and low mathematics and reading achievement groups by performing a median split on each of these achievement test scores.

Data coding procedures

Grounded within the 14 categories of strategic behavior described previously (see Appendix A; Purdie & Hatie, 1996; Purdie et al., 1996; Zimmerman & Martinez-Pons, 1986, 1988), two coders used a constant-comparative methodology to classify each strategy. Strategies were compared with the category descriptions provided by prior researchers and examined in relation to the specific scenario in which they were reported. When differences between these strategies and prior descriptions or when anomalies were noticed, the original descriptions were modified and categories were expanded.

From the videotaped recordings of the children's problem-solving behaviors, the researcher listed a description of each observed behavior in sequential order. For example, the number of each sentence audibly read or reread was recorded and the last word read was noted. Other behaviors recorded included gestures indicating reference to the problem's text without audible indication, performing calculations audibly or inaudibly, statements of intermediate and final answers, and direct quotes such as explanations or justifications for calculations performed. Each solution was coded as correct if the appropriate numerical answer was recorded.

Students' *pattern of behavior* was coded using two categories developed based on Hegarty et al. (1995) descriptions of problem-solving behavior. A participant's solution strategy was classified as exhibiting a *direct translation approach* when one or more of the following was observed as the predominant behavior:

(1) The student referred to and/or recorded elements of the problem without the appropriate context;
(2) The student repeatedly stated the numbers without relevant context;
(3) The student repeatedly reread individual sentences without recording or transforming the given information; and/or

(4) The student carried out mathematical computations without referring to or rereading the text of the problem.

Thus, students who read the problem and directly translated its components into a mathematical operation without providing evidence of transformative behaviors were classified as using a direct translation approach.

A participant's solution strategy was classified as a *meaningful approach* when one or more of the following was observed as the predominant behavior:

(1) The student read each sentence separately and recorded the given information with the appropriate context;
(2) The student first read the whole problem and then reread each individual sentence while recording the given information;
(3) The student stated and/or recorded given information within an appropriate context, or the student provided an explanation for the computational steps performed; and/or
(4) The student stated or wrote intermediate and/or final answers as a complete sentence or made an audible statement, which incorporated the appropriate context.

Thus, students whose behaviors provided evidence of transforming the information in the word problem and using the problem's context to understand and solve the problem were classified as using a meaningful approach.

Several indices of strategic behavior were developed: (1) total number of strategies, (2) total number of different strategies (i.e., redundant strategies not counted), (3) total number of categories, (4) mean frequency rating, and (5) mean confidence rating. Two variables were calculated from the verbal protocols: (1) number of problems solved correctly and (2) number of problems solved using a meaningful approach. ANOVA analyses indicated that students did not differ significantly on strategy use, problem-solving behavior or success, or mathematics or reading achievement due to gender or ethnicity. Thus, the data were collapsed across each of these variables.

Results

Exploring categories of strategies

The first goal of this study was to explore middle school students' self-reported strategic behavior to fully elaborate the categories provided by Zimmerman and Martinez-Pons (1986, 1988) and Purdie and colleagues (Purdie & Hattie, 1996; Purdie et al., 1996). The second goal was to investigate the relative frequencies of these categories among middle school children. Prior researchers' category definitions and examples of student strategies

reported in the present study for two contexts, reading-related contexts and mathematics problem-solving contexts, are provided in Appendix A.

Descriptive data for these categories of strategic behavior listed in the order of the number of participants who reported each category are presented in Table 1. The number and percentage of participants who reported each category are listed in the first column. Strategy use, defined as the mean number of times a category was reported, and number of different strategies within each category are reported for all participants in the second two columns. In the last two columns, these same indicators of strategy use are reported for the subsample of participants who reported that category only. Three clusters of categories have been constructed for analysis. Clusters 1 and 2 represent strategies reported by more than 50% of participants and are distinguished from each other by the number of strategies and number of different strategies reported in each category. Cluster 3 categories were reported by fewer than 50% of participants. In the following section, we describe middle school children's self-reported strategies within each of these clusters. We provide examples of the strategies for each category of behavior and describe ways in which we have changed the categorization schemes provided by prior researchers to more fully differentiate several of these categories.

Cluster 1: High percentage usage, varied strategies

Four categories of strategic behavior were reported in large numbers by a large proportion of participants: *seeking information*, *seeking social assistance (all forms)*, *goal setting and monitoring*, and *organizing and transforming*. Virtually all students reported *seeking information* and *seeking social assistance* (all forms including self-evaluation). Not only were these strategies reported by the largest numbers of participants (99% and 98%, respectively), students reported these strategies most frequently, averaging between eight and nine times over the five contexts. This is approximately twice as often as any other category of strategic behavior (except organizing and transforming). A strategy was classified as seeking information when students indicated initial reading of text material, rereading to understand, or seeking out additional references to gain information. Thus, this category included skimming, reading, and rereading text or searching out definitions of unknown words. In addition, tool use such as using a calculator within mathematics problem-solving contexts was classified as seeking information. Students reported approximately three (M = 3.03, SD = 1.42) different strategies within this category over five contexts.

Seeking social assistance, an important strategy for self-regulation (Newman & Schwager, 1995), was reported by 98% of these middle school

Table 1. Number of participants and mean (*SD*) strategy use indicators for each category

Category of strategic behavior	N[1] (%)	Strategy use[2]	Number different strategies[2]	Strategy use[3]	Number different strategies[3]
Seeking information	79 (99)	7.64 (4.07)	3.03 (1.45)	7.73 (4.00)	3.06 (1.42)
Seeking social assistance (all forms)	78 (98)	8.71 (5.64)	3.43 (1.61)	8.94 (5.53)	3.51 (1.53)
Goal setting and planning	73 (91)	3.64 (2.37)	2.84 (1.72)	3.99 (2.18)	3.11 (1.55)
Organizing and transforming	67 (84)	3.98 (3.49)	2.54 (1.99)	4.75 (3.30)	3.03 (1.80)
Seeking social assistance from teachers	65 (81)	2.84 (2.48)	1.15 (0.73)	3.49 (2.30)	1.42 (0.53)
Seeking social assistance from others	63 (79)	2.46 (2.74)	0.65 (0.66)	3.13 (2.73)	1.18[4] (0.39)
Reviewing records	63 (79)	2.20 (2.40)	1.65 (1.49)	2.79 (2.38)	2.10 (1.36)
Self-evaluation by student him or herself	60 (75)	2.03 (2.05)	1.46 (1.32)	2.70 (1.94)	1.95 (1.17)
Seeking social assistance from parents	54 (68)	1.91 (2.26)	0.74 (0.59)	2.83 (2.22)	1.09 (0.35)
Seeking social assistance from peers	33 (41)	1.06 (1.80)	0.51 (0.68)	2.58 (1.98)	1.24 (0.44)
Self-evaluation with other's assistance	24 (30)	0.44 (0.84)	0.38 (0.64)	1.46 (0.93)	1.25 (0.53)
Rehearsing and memorizing	19 (24)	0.35 (0.75)	0.33 (0.65)	1.47 (0.84)	1.37 (0.60)
Attentional control	14 (18)	0.44 (1.52)	0.26 (0.79)	2.50 (2.90)	1.50 (1.35)
Keeping records and monitoring	7 (09)	0.18 (0.71)	0.10 (0.34)	2.00 (1.53)	1.14 (0.38)
Environmental structuring: Physical environment	6 (08)	0.13 (0.49)	0.09 (0.33)	1.67 (0.82)	1.17 (0.41)
Self-consequences	2 (03)	0.06 (0.40)	0.05 (0.31)	2.50 (0.71)	2.00 (0.00)

[1]Number of participants who reported each category of strategic behavior.
[2]Mean (*SD*) numbers of strategies and number of different strategies reported for all participants ($n = 80$).
[3]Mean (*SD*) number of strategies and number of different strategies reported for participants who reported that category of strategy.
[4] Since many strategies in the "Seeking Social Assistance from Others" category were the same as those in other social assistance categories, the number of different strategies for this category is based on a smaller number of participants ($n = 44$).

children. Students reported seeking social assistance most frequently (M = 8.94, SD = 5.53) and provided varied strategies within this category with a mean of 3.51 (SD = 1.53) different help-seeking behaviors over the five contexts. Strategies in this category included "asking parents (teachers) (peers) to explain it," "tell teacher that I don't understand," and "call dial-a-teacher." Seeking social assistance strategies were further classified into four subcategories depending on the source of assistance: *seeking help from parents, seeking help from teacher, seeking help from peers*, and *seeking help from others.* Seeking help from teachers and unidentified others were the most predominant subcategories with approximately 80% of participants reporting such strategies. Seeking social assistance from parents was reported by 68% of students while seeking assistance from peers was a strategy reported by far fewer individuals (n = 33; 41%).

One group of strategies within the seeking social assistance category involved help-seeking behavior with the goal of evaluating understanding or progress. These statements also belong with similar strategies in the *self-evaluation* category (described more fully below). Therefore, we subdivided the self-evaluation category into two subcategories reflecting statements of self-evaluation with and without the help of others. A smaller proportion of participants (n = 24; 30%) reported self-evaluation with the help of others.

Approximately 85–90% of students reported *goal setting and planning* or *organizing and transforming* information in order to come to a better understanding of the material. Participants reported these strategies approximately four times over the five contexts, and those participants who stated these categories reported approximately three different forms of each of these behaviors. Goal setting and planning strategies within reading-related contexts included statements such as "write down what [the student] has to do," "just skip it and move on, it will make sense later," "read a little at a time and ask yourself what the characters are doing," and "break the report up into sections." For the mathematics contexts, strategies within this category included "finish easy questions first" and "solve the problem step-by-step." Many of these strategies indicated student efforts to plan for accomplishing academic tasks or sequencing behaviors.

Organizing and transforming statements included many important strategies that involved re-representing information to be learned with the goal of greater understanding. Students indicated they would "write an outline," "tape myself on a tape [recorder] and listen to it over and over," and "make predictions about the story" in reading-related contexts. Many of these strategies are similar to those of expert readers (Pressley & Afflerbach, 1995). Within mathematical problem-solving contexts, these middle school students reported "us[ing] objects [manipulative materials] to model [the] problem

for understanding," "organiz[ing] information in a table," and "rereading the question underlining the important facts." Each of these strategies represents important behaviors needed to develop a situational or mental model for the problem (English, 1997; Mayer, 1992; Verschaffel et al., 2000).

The distinction between the total number of times a strategy is reported and the number of different strategies reported within a category is important because these two indicators of strategic behavior may reflect different qualities in the academic behaviors of students. It is important to note, that although seeking information and seeking social assistance were reported more frequently than goal setting and planning, and organizing and transforming, on average students reported approximately the same number of different strategies for each of these four categories. Students who reported strategies in the former two categories tended to repeat these strategies more frequently. Perhaps students relied on these two categories of behaviors when they were not able to think of other more effective behaviors to report.

Cluster 2: High percentage usage, less varied strategies

Categories in this grouping were reported by approximately 70–80% of participants, but students did not report a variety of these strategies. Five categories of strategies were included within this grouping: three of the subcategories of seeking social assistance, from teachers, others, and parents; *reviewing records;* and *self-evaluation by student him or herself.*

The distinction between reviewing records and seeking information strategies was difficult to establish. To make these categories distinct, only strategies that explicitly stated reviewing (e.g., go over) notes or outlines were classified as reviewing records. As stated earlier, efforts to "reread for understanding" were classified as seeking information rather than reviewing records. These strategies were reported by approximately 80% of participants. Individuals who reported reviewing records did so approximately 2.80 (SD = 2.38) times over five contexts and among these there were 2.10 (SD = 1.36) different strategies reported per participant.

Seventy-five percent of participants indicated statements such as "proof reading" and "come up with questions to answer for each chapter" for the reading-related contexts and "check answers," "create similar problems to quiz oneself," and "do examples in the book" for the problem-solving contexts, which were classified as self-evaluation by student him or herself. Combining these statements with those referring to self-evaluation with other's assistance, 80% (n = 64) of participants reported efforts to evaluate their progress toward accomplishing academic tasks. These strategies were reported approximately three (SD = 2.10) times over the five contexts with 2.30 (SD = 1.40) different strategies reported per participant.

Cluster 3: Low percentage usage
Fewer than 50% of participants reported *seeking assistance from peers*, *self-evaluation with other's assistance*, *rehearsing and memorizing, attentional control, keeping records and monitoring, environmental structuring*, and *self-consequences*. Students reported just more than one different strategy per category for the majority of these categories except self-consequences. Rehearsing and memorizing was a surprisingly small category reported by only 19 participants (24%) but may not have been reported by many students because the nature of the scenarios did not lend themselves to rehearsing and memorizing behavior.

The environmental structuring category was differentiated into two categories, structuring *physical environment* and structuring one's internal environment or *attentional control*. Strategies within these categories were not context specific. Physical environmental structuring included statements such as "move away from disturbing student in class," "don't read with the TV on," or "work in a quiet place." The latter category included statements of calming one's self while working, listening carefully, and clearing one's mind. Few strategies overall were classified as self-consequences. These strategies include taking a break, having a snack, and going to a movie. The final category within this cluster, keeping records and monitoring, included statements of writing out the steps of a procedure or "showing all work." No strategies reported within the reading-related contexts were classified as keeping records and monitoring. Each of these final categories was reported by less than 20% of participants. One might question whether these were so infrequent because the students don't carry out these strategies or whether they do not see these strategies as strategies.

Strategic behavior and academic achievement

Strategy use descriptive statistics for the total sample and for high and low achievement subgroups are presented in Table 2. T-tests were used to compare median-split low and high mathematics and reading achievement groups on each of these indicators of strategic behavior. In addition, we explored the relationship between strategic behavior and academic achievement using correlation analyses (see Table 3).

On average, participants reported 29.34 (SD = 9.68) strategies each over the five contexts averaging six strategies per context. The total number of strategies reported ranged from 12 to 68 per participant. Students duplicated their strategies across the five contexts resulting in an average of approximately half the total number of strategies being different strategies (M = 15.76, SD = 5.51). These strategies were classified in six different categories on average with a range of three to nine different categories per partic-

Table 2. Mean (*SD*) problem solving and strategy data for total sample and low and high mathematics and reading groups

	Total sample ($N = 80$)	Low math achievement ($n = 40$)	High math achievement ($n = 40$)	Low reading achievement ($n = 41$)	High reading achievement ($n = 39$)
Total number of strategies	29.34 (9.68)	28.70 (10.22)	29.98 (9.19)	28.15 (10.32)	30.59 (8.92)
Total number of different strategies	15.76 (5.51)	14.33 (5.61)	17.20* (5.07)	14.68 (5.64)	16.90 (5.20)
Total number of different categories	5.90 (1.21)	5.55 (1.13)	6.25** (1.19)	5.56 (1.16)	6.26** (1.16)
Mean frequency rating	3.09 (0.42)	3.09 (0.43)	3.09 (0.42)	3.05 (0.44)	3.12 (0.40)
Mean confidence rating	3.34 (0.43)	3.35 (0.47)	3.34 (0.39)	3.31 (0.44)	3.38 (0.41)

*$p < 0.05$; **$p < 0.01$.

ipant. Frequency and confidence ratings were quite high overall and exhibited little variation. Participants reported using their self-identified strategies "frequently" on a four-point scale ($M = 3.09$, $SD = 0.42$) and estimated their confidence to be quite high, approximately 3.34 ($SD = 0.43$) on a four-point scale.

Three comparisons yielded no statistically significant differences for mathematics or reading achievement groups. Low and high achievement group students reported approximately the same total number of strategies, mean frequency ratings, and mean confidence ratings. High mathematics achievement group students reported more different strategies ($M = 17.20$, $SD = 5.07$) than low mathematics achievement group students ($M = 14.33$, $SD = 5.61$), $t(78) = 2.40$, $p = 0.02$. The effect of this difference, $d = 0.54$, is moderate according to Cohen's (1977, 1994) effect size index. This result was not found for reading achievement groups. Achievement groups consistently differed in the number of different categories of strategic behavior each group reported. High mathematics achievement group students reported using 6.25 ($SD = 1.19$) different categories of strategic behavior, which contrasts that of low mathematics achievement group students who reported 5.55 ($SD = 1.16$) different strategy categories, $t(78) = 2.69$, $p = 0.009$, $d = 0.60$. Similar results were found for number of different categories among low and high reading achievement groups. Correlation analyses confirmed these relationships between indicators of strategy use and standardized test scores (see Table 3). The relationship between each of the measures of academic achievement, the number of different strategies, and categories of strategies

Table 3. Correlations between all study variables for total sample ($N = 80$)

		1	2	3	4	5	6	7	8	9
1.	Mathematics achievement									
2.	Reading achievement	0.75***								
3.	Problem-solving success	0.72***	0.62***							
4.	Problems solved using meaningful approach	0.32**	0.41***	0.30**						
5.	Number of strategies	0.09	0.08	0.10	0.14					
6.	Number of different strategies	0.27*	0.25*	0.14	0.23*	0.80***				
7.	Number of categories	0.28*	0.26*	0.27*	0.24*	0.56***	0.68***			
8.	Mean frequency rating	–0.03	–0.02	0.04	–0.02	–0.03	–0.12	0.02		
9.	Mean confidence rating	–0.02	0.01	0.06	–0.01	0.12	–0.13	–0.11	0.35**	

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

reported by the participants was significant and the degree of relationship was moderate. The total numbers of strategies, mean frequency rating, and mean confidence rating were again not related to mathematics or reading standardized test scores.

Strategic behavior and mathematical problem-solving

The relationships between strategic behavior, problem-solving success, and problem-solving behavior were examined using correlation analyses. Correlations between composite strategic behavior variables and the two problem-solving indices preserved the patterns found within the academic achievement analyses discussed above (see Table 3). Students who reported more categories of strategic behavior solved significantly more problems correctly ($r = 0.27$, $p = 0.02$). Problem-solving success was not related to the total number of strategies or different strategies reported or to students' mean frequency or confidence ratings. The number of problems solved using a meaningful approach was associated with the number of different strategies and categories of strategic behavior. Students who used a meaningful approach reported more different strategies ($r = 0.23$, $p = 0.04$) and more categories of strategic behavior ($r = 0.24$, $p = 0.03$). While each of these relationships is moderate in size, the pattern of relationships is consistent throughout the results reported here.

To further analyze these findings, the relationship between the two problem-solving indices and number of different strategies within each of the categories of strategic behaviors were investigated (see Table 4). Since the total number of strategies was not associated with indices of problem solving, these correlations were not examined here. While in the last analysis the number of different categories was found to relate to problem-solving success, none of the individual categories of behaviors was significantly related to success. The number of problems participants solved using a meaningful approach, however, was significantly related to reports of self-evaluation with other's assistance ($r = 0.26$, $p = 0.02$), organizing and transforming ($r = 0.27$, $p = 0.02$), goal setting and monitoring ($r = 0.31$, $p = 0.02$), physical environmental structuring ($r = 0.29$, $p = 0.01$), and self-consequences ($r = 0.37$, $p = 0.001$). Each of these relationships was small to moderate and in the positive direction.

Limitations

One group of strategies, those involving reading and rereading statements, posed considerable difficulties because these statements could potentially be classified into several categories. Reading texts assigned by the teacher the first time or "rereading for understanding" were categorized as seeking

Table 4. Correlation between number of different strategies within categories and problem-solving success and behaviors

	Problem-solving success	Problems solved using a meaningful approach
Self-evaluation	0.13	0.15
Self-evaluation by student him or herself	0.09	0.05
Self-evaluation with other's assistance	0.13	0.26*
Organizing and transforming	0.08	0.27*
Goal setting and planning	0.18	0.31***
Seeking information	0.10	0.06
Keeping records and monitoring	0.13	0.21
Environmental structuring: Physical environment	0.08	0.29***
Attentional control	–0.08	0.02
Self-consequences	0.12	0.37***
Rehearsing and memorizing	0.08	0.00
Seeking social assistance (all forms)	0.02	–0.14
Seeking social assistance from parents	0.08	–0.06
Seeking social assistance from teachers	–0.07	–0.07
Seeking social assistance from peers	0.04	–0.06
Seeking social assistance from others	0.02	–0.13
Reviewing records	–0.13	–0.14

*$p < 0.05$; ***$p < 0.001$.

information, but statements that specifically included reading or rereading "to make certain that I understand" were thought to indicate an evaluative quality and were therefore classified as self-evaluation. Still further, rereading statements that included reference to the goal of memorizing and rehearsing were characterized as rehearsing and memorizing. Only statements that specifically indicated reviewing materials such as an outline were coded as reviewing records. This may have biased the coding scheme toward increasing the seeking information strategy statements, but this data coding policy limited the degree of subjectivity inherent within other potential approaches.

Discussion and conclusions

These middle school students reported using varied strategic behaviors to accomplish academic tasks (see Appendix A). The strategies presented here have elaborated and extended prior descriptions by establishing an extensive list of strategies middle school children report using. The categories differ

from earlier classification schemes (Zimmerman & Martinez-Pons, 1986, 1988) in several ways. First, the original scheme treated each subcategory for seeking social assistance (i.e., from peers, teachers, and adults) and reviewing records (i.e., from tests, notes, and textbooks) as separate resulting in 14 categories. We have grouped these subcategories together because of the similarity of the strategies reported within each category resulting in a more parsimonious 11 category scheme. Second, two distinctions of larger categories have been made. Self-evaluation by the student has been distinguished from self-evaluation with the help of others, and physical environmental structuring has been distinguished from attentional control or the control of one's internal environment.

There are several compelling findings within the patterns of strategy use frequency data. More than 80% of the students reported important academic behaviors such as seeking information, seeking social assistance, goal setting and planning, and organizing and transforming. Students' reports of setting goals and planning for academic tasks and of organizing and transforming academic information were related to whether students chose a meaningful approach to solving these mathematics word problems. Using a meaningful approach exemplifies transformative behavior necessary to solve mathematics word problems (Pape, in press, in review; Verschaffel et al., 2000). Few students, however, use this approach. Only 30% of the word problem solutions were coded as exemplifying a meaningful approach, which in turn is associated with solution success (Pape, in press). Thus, many students reported using categories of strategies associated with transformative behavior (i.e., organizing and transforming; goal setting and planning), and these strategies were found to be associated with using a meaningful approach, but far fewer students provide evidence of these strategies in the problem-solving verbal protocols. Perhaps these findings may be interpreted to indicate that although students understand the importance of transforming information, they do not necessarily know how to do so when performing learning tasks such as solving mathematical word problems.

A third category of behavior associated with whether students used a meaningful approach to solve word problems was self-evaluation with other's assistance, reported by 30% of students. This category combines two important strategies: self-evaluation and help seeking. It is important to note that help-seeking behavior (all forms) resulted in a non-significant negative association with using a meaningful approach. Further, although reported most frequently by students, it was the only category in Cluster 1 not significantly associated with this more active stance toward problem solving. Students may report this strategy when they have no other strategy to report. When help-seeking behavior was purposeful (i.e., to evaluate one's performance), however, it was related to transformative problem-solving behavior.

Finally, while self-consequences and environmental restructuring were correlated with using a meaningful approach, they were reported by small numbers of participants, overall.

A surprising finding in this study was that fewer than 25% of participants reported rehearsing and memorizing strategies. As mentioned earlier, this may have been due to the particular scenarios to which the students responded. In addition, to limit the subjectivity of classifying strategies only statements that explicitly stated memorization as a goal were classified in this category. In addition, few students overall mentioned attentional control, keeping records and monitoring, physical environmental structuring and self-consequences.

The most robust differences between achievement groups were related to the variety of strategies and categories of strategies. High achieving students reported more categories of strategic behavior and high achieving mathematics students reported more different strategies than their low achieving counterparts. In turn, these variables were associated with problem-solving behavior and outcomes. The lack of significant associations between the total number of strategies reported and other study variables implies that simply being able to report many strategies is not as important as being able to recall a wide variety of strategies.

Contextualized strategy intervention has been shown to be effective (Butler, 2002). From the present work, several research studies are being pursued to examine the impact of making strategic behavior an explicit part of classroom discourse. Seventh-grade students were asked to articulate their strategies for learning and to classify these strategies using the categories discussed in this article. From a year-long investigation of these classroom discussions, principles for establishing explicit strategic behavior in a mathematics classroom have been developed (Pape et al., 2002). Subsequent research is examining changes in the quality of the strategies students report and exhibit while solving mathematical word problems as a result of this explicit strategy instruction.

The findings of the present study coupled with these subsequent analyses hold promising implications for teachers as they work toward developing self-regulated students. The present analysis highlights the importance of exposing students to varying strategies for accomplishing academic tasks and helping them identify the strategies they are using by categorizing them using this scheme. This identification process may provide students the context for establishing conditional knowledge for particular strategies. By helping students identify and share their strategies for specific academic tasks, teachers may build a repertoire of strategies with and within their students leading to more varied behaviors dependent upon the learning context.

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Appendix A

Descriptions of categories of strategic behavior and examples from middle school students

Category definitions according to Zimmerman and Martinez-Pons (1986, 1988) or Purdie et al. (1996)	Examples of middle school students' strategies	
	Reading and writing scenarios	Mathematical problem-solving scenarios
1. Self-evaluating		
Student-initiated evaluations of the quality or progress of their work (Zimmerman). 1. Checking quality of work or effort. • redoing, reworking, rereading • using different methods 2. Using other sources to check work. • Asking others to check work 3. Testing the extent of knowledge or ability to perform a task. • Self-testing (Purdie)	1.1 Self-evaluation initiated by self. • Proofread a report; Reread for mistakes • Rewrite the draft • Come up with questions to answer • Ask myself what is happening while reading 1.2 Evaluation with other's help. • Get somebody to ask you questions • Make someone to check the grammar • Take a test with my parents • Ask teacher to quiz class • Read to mom to proofread	1.1 Self-evaluation initiated by self. • Check answers; Redoing problems • Created similar problems to quiz oneself • Try to solve similar problems/different ways • Use a calculator for reassurance • Prove how I got the answer • Review the steps taken to solve problem 1.2 Evaluation with other's help. • Ask parent to check answer/make problems • Go over problem with experienced person • Exchange problems with friends
2. Organizing and transforming		
Statements indicating student-initiated overt or covert rearrangement of	• Write an outline/summary/chart; Write all facts down; Put events in numerical order	• Use objects/manipulative materials to model problem for understanding

Continued

Category definitions according to Zimmerman and Martinez-Pons (1986, 1988) or Purdie et al. (1996)	Examples of middle school students' strategies	
	Reading and writing scenarios	Mathematical problem-solving scenarios
instructional materials to improve learning (Zimmerman). • Summarizing, making notes • Writing outlines/drafts • Mental planning of a task • Organizing files/notes and writing final copies of work (Purdie)	• Take notes/highlight important parts/main idea of book/story/problem • Tape myself on a tape reading and listen to it • Make believe I am main character • Make a play/poem/rhyme of the story; Make picture in my mind • Make predictions about the story • Motives or reasons for the situation to occur – reread or try to relate • Rewrite words I don't understand	• Try to make them easier by sorting out unnecessary information • Make a picture/reread in my mind • Break down the problem • Organize information in a table • Write down steps/information • Act it out • Reread the question underlining the important facts • Pretend the actions are in front of you
3. Goal-setting and planning		
Statements indicating students' setting of educational goals or subgoals and planning for sequencing, timing, and completing activities related to those goals (Zimmerman).	• Plan out/write down what I am going to do • Go to library; Ask to take home the book • Pick an easier/appropriate/interesting book • Study from day teacher tells me until exam • Skip it and read on, it will make sense after • Read a little at a time/10–15 min a night and ask yourself what the characters are doing	• Skip difficult question and go to the next one; Finish easy questions first • Choose strategy to use to solve a problem; think about the steps to take • Solve the problem step-by-step; Do one thing at a time; Do 5 steps I learned in math • Try to remember smaller problems

Continued

Category definitions according to Zimmerman and Martinez-Pons (1986, 1988) or Purdie et al. (1996)	Examples of middle school students' strategies	
	Reading and writing scenarios	Mathematical problem-solving scenarios
	• Break report up into sections • Keep a dictionary at my side • Read book quickly while still understanding it	• Guess and check • Write things I do on scrap paper before writing it
4. Seeking information		
Statements indicating student-initiated efforts to secure further task information from nonsocial sources when undertaking an assignment (Zimmerman).	• Read the book carefully the first time; Skim the book; Silently read along with the teacher • Read or reread to make certain that I understand/to see if I missed anything • Read table of contents/back of book for summary/last pages/about the author • Look in the dictionary for the words • I look at the timeline and read out the important things	• Read or reread (study hard) for understanding (to make certain I understand) • Use a calculator; Look up the words in dictionary • Pick out (Go over) the numbers/facts; Go back to problem • Find out what the teacher is looking for • Look for clues in the problem that will help me to solve it
5. Keeping records and monitoring		
Statements indicating student-initiated efforts to record events or results		• Write whatever you did out • Try to answer it showing all work

Continued

Category definitions according to Zimmerman and Martinez-Pons (1986, 1988) or Purdie et al. (1996)	Examples of middle school students' strategies	
	Reading and writing scenarios	Mathematical problem-solving scenarios
(Zimmerman). • Note taking during class/activity • Writing list to keep track • Recording grades/indicators		• Carefully show my work and label what I am doing
6. Environmental structuring: Physical		
Statements indicating student-initiated efforts to select or arrange the physical setting to make learning easier (Zimmerman).	• Move away form a disturbing student in class • Work in a quiet place • Don't read with the music/TV on	• Move away for a disturbing student in class • Work (think) in a quiet place (alone) • Listen to the radio • Stay away from TV • I shut myself in a room
7. Attentional control		
Self-environment – perform a particular personal behavior so that learning is improved (Purdie).	• Go home and relax; Stay calm; Be happy • Pay attention • Stay tuned to what is happening • Listen carefully when the book is read • Extremely confident	• Be calm; Be happy; Relax; Be confident • Concentrate on computing method (steps) • Clear my mind; Keep my head on problem • Express your feelings • Pay very close attention

Continued

Category definitions according to Zimmerman and Martinez-Pons (1986, 1988) or Purdie et al. (1996)	Examples of middle school students' strategies	
	Reading and writing scenarios	Mathematical problem-solving scenarios
8. Self-consequences Statements indicating student arrangement or imagination of rewards or punishment for success or failure (Zimmerman).		• Have a drink or snack • Take a break • See a movie
9. Rehearsing and memorizing Statements indicating student-initiated efforts to memorize material by overt or covert practice (Zimmerman). • Memorizing • Get it stuck in your head • Doing practice exercises to improve skill development or understanding (Purdie).	• Memorize the main points of the book or details of a particular problem • Reread to memorize or rehearse • Say part over again; Retell major events • Try to recall to the best of my ability • Read it until you can't stop thinking of it • Repeat or keep on writing the important things which you read about	• Try to memorize the method • Memorize important words, numbers, or definitions

Continued

Category definitions according to Zimmerman and Martinez-Pons (1986, 1988) or Purdie et al. (1996)	Examples of middle school students' strategies	
	Reading and writing scenarios	Mathematical problem-solving scenarios
10. Seeking social assistance		
Statements indicating student-initiated efforts to solicit help from adults, teachers, or peers (Zimmerman).	10.1 Seeking help from parent. • If parents read book ask them • Go home and read my short story to mom • Ask my parents on their opinion	10.1 Seeking help from parent. • Try it first and if the answer doesn't make sense ask a parent for help • Study with my dad
	10.2 Seeking help from teacher. • Ask teacher for help/to explain it • Tell teacher that I don't understand • Ask the teacher for suggestions/for format • Ask her to simplify the questions	10.2 Seeking help from teacher. • Ask the teacher how to solve problem • Ask the teacher to explain to me • Tell teacher you don't understand • Call "dial-a-teacher"
	10.3 Seeking help from peers. • Call up a friend • Discuss the book with a friend • Talk to my friends to see what they know • Study with a friend/make a study group	10.3 Seeking help from peers. • Study with a friend • Ask classmate who understands to explain • Do it with a friend who also has trouble • Work with partner and exchange answers

Continued

Category definitions according to Zimmerman and Martinez-Pons (1986, 1988) or Purdie et al. (1996)	Examples of middle school students' strategies	
	Reading and writing scenarios	Mathematical problem-solving scenarios
	10.4 Seeking help from others. • Have someone else read the book to me so that I can listen and understand • Ask questions on part I don't understand • Read a little to your family • Ask my sister to help me understand the story • Ask people if they recommend a book	10.4 Seeking help from others. • Ask for advice (questions) (how to do it) • Ask other people to explain it • Go to my computer and get homework help • Call homework hotline • Have someone explain or give an example of how to do the problem
11. Reviewing records Statements indicating student-initiated efforts to reread notes, tests, or textbooks (Zimmerman).	• Read/reread notes/book/major events to prepare outline or summary/list of events • Review the important part of the story • Go over notes taken in class • Study them/the story • Read the question again • Play it in your sleep; Think about the play you made up • Check on what the teacher said has to be in it; Double check the assignment; Remember	• Read/reread notes • Go back to textbook or notes • Review math books; Use my math textbook to help solve if I don't understand (the chapter on percents); Look back at the records; Go over some examples • Think of questions from other problems • Try to think back in the lesson; Review all the materials I learned in math; Try to think back in the lesson

Continued

Category definitions according to Zimmerman and Martinez-Pons (1986, 1988) or Purdie et al. (1996)	Examples of middle school students' strategies	
	Reading and writing scenarios	Mathematical problem-solving scenarios
	what the teacher asks for • Think about previous class discussions • Study tests/homework that I did on the story	• Study all operations • Review steps I took to solve it • Go over the order of operations
12. Other		
Statements indicating learning behavior that is initiated by other persons such as teachers or parents, and all unclear verbal responses (Zimmerman). • Using willpower; Cheating • Other (vague, unclassifiable) (Purdie)	Miscellaneous/uncertain category – Responses vary • Study • Copy the whole book • Think hard • Do nothing and hope I remember • Just fail the test; Give in and say "this is the best I could do" • Be sad • Talk to myself	Miscellaneous/uncertain category – Responses vary • Study hard(er) • Don't do it; Move on • Guess an answer which sounds right • Be independent • Put under my pillow for good luck • Think of consequences • Do what it says • Be frequent about it

Appendix B

Strategy questionnaire scenarios

1. Assume your class is reading a novel or short story. Your teacher says that your class will be discussing the elements or major events of the novel or short story the following week.
   (a) What do you do to help you learn and remember the elements or major events of the novel or short story for discussion in class?
   (b) What do you do when you are having trouble understanding or remembering the story?
2. Assume your Mathematics teacher is discussing a problem-solving topic with your class. A problem such as the following is given:
   Mary and Sue run together every day at the neighborhood high school track. Mary runs a six-minute mile, and Sue runs a five and a half minute mile. If they race each other, who will probably win the race? If the race is two miles long, how much longer will it take the loser to run the race?
   Your teacher tells you that the class will be doing problems similar to this in class.
   (a) What do you do so that you would be able to solve the problems?
   (b) What do you do when you are having difficulty solving the problems?
3. Teachers often give their students math word problems to solve for homework. Teachers also expect students' homework assignments to be completed correctly or accurately, and many of these assignments must be completed at home without the help of a teacher.
   (a) What types of things do you do to solve word problems when you are doing your homework?
   (b) What do you do when they are very difficult problems to solve?
4. Suppose your teacher assigns you a book report that is due in 4 weeks. You are allowed to choose any book, but you will need your teacher's approval before you can begin the assignment.
   (a) What do you do to help you complete this assignment?
   (b) What do you do when you are having difficulty understanding the book or writing the report?
5. Teachers often give their students word problems to do in class. A problem such as the following may be given:
   According to the *New York Times*, scientists studying the atmosphere have recently detected a decrease in the level of methyl chloroform, an industrial solvent that is harmful to the ozone layer. In 1990, the level of methyl chloroform was 150 ppt (parts per trillion), but by 1994 the level had fallen to 120 ppt. By what percentage did the level of methyl chloroform decrease between 1990 and 1994?
   (a) What do you do to help you understand the problem?
   (b) What do you do to help you solve the problem?
   (c) What do you do when the problem is very difficult to understand?
   (d) What do you do when you are having difficulty solving the problem?