An Exploration of Selected Conative Constructs and Their Relation to Science Learning

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ABSTRACT

The conative domain of aptitude constructs spans the domains of individual differences in motivation and volition. Conative constructs are implicated whenever students select from alternative courses of action and maintain effort and persistence until their goals are achieved or abandoned for new goals. This research sampled a broad range of conative constructs, including achievement motivation, anxiety, goal orientations, interest, and expectancies, among others. The purpose was threefold: (a) to explore and clarify relationships among conative constructs hypothesized to affect student commitment to learning and subsequent performance; (b) to determine whether or not individual differences in conative constructs were associated with the learning activities and time-on-task of students engaged in a computerized science learning task; and (c) to ascertain whether or not the conative constructs and the time and activity variables from a learning task were associated with performance differences in a paper-and-pencil science recall measure.

This research consisted of three separate studies. Study I was based on 60 U.S. college students. In Study II, a total of 234 Canadian high school students participated. These two studies investigated the construct validity of a selection of conative constructs deemed promising for future educational research and application. Verbal ability measures were also administered in Study II. Scores from the conative questionnaires were intercorrelated and formed meaningful patterns of correlations. A principal components analysis of the measures was undertaken and yielded seven components: *Pursuit of Excellence*, *Evaluation Anxiety*, *Self-Reported Grades*, *Science Confidence*, *Science Interest vs. Science Avoidance*, *Performance Orientation*, and *Verbal Ability*.

For Study III, 82 Canadian high school students completed the same conative questionnaire administered in Study II. A computerized science learning environment was developed for Study III patterned after an Internet browser. The computerized environment allowed students to browse science text, figures, definitions and comprehension testing questions about disease-causing microbes. In the computerized environment, students could also elect to play one of two computer games. The time students spent on each activity and the frequency of each activity were recorded by computer. These yielded aggregate measures of the time spent playing games, the time spent learning science, the number of games played, and the number of science-related learning activities engaged in by each student. Following administration of the computerized learning environment, students were administered a paper-and-pencil science recall measure.

Study III found support for the educational importance of the conative variables. Among the principal components, the strongest positive relationship was found between Science Interest vs. Science Avoidance and performance on the recall measure. A performance orientation was also positively correlated with scores on the science recall measure. Scores on the conative variables were also correlated with both the time and activity variables from the computerized learning task. The implications of the findings are discussed with regard to the construct validation of conative constructs, the use of conative constructs for future educational research, and the design of computerized learning environments for both educational research and applied use.

CHAPTER 1

INTRODUCTION

Need for the Study

In recent decades, instructional psychology has seen a burgeoning in the number and kinds of constructs put forth for use in educational research (Snow, 1990). Many of these constructs emphasize aspects of student learning and performance that fall outside of the traditional realm of cognitive aptitude and achievement. Many of these constructs are implicated when students are faced with less structured situations and must decide for themselves what goals and structure to impose on tasks. Thus, students must choose from alternative courses of action, select an appropriate level of effort, and finally persist until their goals are either achieved or set aside in favor of new goals. These motivational and volitional constructs are referred to collectively as the "conative domain"; conation is defined as the "tendency to take and maintain purposive action or direction toward goals" (Snow, Corno, & Jackson, 1996, p. 264). The conative domain has historically been distinguished from the "cognitive" and "affective" domains (Hilgard, 1980). Although all human behavior involves some mixture of these three components, a review of the literature reveals that conative constructs generally have been neglected in educational assessment (Snow & Jackson, 1992). There is thus need to develop a taxonomy of constructs to help guide research in this area.

Snow and Jackson (1992) observed that the conative domain was loosely divided into five areas:

Achievement motivation and related constructs. Included in this area are constructs of achievement motivation, anxiety, and individual differences in goals and the positive or negative expectations associated with them.

Self-regulation and related constructs. Included in this area are volitional constructs of individual differences in intentions, effort investment, action control, and self-regulation. Also included are self-motivational strategies that share a fuzzy boundary with cognitive and metacognitive strategies.

Interests and styles in learning. Included in this area are subject matter interests, preferences for specific kinds of activities or situations, and a broad range of learning style constructs.

Self-related concepts. Included in this area are self-esteem, self-efficacy and personal agency beliefs.

Other-related concepts. Parallel to the self-related constructs are other-related concepts that include conceptions relevant to subject matter domains, persuasability, and other qualitative changes during learning.

Need for Research

There is evidence suggesting that constructs from all of these areas are important in understanding student performance and commitment to learning. But a number of issues can be identified that require further research:

Psychometric properties of the questionnaires. Many constructs are measured using questionnaires of questionable psychometric quality. There is need to evaluate the psychometric properties of these questionnaires to determine which of them are most appropriate for future educational research.

Convergent and discriminant validation. Many studies are small-scale investigations of one or a few constructs in isolation that do not include measures of other constructs with which they may overlap substantially. Furthermore, some constructs appear to be defined and described in similar ways, yet are measured using different procedures, leading to differences in empirical results (e.g., Spangler, 1992). There is a need for basic convergent and discriminant validation research that includes a broad set of measures in one sample of students to examine issues of overlap and redundancy.

Conative constructs and educational achievement. There has been a rapid increase in the number of constructs hypothesized to have educational significance. Thus, there is a need to determine which constructs show the strongest relationships with important educational outcomes.

Statement of the Problem

This thesis thus examines relationships among a broad sample of conative constructs hypothesized to affect student commitment to learning and performance. The goal is first to explore and to evaluate a range of measures thought to be related to conative individual difference constructs. The second goal is to select the best measures and to employ them in further research to examine whether or not individual differences in high school students' motivational and volitional orientations are associated with their differences in learning. Of particular interest are students' differences in learning strategies used during a computerized science learning task and their subsequent performance on a science achievement assessment. Results from these analyses may assist researchers in understanding better the motivational and volitional aspects of human behavior within the context of student learning and performance.

The major hypotheses to be examined are the following:

Hypothesis 1—Construct validity of conative constructs. Newly proposed conative constructs will show significant relationships with established motivational constructs, including achievement motivation and test anxiety, but will possess substantial unique variance as well.

Hypothesis 2—Relationships between science achievement and conative constructs. The conative constructs will correlate with the science achievement measures independently of verbal ability.

Hypothesis 3—Relationships between science achievement and learning activities. Performance on a paper-and-pencil assessment of the science material presented in the computerized task will correlate positively with (a) the frequency students engaged in science learning activities during the computerized science task, and (b) the time spent learning science material. Performance on the assessment will correlate negatively with (a) the frequency students engage in game playing activities, and (b) the time spent playing games.

Hypothesis 4—Relationships between conative constructs and learning activities. The conative constructs will correlate with (a) the frequency with which students engaged in science learning activities during the computerized science task, and (b) the time spent learning science material.

Overview of the Study

This investigation consisted of three parts designed to address the previously mentioned issues and hypotheses. Study I was a pilot study, the purpose of which was to gain familiarity with the instruments used to measure a selection of conative constructs. In particular, the pilot study involved 60 college students who gave important information on the time needed to administer each measure, as well as data needed to explore the psychometric properties of each questionnaire. Additionally, the pilot study provided a preliminary understanding of the interrelationships among the various conative constructs as measured by these initial questionnaires.

Study II was a construct validation study involving 234 high school students. Its purpose was to assess a broad range of conative individual difference constructs and to examine their interrelationships in a large sample of high school students. It was hypothesized that some of the constructs in this set of measures would be redundant. For example, measures of motivation (intrinsic motivation) might not be empirically distinct from measures of learning goal orientation. Then, overlapping constructs could be merged to yield a new set of distinctions.

Study III investigated 82 high school students learning computer-based science material. The purpose here was to study the best measures found in Studies I and II in relation to science learning and to determine whether individual differences in these conative constructs were associated with student differences in learning strategies and students' subsequent achievement.

CHAPTER 2

LITERATURE REVIEW

Apart from conventional constructs of cognitive ability, there are a great many conative constructs that have been identified as important to learning from instruction. The term "conative" is used here to encompass a diverse set of constructs that span both motivational and volitional aspects of human behavior, and also to distinguish this set from the other important sets of constructs that emphasize cognition and affection.

This literature review is organized into three sections. The first section defines conation more fully and examines two taxonomies of the conative domain, emphasizing the need for construct validational research in this area. The second section provides a rationale for including particular constructs selected from the two taxonomies and describes these constructs in detail. The third section complements the first two sections by describing research linking these conative constructs to desired outcomes including cognitive engagement, use of learning strategies, and academic achievement.

Conative Aptitudes

This research is guided by the notion that a learner brings certain individual characteristics, or "aptitudes" (Corno & Snow, 1986) to the learning situation. Aptitude, as the term is used here, encompasses cognitive, motivational, volitional, and affective individual characteristics and thus refers to a broader multivariate concept than aptitude as it has traditionally been conceived in cognitive ability research (Snow, 1992). In a learning situation, these aptitudes interact with an individual's construction of the situation and its affordances to influence the learning strategies used and the performance outcomes that result (Ainley, 1993).

Cognitive Models of Student Learning

Cognitive models of student learning have been developed to demonstrate the importance of students' knowledge and strategy in academic learning and performance (Snow & Lohman, 1989). But cognitive accounts have difficulty explaining why capable students often fail to use their knowledge or skills for many school tasks. By ignoring students' intentions, goals, and purposes, these cognitive models are of limited usefulness when taken out of the laboratory and applied to actual student performance in classroom settings where students choose their own levels of cognitive engagement (Pintrich & Schrauben, 1992). Numerous investigators have pointed out the need to expand "beyond cold cognition" (Zajonc, 1980) and to include motivational, volitional, and affective aptitudes as well as cognitive aptitudes for learning (Brown, 1988; Brown, Bransford, Ferrara, & Campione, 1983; Lepper, 1988; Pintrich, 1990).

Pintrich and his colleagues (Pintrich & De Groot, 1990a, 1990b; Pintrich & Garcia, 1991; Pintrich & Schrauben, 1992; Pintrich, Smith, Garcia, & McKeachie, 1991), guided by a general social cognitive model of student motivation, have developed another taxonomy that aims to clarify the domain of conative and cognitive constructs in relation to student learning. In their work (Pintrich & Schrauben, 1992), the historical distinction between motivational and cognitive variables is fundamental. On the motivational side of a general expectancy-value model, three aspects of students' motivational beliefs are distinguished: expectancy, value, and affect. Expectancy components include self-efficacy and control beliefs. The value components include intrinsic and extrinsic goal orientations, as well as task value, a construct that shares much in common with task interest. The affective component is test anxiety, but Pintrich acknowledges that other components, such as pride, shame, and emotional needs related to self-worth or self-esteem (Covington & Beery, 1976) fall in this category. On the cognitive side of the model, a distinction is made between general cognitive strategies (e.g. rehearsal, elaboration, organization) and a variety of metacognitive and self-regulatory strategies (e.g. planning, monitoring, and regulating).

The Pintrich et al. taxonomy (1991) is largely consistent with Snow et al.'s (1996) work with regard to which constructs are important, but Pintrich and colleagues differ somewhat in how the constructs are organized in the taxonomy. The differences in organization between the two taxonomies reflect the fact that many of the constructs combine expectancies, values, beliefs, strategies, and affect in varying proportions, and some constructs could comfortably be accommodated in a number of categories. Furthermore, the Pintrich taxonomy emphasizes motivational constructs and cognitive strategies, while the Snow and Jackson (1992) taxonomy was conceived to span the more varied range of conative constructs found in the literature, including learning styles, self-concepts, future time perspectives, and action control, constructs that are not included in the Pintrich et al. (1991) work.

Need for Construct Validation Research

A program of construct validational research would help to determine what theoretical and practical distinctions are justified, and what kinds of measurement will be most helpful to improving instructional research and evaluation. It would also help by linking research findings from studies that use variables that on the surface appear to be different, but are really measuring the same underlying constructs. A logical first step would be to collect together instruments measuring a selection of these conative constructs and to administer them together. This would show the interrelationships among the constructs and would help to determine which constructs overlap substantially, and which ones represent distinctions that bear on future educational research, and ultimately on educational practice.

Rationale for Selection of Constructs

The present research includes measures of achievement motivation and goal orientations, self-regulation and cognitive strategy use, action (versus state) orientation, anxiety, situational interest, and deep versus surface learning strategies. These constructs were selected because (a) several recent studies have explored their relationship to learning and achievement outcomes; (b) assessment instruments were available with demonstrated sufficient reliability; and (c) they combined empirically well established constructs with newer, more speculative constructs. The remainder of this section describes each of these constructs in turn.

Motivational Goal Orientations

Several incarnations of the distinction between “intrinsic” and “extrinsic” motivation have appeared, especially in the past decade (Berlyne, 1960; Harter, 1981; White, 1959). These have been referred to as goal orientations that are task-involved versus ego-involved (Maehr & Nicholls, 1980; Nicholls, Patashnick, & Nolen, 1985), mastery oriented versus performance oriented (Dweck & Leggett, 1988; Elliot & Dweck, 1988), and mastery focused versus ability focused (Ames, 1984; Ames & Archer, 1988). Common to these goal orientations is a distinction between behavior engaged in because of the learning or enjoyment it provides and behavior undertaken for external and instrumental reasons (Lepper, 1988). Goals are considered cognitive representations of students' objectives in different achievement situations.

Lepper (1988) also points out some differences among these constructs. Intrinsic and extrinsic motivation are broader constructs than the other goal orientations because these do not necessarily involve competition or comparison of one's performance with that of peers. Furthermore, the intrinsic-versus-extrinsic distinction can be applied to other, noneducational and non-achievement-related activities. Nonetheless, the goal orientation constructs discussed here are more alike than they are different, and their similarities will be emphasized here. Thus, the term "learning orientation" will be used to encompass intrinsic, task-involved, and mastery goal orientations, and "performance orientation" will be used for extrinsic, ego-involved, performance goal orientations.

Learning-oriented students seek challenging tasks and maintain effective striving under failure (Dweck & Leggett, 1988). They pursue learning goals in achievement situations and put forth effort to increase their competence (Elliot & Dweck, 1988). In contrast, performance-oriented students are characterized by avoidance of challenge and impaired performance in the face of failure (Elliot & Dweck, 1988). They pursue performance goals, seeking to maintain positive judgments of their ability and avoid negative judgments (Elliot & Dweck, 1988). Kanfer and Kanfer (1991) have suggested that performance-oriented students, in contrast to learning-oriented students, devote relatively more of their working memory to thoughts about their performance, ability, and what others think of them. This leaves less working memory capacity available for task-related cognitions, and consequently performance-oriented students appear to have impaired performance.

The salience of situational characteristics such as grading practices and social comparison information can elicit different goal orientations (Ames & Archer, 1988), but goal orientations can also be conceived of as more stable individual differences (Maehr, 1984), which develop through parental influences (Ames & Archer, 1987), or through prior academic experiences (Stipek & Hoffman, 1980). Furthermore, there is evidence that students pursue learning and performance goals simultaneously (Nicholls et al., 1985; Wentzel, 1989, 1993), as in the example of a student who studies to obtain good grades in science to please her parents, but also studies because she is genuinely interested in learning the material. Finally, besides learning and performance goal orientations, students can be oriented towards work-avoidance goals (Nicholls et al., 1985; Pintrich et al., 1991) or can be motivated to pursue social goals (Wentzel, 1991, 1993). Work-avoidant students are not engaged by the material, nor are they interested in its content. These students do not really know why they have to learn the material, put forth minimal effort, and tend to be unconcerned with how others evaluate their performance.

Action Versus State Orientation

Regardless of whether a student is oriented toward learning goals or performance goals, she must take action to see that her goals are realized. Action control falls on the volitional side of conation. According to Action Control Theory (Kuhl 1981, 1984, 1990; Kuhl & Beckman, 1985; Kuhl & Kraska, 1989), when an individual perceives that an intended action is difficult to enact, volitional control processes will be used to maintain intended actions and to inhibit distractions. Action versus state orientation is both an ability-like and state-like construct hypothesized to influence the difficulty of enacting an intention.

Action-oriented individuals tend to take immediate action to enact their intentions. They are characterized by having situationally appropriate intentions and an awareness of a means of transforming their current situation into some desired future state. In contrast, state-oriented individuals are marked by intentions that are either unrealistic or should be postponed. The state-oriented individual is often fixated on "past, present, or future states, for example, on a past failure to attain a goal, on the present emotional consequences of that failure, or on the desired future goal state itself" (Kuhl & Kraska, 1989, p. 366).

Science Interest

Interest in the material to be learned may affect students' ability to use volitional control processes to enact difficult intentions. The model of interest in this study is based on Mitchell's (1993) theoretical model of interest in secondary school mathematics, but adapted to apply to secondary school science. This model builds upon the work of Moos (1976, 1979), Hidi and Baird (1988), Malone and Lepper (1987), Schiefele (1991) and others. It distinguishes between personal interest, the interest that people bring to an environment or context, and situational interest, the interest that develops by participating in an environment or context. This distinction parallels the trait-versus-state distinction used in research on numerous conative constructs. The focus in Mitchell's model is on situational interest because it is considered of greater educational significance. Situational interest is malleable through interaction with learning situations, and multifaceted, with "catch" and "hold" facets. "Catch" facets use cognitive and sensory stimulation to attract students' interest but tend to be ephemeral. The theory contains three catch facets: group work, computers, and puzzles. "Hold" facets are features of an educational task or situation that maintain interest over time by empowering students. The two "hold" facets in the model are meaningfulness and involvement. Meaningfulness refers to the extent that students perceive the content of the domain (e.g., science) as important to their daily or future lives. Involvement is the degree of active participation by the students in the learning situation.

Expectancies

The two expectancy constructs in this research are self-efficacy beliefs and control beliefs, consistent with Pintrich and Schrauben's (1992) taxonomy. Self-efficacy refers to individuals' beliefs about their performance abilities in a particular domain (Bandura, 1982), whereas control beliefs emphasize whether students believe that the environment will be responsive to their actions.

Deep Versus Surface Learning Strategies

According to Marton and Säljö (1976) and Entwistle (1981, 1987a, 1987b), and their coworkers (Entwistle & Ramsden, 1983; Marton, Hounsell, & Entwistle, 1984), students approach learning situations in several characteristic ways. One of the principal distinctions made is between students who adopt a deep approach versus those who adopt a surface approach. Central in this distinction is the degree to which intention and commitment to learning are characteristic of students. Students who adopt a deep approach regard the text or problem material to be learned as instrumental to understanding the underlying meaning found in the material. These students are characterized in the following ways: (a) by having little concern for others' evaluations of their performance;

(b) having an active interest in the learning material; (c) attempting by themselves to evaluate the evidence presented; and (d) by relating the evidence to other topics in order to draw their own conclusions. For those students who adopt a deep approach, learning is viewed as a process of constructing meaning and of understanding the world.

In contrast, students who adopt a surface approach regard the particular learning material as what needs to be learned. They tend not to link information to a larger conceptual framework. Their surface approach is often the result when performance is to be evaluated, and they are motivated to satisfy the demands of others. Learning is viewed as emphasizing the transmission of the content of the learning materials into the head/mind of the learner. The focus is on memorization and passive knowledge acquisition in order to permit reproduction of the material on tests and evaluations.

In the measurement of deep versus surface approaches to learning, Entwistle and Tait's (1992) Approaches to Studying Inventory contains items that reflect the following: (a) students' intentions to learn, (b) students' attitudes towards learning, and (c) the strategies that students use while engaged in learning. This study considers students' learning goals as separate from the strategies students use to achieve these goals, but the deep-versus-surface distinction is maintained here as a means of categorizing learning strategies.

Learning strategies can be regarded as either deep (emphasizing elaborative processing) or surface (emphasizing rehearsal). Students who adopt a deep approach to learning are hypothesized to use "deeper" or more elaborative processing in contrast to students who adopt a surface approach. Deep learning strategies identified by Corno (1986, 1989), Corno and Mandinach (1983), Entwistle and Tait (1992), Pintrich et al. (1991), and Zimmerman and Martinez-Pons (1986) include elaboration, organization, critical thinking, self-regulation, effort regulation, relating ideas, and using evidence. Surface learning strategies include reproducing, passive learning, unrelated memorizing, rehearsal, and help seeking. Deep processing is more likely to result in conceptual understanding and retention than is surface-level processing (Entwistle & Ramsden, 1983). Furthermore, students who are interested in a topic are more likely to use deep processing strategies. In a correlational study investigating relationships among interest in studying, motivational variables, and the use of learning strategies (Schiefele, Winterler, & Krapp, 1991), it was found that interest correlated positively with elaboration and information-seeking strategies (deep learning), but negatively with rehearsal strategies (surface learning).

Mindfulness is a construct that appears to be closely related to a deep approach to learning. Mindfulness refers to intentional, purposeful, metacognitively guided employment of nonautomatic, hence effort-demanding, mental processes (Salomon, 1983, 1984, 1987). A learner rarely applies knowledge and skill automatically when needed or when appropriate. There must be an intention to mobilize and to apply knowledge and skill to a new situation. This intentional mobilization is mentally taxing—it demands effort investment in a mindful application of knowledge and skill. The difference between what a person can do and what a person actually does in a situation indicates the effect of mindful effort investment. The distinction between mindfulness and mindlessness is also parallel to that between controlled and automatic processing.

Empirical Research Involving Conative Constructs

Empirical Relations Between Goal Orientation and Strategy Use

A number of studies have explored the specific goals toward which students are oriented in relation to cognitive and metacognitive strategy use. Several of these studies are described here because they suggest how future research might be directed.

First, a series of studies by Pintrich and his colleagues have examined the relationships between individual differences in conation and cognitive engagement in college students (McKeachie, Pintrich, & Lin, 1985a, 1985b; Pintrich, 1985, 1986, 1987, 1989; Pintrich & Garcia, 1991) and junior high school students (Pintrich & De Groot, 1988, 1990a, 1990b). The findings of these studies have been largely consistent across the two different populations. Pintrich's research program has relied heavily upon correlational data and self-report measures, but it is classroom based. Much of his research has used scales from The Motivated Strategies for Learning Questionnaire or MSLQ (Pintrich et al., 1991), a multiscale measure of his taxonomy of motivational, cognitive and metacognitive constructs. Although his research program has included a range of motivational variables, including self-efficacy, task value, and goal orientation, the emphasis here is on student goal orientations because this is most central to the present research.

Typically, Pintrich asks college students to report their motivational beliefs and cognitive strategy use on the MSLQ. This questionnaire is administered at the beginning and end of a particular college class. The preclass and postclass results are compared to performance data on academic tasks completed as part of the course, including exams, papers, and final course grade. In Pintrich's samples, which range from around 80 to 758, he found that college students who are high in learning goal orientation are more likely to report using rehearsal, elaboration, organizational, and self-regulatory strategies. Students also reported being better managers of their time and effort. They also achieved higher standings on academic tasks.

Pintrich and Garcia (1991) explored interactions between learning goal orientations and performance goal orientations (referred to by them as intrinsic and extrinsic orientations). A learning goal orientation correlated significantly with the self-report cognitive engagement variables. This was consistent with Pintrich's other studies. A performance goal orientation was not correlated with reported cognitive or self-regulatory strategy use, but it did moderate the effect of a learning goal orientation on the use of elaboration, organization, and self-regulatory strategies. Pintrich and Garcia (1991) found that when performance goal orientation was low, the learning goals were positively related to cognitive engagement. When performance goal orientation was high, no relationship was found between learning goal orientation and cognitive engagement. Pintrich and Garcia (1991) interpreted this finding as suggesting that it is better to be motivated by learning goals, but in their absence, it is better at least to be concerned about grades and to participate in the classroom than to be alienated from it.

Pintrich's studies with junior high school students (Pintrich & De Groot, 1988, 1990a, 1990b) have not included separate measures for learning and performance goal orientations, so this finding has not been replicated in a younger sample. Nonetheless, results from the junior high samples have consistently supported a positive correlation between "intrinsic value" (a hybrid scale combining task value and intrinsic orientation) and reported cognitive strategy use. In one study (Pintrich & De Groot, 1990a), this correlation was moderately high (r = .73). In another study, Pintrich and De Groot (1990b) reported that across the domains of English, science, and social studies, individuals who possessed learning goals in one domain also tended to report learning goals in the other two domains and reported greater use of cognitive and self-regulatory strategies in all three domains. Pintrich and De Groot (1988) also found that when cognitive and metacognitive strategy variables were included as predictors of academic performance, they moderated the effect of learning goal orientation. This suggests that learning goal orientation indirectly affects classroom achievement through its direct effect on cognitive strategy use and self-regulation (Pintrich & Schrauben, 1992).

The robustness of Pintrich's findings across college and junior high school samples suggests that such findings would probably be observed in high school samples as well, but few studies (see, for example, Pokay & Blumenfeld, 1990) have investigated this directly. Furthermore, some of the conceptual distinctions in this research have not been supported empirically. For example, Pintrich and De Groot (1990a) reported that the factor analyses of the scales designed to measure metacognitive and effort management strategies did not support the construction of separate scales. This indicates that there is room for further construct refinement and additional construct validational research. Finally, although Pintrich's research program uses actual classroom data, it relies heavily on self-report data; the results have not been replicated using other measures, such as think-aloud protocols, stimulated recall procedures, structured interviews, or behavioral measures (Pintrich & De Groot, 1988). It may be difficult for students to report their use of cognitive and self-regulatory strategies accurately for an entire course, or even the extent to which they use particular strategies for a given task (Brown, 1988; Brown et al., 1983; Nisbett & Wilson, 1977). It would be much better to include other measures of strategy use to give an indication of the degree to which students actually use the strategies they report using.

Nolen (1988) reports on one of the few studies using this approach. Nolen (1988) recorded students' use of learning strategies by direct observation and by self-report and found both methods to be highly correlated. This study explored how eighth-grade students' goal orientations influence their valuing and use of deep- versus surface-level study strategies. The students were assessed by self-report on three goal orientations: (a) learning goal orientation (task orientation), (b) performance goal orientation (ego orientation) and (c) work-avoidant goal orientation. Two classes of study strategies were distinguished based on the work of Entwistle and Ramsden (1983): (a) deep processing strategies, including discriminating important from less important information, incorporating new knowledge with existing knowledge, and monitoring one's comprehension; and (b) surface-level strategies such as re-reading a passage, rehearsal, and memorization. Students were administered self-report measures of goal orientation, strategy value, and perceived ability. After four to six weeks, students met in small groups and were asked to study "an interesting article from a popular science magazine" until they felt they could explain the article to someone else in their own words. The experimenter recorded students' overt behaviors while studying. After students studied the articles, they completed measures of task-specific strategy use, task-specific strategy value, and task-specific motivational state questionnaires, and free and cued recall of the passages.

One important hypothesis in Nolen's study was that students' motivational orientation would influence both their knowledge and use of strategies when engaged in studying science text. This was supported. Students who regarded learning as an end in itself both valued and used deep processing strategies more than students who aimed to demonstrate their performance to others. In addition, the strategies students reported using were more closely related to their learning orientation rather than to their knowledge of the relative value of deep and surface processing strategies. Unfortunately, Nolen was unable to demonstrate strong relationships between the use of these deeper strategies and better knowledge and understanding of the text at recall. Recall performance was low for almost all students, presumably because the text was too difficult, or the participants did not believe their recall would be tested. Furthermore, Nolen (1988) did not include any verbal ability measures, so it is unknown whether this source of variance might have carried the weak relationship found between strategy use and recall performance.

Meece, Blumenfeld, and Hoyle (1988) report a study that included a standardized achievement measure and explored relationships between students' goal orientations and their cognitive engagement in science learning. Fifth- and sixth-grade students from 10 classrooms (N = 275) completed a set of questionnaires assessing their goal orientations and their use of strategies while working on six different science activities. There are two points worth noting. First, small to moderate positive correlations were found between standardized achievement and perceived competence, intrinsic motivation, science attitudes, and superficial engagement. Small negative correlations were found between achievement and both performance and work-avoidant goal orientations. A learning or task mastery goal orientation did not correlate with achievement. This suggests that much of the variance in the goal orientation measures is not accounted for by achievement, at least in this population of younger students. Second, Meece et al. (1988) represented students' goal orientations at several levels of generality: (a) General orientation towards learning was measured by a scale of intrinsic motivation; (b) attitudes and goals related to science in general formed the next level; and (c) task mastery, ego/social, and work-avoidant goal orientations measured with regard to particular science classes formed the lowest level. The implication is that a student's goal orientation can exist at multiple levels. In their sample, Meece et al. (1988) found correlations around .50 for these different levels. Since some (e.g., Brown, 1988) have questioned measuring goal orientations at a general level, this dissertation research assesses goal orientations at the science class level and task level.

Reference Constructs

Research on general ability has consistently demonstrated positive relationships with learning and achievement outcomes (Snow & Yalow, 1982). Likewise, there is a substantial corpus of research linking individual differences in conation to learning and performance outcomes (Snow & Jackson, 1992). Unfortunately, the latter research tends to ignore or inadequately control for general ability, even though one might suspect that students' general ability might correlate with, for example, their use of deep versus surface learning strategies or their orientation towards learning versus pleasing the teacher.

In a similar vein, older and well-established conative constructs including achievement motivation and anxiety should be included in studies that aim to explore newer and more speculative conative constructs. For these reasons, this dissertation research includes standardized measures of ability, achievement motivation, and anxiety as reference constructs.

Summary of Literature Review

This literature review documents the need for research in the following areas.

Construct validational research. There is a great need for construct validational research in this area (a) to distill the broad array of constructs found in these reported studies, and (b) to identify those constructs that appear most promising. In particular, relationships between traditional ability and motivational constructs, on the one hand, and goal orientations and cognitive strategy use, on the other, have been inadequately explored.

Goal orientations in high school students. Most of the research exploring goal orientations has been conducted with elementary school students or college students. Study I of this research uses college students. Studies II and III use high school students. It is important to include high school students in the study of goal orientation given that motivational problems are associated frequently with this group.

Relation of goal orientation to performance differences. Few studies have examined how student differences in goal orientations lead to differences in performance, especially when students are engaged in actual tasks. Most research has emphasized correlations among self-report measures but has ignored other sources of data, such as direct observation and strategy measures, time on task, think-aloud protocols, and retrospective interviews.

Individual differences in conation. Others (Calfee & Curley, 1995) have lamented the absence of systematic investigations of the relation of individual differences in motivation to reading, writing, or oral literacy. Additionally, there have been few if any systematic investigations that study individual differences in motivation in relation to learning in science.

CHAPTER 3

STUDY I (PILOT STUDY)

Conative and cognitive aptitude measures were administered to California Polytechnic State University students. As mentioned earlier, the purpose of this pilot study was (a) to gain a familiarity with the instruments used to measure a selection of conative constructs; (b) to determine how long each measure would take to administer; (c) to provide data on the psychometric properties of each questionnaire; (d) to obtain a preliminary understanding of the interrelationships among the various measures; and (e) to determine which measures would be most appropriate for use in later studies.

Method

Sample

A total of 60 students from the California Polytechnic State University participated in the pilot study. The sample consisted of 31 males and 29 females, ranging in age from 20 to 25 years, with a median age of 22 years.

Measures

Table 1 lists the background variables and measures used in the questionnaire for the pilot study. These measures were the Approaches to Studying Inventory, Action Control Scale, Intellectual Achievement Responsibility Scale and the Mindfulness Scale. A description of the measures and the scale variables derived from each follows.

Approaches to Studying Inventory. This questionnaire is designed to measure several characteristic ways in which students approach learning situations. It has undergone numerous revisions since its introduction (Entwistle 1981, 1987a, 1987b; Entwistle & Ramsden, 1983; Marton & Säljö, 1976; Säljö, 1975). The most recent revision (Entwistle & Tait, 1992) contains a total of 60 five-choice Likert scale items measuring four approaches to learning: Deep (16 items), Surface (16 items), Strategic (16 items), and Apathetic (8 items). A brief scale measuring Academic Self-Confidence (4 items) was also included. This inventory was developed primarily for United Kingdom college students;

Table 1

List of Background and Questionnaire Variables for Study I

Description	Possible values	Items
1. Background variables		
ID for pilot study subjects	1-60	1
Gender	0,1	1
Age in years	20-25	1
2. Approaches to Studying Inventory; Entwistle (1992); 5-point Likert		
Deep Approach to Learning scale	16-80	16
Surface Approach to Learning scale	16-80	16
Strategic Approach to Learning scale	16-80	16
Apathetic Approach to Learning scale	8-40	8
Academic Self-Confidence scale	4-20	4
3. Action Control Scale; Kuhl et al. (1991); Forced choice		
Action Control-Performance subscale	0-20	20
Action Control-Decision subscale	0-20	20
Action Control-Failure subscale	0-12	20
4. Intellectual Achievement Responsibility Scale; Crandall et al. (1965); Forced choice		
Mastery score; Dweck & Henderson's (1989) scoring	0-10	10
5. Mindfulness; Salomon (1987); 5-point Likert + 3 points		
Mindfulness scale	32-163	32

therefore, some words in the items were replaced by their U.S. counterparts to make the items more appropriate for North American college students.

Action Control Scale. The Action Control Scale was used to assess Action vs. State Orientation following the research of Kuhl (1981, 1984, 1990; Kuhl & Beckman, 1985; Kuhl & Kraska, 1989). The three subscales included Performance-Related (20 items, $r_{xx'}$ = .52), Decision-Related (20 items, $r_{xx'}$ = .76) and Failure-Related Action Orientation (20 items, $r_{xx'}$ = .72), (Kanfer, Dugdale, & McDonald, 1985). Each item specifies a situation followed by an action-oriented and a state-oriented response, with scores for each scale computed as the number of action-oriented responses selected.

The Performance-Related scale has undergone serious revision since its inception. It was originally designed under the assumption that success-related thoughts were associated with an action orientation, but it was later revised when evidence was found that state orientation was characterized by persevering thoughts, which could be either positive or negative. The revised scale measures the ability to persist at self-initiated and pleasant activities without shifting prematurely to alternative activities. It is sometimes referred to as the Volatility scale and can be interpreted as measuring an "over-functioning" of the action initiation system. Kuhl reports that it is empirically orthogonal to the other two action control scales.

The Decision-Related scale measures difficulty in taking action once a decision has been made. It does not measure inability to terminate the decision process. Kuhl sometimes refers to this scale as the Hesitation scale.

The Failure Orientation scale contains items assessing preoccupation with negative experiences. Its label is somewhat misleading because only about half of the items are related to experiences of failure while the remainder describe unpleasant situations that do not involve achievement. The Failure Orientation scale thus measures preoccupation that is not confined to achievement settings. This scale stands in contrast to the worry component of evaluation anxiety, which is confined to achievement settings. The Failure Orientation scale is sometimes referred to as the Preoccupation scale.

Kuhl (1984) and Kanfer et al. (1985) report moderate correlations between Action Orientation subscale scores and personality variables such as test anxiety, extraversion, self-consciousness, achievement motivation, future orientation, and cognitive complexity. These correlations reflect the theoretically expected overlap but also indicate that a sizable proportion of variance in Action-Orientation scores cannot be accounted for by these variables.

Intellectual Achievement Responsibility Scale: Mastery versus Performance Orientation. Dweck has explored several methods for determining whether students hold a Mastery vs. Performance Orientation, including use of a questionnaire method and application of several single-item procedures (Dweck & Henderson, 1989). The questionnaire method was explored in this study and involves using the Intellectual Achievement Responsibility Scale (IAR; Crandall, Katkovsky, & Crandall, 1965). The IAR is a 34-item attributional scale designed for primary school children and was chosen because past research (Dweck, 1975) has shown that the major difference between the mastery and performance orientations was in the respective tendency to neglect or to emphasize the role of effort in determining failure. Mastery-Oriented students regard effort as the major cause of failure and increase their effort when faced with task difficulty or failure. Performance-Oriented students, on the other hand, regard failure as a consequence of inadequate ability and view additional effort as unhelpful. Dweck administers the entire IAR but uses a subset of 10 items to determine mastery vs. performance orientation. These 10 items describe positive and negative achievement outcomes and list two choices. One choice indicates that the outcome was caused by the child's effort, and the other choice indicates that the outcome was the result of someone or something in the environment. Scores of 7 or less indicate attributions to the environment and a Performance Orientation. Scores of 8 or more indicate attributions to the child and a Mastery Orientation. This was the method used to measure Mastery vs. Performance Orientation in this study, except that instead of Dweck's dichotomous score, a continuous score (out of 10) was used as a measure of Mastery Orientation.

Mindfulness scale. Mindfulness was assessed by the Amount of Mental Effort Invested (AIME) questionnaire from Salomon's (1981) work. This self-report measure consists of 33 statements describing the application of mindful effort in various situations. Respondents are directed to indicate their agreement or disagreement with each statement on a 5-point Likert scale.

In summary, test booklets were created to contain the questionnaires described above. Table 1 lists the questionnaires in the same order as they appeared in the test booklets.

Procedure for Study I (Pilot Study)

Data collection. During speech communication classes, participants were administered the above measures by questionnaire in booklet form. Classes were approximately 90 minutes long, and questionnaires were completed within that time frame. Participants turned in their questionnaires at the end of the class period and received a debriefing form (see Appendix A). The speech communication classes at California Polytechnic State University are required for students majoring in all academic fields, so they are representative of this population of students.

Results

Descriptive Statistics

Frequency histograms for each variable were plotted and found to be normally distributed, with no floor or ceiling effects. Means, standard deviations, reliabilities, and correlations among all aptitude variables are presented in Table 2.

Reliability Analyses

Cronbach alpha reliabilities listed in parentheses in the diagonal in Table 2 ranged from .54 to .85; most were above .70. The exceptions were the 8-item Academic Self-Confidence scale ($r_{xx'}$ = .68), the 20-item Action Orientation-Decision scale ($r_{xx'}$ = .66) and the Mastery Orientation scale ($r_{xx'}$ = .54). Item analyses were conducted on the Mastery scale to help understand the low reliability. These analyses revealed that one of the items correlated negatively (-.18) with the remaining items as keyed using Dweck's scoring key. This item was "Suppose a person doesn't think you are very bright or clever. (a) Can you make him change his mind if you try to, or (b) Are there some people who will think you're not very bright no matter what you do?" In these data, the effort attribution associated with changing a person's unfavorable opinion of one's skills is different from other items measuring mastery orientation. Mastery orientation is conceived of as an adaptive response, and choosing option (b) is probably more adaptive, even though it does not involve an effort attribution. With this item removed, the reliability increased from .54 to .65. To be consistent with Dweck (1975), the data reported in Table 2 include this item in the scale.

Correlational Analyses

The correlations below the diagonal in Table 2 were corrected for attenuation caused by unreliability in the measures and are discussed in the following paragraphs. Those correlations above the diagonal are uncorrected. Table 2 shows a number of significant correlations in this set of conative variables, particularly when the Approaches to Learning Inventory is involved. For example, taking a Deep Approach to learning by actively interacting with learning material, looking for meaning, and relating it to one's own life is highly correlated (r_{adj} = .72) with a Strategic Approach to studying (intention to excel, alertness to assessment demands, study organization, and time management). A

Table 2

Cronbach Alpha Reliabilities and Corrected Correlations Among the Measures From Study I (N = 57)

	Measure	Mean	*SD*	DEEP	SURF	STRAT	APATH	CONFID	ACP	ACF	ACD	MAST	MINDF
DEEP	Deep Approach.	63.53	8.83	(.85)	-.38	.56	-.25	.21	.10	-.22	-.28	-.04	.65
SURF	Surface Approach	44.58	9.92	-.46	(.78)	-.40	.46	-.46	-.32	.57	.37	.07	-.30
STRAT	Strategic Approach	58.77	8.93	.72	-.53	(.73)	-.57	.34	-.07	-.24	-.45	.09	.47
APATH	Apathetic Approach	18.06	5.42	-.31	.59	-.74	(.81)	-.29	-.04	.29	.29	-.14	-.21
CONFID	Academic Self-Confid.	16.02	2.73	.28	-.63	.48	-.40	(.68)	.04	-.30	-.21	.10	.18
ACP	Action Control-Perform.	11.38	3.53	.12	-.42	-.10	-.06	.05	(.71)	-.34	-.25	.05	.12
ACF	Action Control-Failure	10.32	4.07	-.27	.74	-.32	.37	-.41	-.45	(.77)	.55	.05	-.10
ACD	Action Control-Decision	10.77	3.47	-.37	.51	-.65	.39	-.31	-.36	.77	(.66)	-.10	-.24
MAST	Mastery Orientation	7.65	1.78	-.06	.11	.15	-.21	.16	.08	.08	-.17	(.54)	.10
MINDF	Mindfulness	108.98	11.95	.82	-.40	.65	-.27	.26	.16	-.13	-.35	.15	(.73)

Note. Decimals omitted for correlations. All correlations have been corrected for unreliability. Cronbach alpha reliabilities appear in parentheses in the diagonal. Three cases were omitted due to missing data. r_{05} approximately = .25 (for N = 57).

Deep Approach is also highly correlated (r_{adj} = .82) with Salomon's (1987) Mindfulness Construct. Surface Approach (intention to reproduce, passive learning, unrelated memorizing, and fear of failure) was highly negatively correlated with Action Control-Failure (preoccupation with negative experiences), and moderately negatively correlated with Deep Approach, Strategic Approach, Academic Self-Confidence, Mindfulness, and Action Control-Decision.

The Action Control scales intercorrelated as expected. Action Control-Performance was negatively correlated with both Action Control-Decision and Action Control-Failure. Action Control-Failure, which measures preoccupation with negative experiences, correlated negatively with a Surface Approach to Learning (r_{adj} = .74). Mastery Orientation did not correlate significantly with any other measures.

Discussion

Psychometric Properties of the Measures

Most of the questionnaires in this study displayed adequate reliability. The Approaches to Studying Inventory seemed particularly well refined and demonstrated moderate to high reliabilities despite a small number of items per scale. The Action Control scales also showed moderate to high reliabilities, but these scales could benefit from further refinements (e.g., another round of item analyses for the Decision-Related Action Orientation scale). The Mindfulness scale was reliable, but a preliminary examination of the item-level data indicated that some items had low loadings, and one item seemed to be correlated negatively with the others, yet was scored correctly. The Mindfulness scale would benefit from further revision. The Mastery scale showed the lowest reliability, with one item correlating -.20 with the remaining items. Given its low reliability and lack of correlation with other variables, the Mastery scale was not used in Studies II and III.

Deep Approach vs. Mindfulness

Perhaps the most striking finding was the high correlation between Deep Approach and Mindfulness. A comparison of the items from the Deep Approach measure and the Mindfulness items reveals that both scales contain items that involve an enjoyment of careful thought and a preference for deliberation and complexity. Despite these similarities, there were some notable differences between the Deep Approach and Mindfulness measures. All of the items measuring a Deep Approach are concerned with school-related learning and activities, whereas items from the Mindfulness scale tend to be much broader, with no direct reference to school learning, except for using the word "assignment" in the general sense in one item. Some of the items could refer to school-relevant situations, but direct references to this domain do not appear in the Mindfulness scale as they do in the Deep Approach measure. A second difference is that all of the Deep Approach items are positively keyed, but the Mindfulness scale contains both positively and negatively keyed items. Furthermore, the latter scale contains several items measuring frequency of behavior and a few open-ended questions about the questionnaire itself. This results in a different and more complicated response format for the Mindfulness scale. Third, the Mindfulness scale contains items tapping domains beyond those in the Deep Approach scale. For example, some of the negatively keyed items refer to Impulsivity (e.g., "I find myself doing things quite impulsively"). Others reflect a disdain for effortful thinking (e.g., "Thinking is not my idea of fun"), and still others seem associated with reflectivity (e.g., "Once I finish an assignment, I move on; I rarely go back and look over it again"). Given these differences between Mindfulness and Deep Approach, the high correlation that was obtained is striking; the two questionnaires appear to be measuring largely the same construct.

Based upon the findings from this study, most measures from Study I were employed in the construct validational study (Study II), which is described next.

CHAPTER 4

STUDY II (CONSTRUCT VALIDATION STUDY)

The purpose of Study II was to investigate the construct validity of a broad range of conative constructs. These measures and the identified constructs were selected because of their reported empirical and theoretical importance in recent research. Specifically, there were two goals: (a) to determine the relationships among a wide variety of conative constructs in a large sample of high school students and (b) to explore the theoretical and practical distinctions among the conative constructs (some of which were measured by questionnaires used in the pilot study). The central hypothesis in Study II was that some of the constructs overlap substantially and can be merged to yield a new set of distinctions

Method

Sample

A total of 234 students from four Ontario (Canada) high schools participated in Study II. Participants were volunteers; that is, they had the right to decline to participate in this school-sanctioned activity. Table 3 presents the demographic data for this sample.

The sample was comprised of 108 males and 125 females. One person failed to indicate his or her gender. The range in age was 15 to 19 years with a mean age of 16.2. Most students were in Grade 10 (56%) and Grade 11 (32%). The ethnic composition of these students was Asian (3), Black (0), Canadian Indian (7), Hispanic (1), Other (12), and White (208). The student body in this sample was predominantly White (88%) and is representative of southwestern Ontario's population of 15- to 19-year-olds. For the majority of students (93%), the first language spoken was English. About 68% of these students planned to go on to a technical school, community college, or university after graduation from high school. Only 5% planned no post high school education, but a sizable percentage of students (25%) were as yet undecided about their plans after high school.

Table 3

Demographics for the Study II Sample (N = 234)

Variable	Levels	Frequency	Variable	Levels	Frequency
Gender			Ethnicity		
	Missing	1		Missing	3
	Male	108		Canadian Indian	7
	Female	125		White	208
				Black	0
Age				Asian	3
	Missing	1		Hispanic	1
	15	59		Other	12
	16	105			
	17	35	First language learned[a]		
	18	25		Missing	5
	≥ 19	9		English	218
				French	1
Grade				French and English	10
	Missing	6		Other	0
	10	131			
	11	75	College plans[b]		
	12	22		Missing	5
				University	77
				Community college	82
				None planned	11
				Undecided	59

[a]Students were asked “What language(s) did you learn when you first began to talk?”

[b]Students were asked “After you graduate from high school, which of the following do you plan to do? (1) Go to university; (2) Go to a technical school or community college; (3) I don’t plan to take any further schooling after high school; (4) Undecided.”

Background Variables

Table 4 lists the background variables used in Study II. The background variables (which include the demographic variables) were school, sex, age, grade, ethnicity, first language learned, educational plans after graduation from high school, total number of science classes taken in high school, self-reported grade in most recent science class, self-reported grade in all science classes taken in high school, and self-reported grade across all classes.

Table 4
List of Background Variables for Study II

Description	Possible values
School number	0-4
Gender	0,1
Age in years	13-19
Grade in high school	9-12
Race (1=First Nation/Canadian Indian; 2=White; 3=Black; 4=Asian; 5=Hispanic; 6=Other)	1-6
Language first learned (1=English; 2=French; 3=Other; 4= Bilingual (English/French)	1-4
Language first learned (if Other selected for LANG1; 1=Vietnamese; 2=German; 3=English & Italian; 4=English & German; 5=Croatian)	1-5
Whether planning to attend university (1=University; 2=Technical school/community college; 3=No further schooling planned; 4=Undecided)	1-4
Total number of science classes taken in high school (NUMSCI)	0-10
Self-reported grade in most recent science class (GRDSCI)	0-100
Self-reported average grade in all science classes taken in high school (AVGSCI)	0-100
Self-reported average grade across all classes (AVGGRD)	0-100

Questionnaire Measures

Table 5 is the list of questionnaire variables from Study II. The following section describes the questionnaires used to measure each of the variables.

Ability measures. The Information (40 items) and Vocabulary (46 items) subscales from the Multidimensional Aptitude Battery (MAB; Jackson, 1984a) were included as reference measures. Verbal ability is a well-established construct, so verbal ability measures were included in Study II to evaluate their relationship with the conative constructs. The MAB manual reports Cronbach alpha reliabilities of .86 and .80 respectively for these subscales. The MAB is a group-administerable paper-and-pencil measure of general ability yielding scores for 10 subscales, as well as verbal, performance, and full scale scores. Full scale standard scores correlate .91 with the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) intelligence quotients (Jackson, 1984a).

Table 5

List of Questionnaire Variables for Study II

Description	Possible values	Items
1. Multidimensional Aptitude Battery; Jackson (1984); Multiple choice		
Information subtest	0-34	34
Vocabulary subtest	0-46	46
2. Six-Factor Personality Questionnaire; Jackson et al. (1996); 5-point Likert		
Industriousness scale	18-90	18
3. Approaches to Studying Inventory; Entwistle and Tait (1992); 5-point Likert		
Deep Approach to Learning scale	16-80	16
Surface Approach to Learning scale	16-80	16
Strategic Approach to Learning scale	16-80	16
Apathetic Approach to Learning scale	8-40	8
Academic Self-Confidence scale	4-20	4
4. Science Activity Questionnaire; Meece et al. (1988); 4-point Likert		
Learning (Task) Orientation for Science	9-36	9
Performance (Ego) Orientation for Science	3-12	3
Work Avoidant Orientation for Science	3-12	3
5. Motivated Strategies for Learning; Pintrich et al. (1991); 7-point Likert		
Intrinsic Goal Orientation	4-28	4
Extrinsic Goal Orientation	4-28	4
Test Anxiety	5-35	5
6. Science Interest Questionnaire; Mitchell (1993); 7-point Likert		
Personal Interest in Science	4-28	4
Situational Interest (in this year's science class)	6-42	6
Meaningfulness (in this year's science class)	4-28	4
Involvement (in this year's science class)	6-42	6
The total Interest score for this year's science class (sum of Situational Interest, Meaningfulness, and Involvement above)	16-112	16
7. Action Control Scale; Kuhl et al. (1991); Forced choice		
Action Control-Decision subscale	0-12	12
Action Control-Failure subscale	0-12	12
8. Section 9-10 in the assessment booklet are supplemental questionnaires administered to a subset (N = 118) of the Study II sample for exploratory purposes; 7-point Likert		
Grade Seeking Strategies	6-42	6
Total Help Seeking score	10-70	10
Rehearsal Strategies (MSLQ)	4-28	4
Elaboration Strategies (MSLQ)	6-42	6
Organization Strategies (MSLQ)	5-35	5
Critical Thinking	5-35	5
Metacognitive Self-Regulation (MSLQ)	12-84	12
Regulating Time and Study Environment (MSLQ)	8-56	8
9. Motivated Strategies for Learning; Pintrich et al. (1991); 7-point Likert		
Perceived Control Over Outcome in Science Class	4-28	4
Science Learning Self-Efficacy	8-56	8
Computerized Science Task Self-Efficacy	3-21	3

Achievement motivation. Achievement motivation was measured by the Industriousness scale from the Six Factor Personality Questionnaire (6FPQ; Jackson, Paunonen, Fraboni, & Goffin, 1996), a new, 6-factor, Likert-format measure of personality derived from the Personality Research Form (PRF; Jackson, 1984b). The Industriousness scale measures three aspects of Achievement Motivation, comprising subscales of Achievement (6 items, $r_{xx'}$ = .75), Endurance (6 items, $r_{xx'}$ = .66), and Play (6 items, $r_{xx'}$ = .74), with Play defining the opposing end to that defined by the Achievement and Endurance scales. Industriousness measures persistence in working hard, often at the expense of fun or recreation. It is closely related to the concepts of Protestant work ethic (Weber, 1904/1958) and Learned Industriousness (Eisenberger, 1992).

Approaches to Learning and Studying (deep, surface, strategic, and apathetic approaches; academic self-confidence). These measures were adapted from the Approaches to Studying Inventory (Entwistle & Tait, 1992). The most recent revision contains a total of 60 five-choice Likert scale items measuring four approaches to learning—deep (16 items), surface (16 items), strategic (16 items), and apathetic (8 items)—and a brief scale measuring academic self-confidence (4 items). Reliabilities for these scales from the pilot study were as follows: Deep ($r_{xx'}$ = .85), Surface ($r_{xx'}$ = .78), Strategic ($r_{xx'}$ = .73), Apathetic ($r_{xx'}$ = .81), and Academic Self-Confidence ($r_{xx'}$ = .68).

Goal orientations. Three goal orientation constructs came from the Science Activity Questionnaire (SAQ; Meece et al., 1988): (a) Learning (Task) Orientation for Science, (b) Performance (Ego) Orientation for Science, and (c) Work Avoidant Orientation for Science. Two goal orientation constructs came from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991): (a) Intrinsic Goal Orientation and (b) Extrinsic Goal Orientation.

The Science Activity Questionnaire was designed to capture the goal orientation distinction described as Task Involved vs. Ego Involved (Maehr & Nicholls, 1980; Nicholls et al., 1985) and Mastery Focused vs. Ability Focused (Ames, 1984; Ames & Ames, 1984). The Task Orientation, Ego Orientation and Work Avoidant Orientation scales used in Study II were adapted from Meece et al. (1988). Items on these scales were in turn adapted from Ames (1984) and Nicholls et al. (1985). Meece et al. (1988) report alpha reliabilities of .94 for Task Mastery (9 items), .85 for Ego/Social Orientation (3 items), and .77 for Work

Avoidant Orientation (3 items). Nicholls et al. (1985) used a 7-point Likert format in their measure, but Meece et al. (1988) used a 4-point Likert format. For this research, the 4-point Likert format was used to be consistent with Meece et al. (1988).

Test anxiety. Two measures of anxiety were selected. A 4-item scale measuring Test Anxiety ($r_{xx'} = .75$) was selected from the Motivated Strategies for Learning Questionnaire (MSLQ) of Pintrich et al. (1991). Items on this scale emphasized worry as opposed to emotionality. A second scale measuring Test Anxiety is the Fear of Failure scale administered as part of the Approaches to Studying Inventory (Entwistle & Tait, 1992).

Science interest. Development of the interest measure was guided by Mitchell's (1993) theoretical model of interest in secondary school mathematics. Items and scales for the mathematics domain were refined by Mitchell using structural equation modeling. The interest measure consists of 38 items from the following seven scales: Personal Interest (long-standing, stable, individual interest, 4 items, $r_{xx'} = .92$), Situational Interest (6 items, $r_{xx'} = .90$), Meaningfulness (4 items, $r_{xx'} = .77$), Involvement (6 items, $r_{xx'} = .86$), Group Work (6 items, $r_{xx'} = .93$), Puzzles (6 items, $r_{xx'} = .88$), and Computers (6 items, $r_{xx'} = .92$). All reliabilities presented here are from Mitchell (1993). The Personal Interest, Situational Interest, Meaningfulness and Involvement scales were used in this research, but adapted to apply to the science domain.

Action orientation. The Decision-Related and Failure-Related subscales from the Action Control Scale were used to assess action vs. state orientation following the research of Kuhl (1981, 1984, 1990; Kuhl & Beckman, 1985; Kuhl & Kraska, 1989). The Performance-Related scale is orthogonal to the Decision- and Failure-Related scales and was not included because of its questionable psychometric properties identified by Kanfer et al. (1985). The Decision-Related scale measures difficulty in taking action once a decision has been made. It does not measure the inability to terminate the decision process. Kuhl sometimes refers to this scale as the Hesitation scale.

The Failure-Related (20 items, $r_{xx'} = .72$) and Decision-Related (20 items, $r_{xx'} = .76$) Action Control scales correlate .49 (Kanfer et al., 1985). Each item specifies a situation followed by an action-oriented and a state-oriented response, with scores for each scale computed as the number of state-oriented responses selected.

Shorter 12-item versions of these scales were used in Studies II and III because of the researcher's concern for time constraints.

The Failure Orientation scale contains items assessing preoccupation with negative experiences. Its label is somewhat misleading because only about half of the items are related to experiences of failure while the remainder describe unpleasant situations that do not involve achievement. The Failure Orientation scale measures preoccupation that is not confined to achievement settings. It stands in contrast to the worry component of evaluation anxiety, which is confined to achievement settings. Action Control-Failure is sometimes referred to as the Preoccupation scale.

Science learning control beliefs. The measure of Science Learning Control Beliefs was adapted from the Control Beliefs subscale of Pintrich et al.'s (1991) MSLQ. The scale consists of five items that emphasize students' use of effort to control their performance versus having their performance controlled by the instructor, or by teaching and grading practices.

Science learning self-efficacy. The measure of Science Self-Efficacy was constructed for this study using the same format as similar scales from Zimmerman, Bandura, and Martinez-Pons (1992) and items from Pintrich et al. (1991). Students were asked to rate their perceived capability to learn science on a 7-point Likert scale.

Science task self-efficacy. Similarly, a 3-item measure of Science Task Self-Efficacy was constructed by describing the science task and asking students to rate how well they would learn and understand the computer-presented science text.

Supplemental Questionnaires: Cognitive and Metacognitive Strategies

The measures of cognitive and metacognitive strategies that were administered to a subset of the Study II participants came from Pintrich et al.'s (1991) Motivated Strategies for Learning Questionnaire. Each of these measures consists of between four and twelve 7-point Likert items. They were administered to a subset of the Study II participants for exploratory purposes only. No hypotheses were made linking these measures to particular constructs. Each measure is described in detail below.

Rehearsal strategies. Rehearsal strategies involve reciting or repeating a list of items to be learned. These strategies are effective for short-term storage and information acquisition because they influence the attention and encoding processes. They are less well suited for constructing internal connections in long-term memory or for integrating new information with existing knowledge (Pintrich et al., 1991). The Rehearsal scale from the Motivated Strategies for Learning Questionnaire (4 items; $r_{xx'} = .69$) was used as a measure of rehearsal strategies.

Elaboration strategies. Unlike rehearsal strategies, elaboration strategies are useful for storing information in long-term memory. This occurs by building internal associations among the items to be learned. Examples of elaboration strategies are paraphrasing, summarizing, creating analogies, and integrating different sources of information. The Elaboration scale (6 items; $r_{xx'} = .76$) was used as a measure of elaboration strategies.

Organization strategies. Organization strategies are closely related to elaboration strategies, and they also help students to build connections among the items to be learned. Examples of organization strategies from the MSLQ Organization scale (4 items, $r_{xx'} = .64$) include outlining, clustering, and selecting main ideas from a reading passage.

Critical thinking strategies. Critical thinking involves applying previous knowledge to new situations in order to solve problems, to make decisions, or to evaluate alternatives. Items from the Critical Thinking scale of the MSLQ (5 items; $r_{xx'} = .80$) emphasize evaluating the strength of supporting evidence, looking for alternative explanations, and being skeptical of conclusions.

Metacognitive self-regulation. The Metacognitive Self-Regulation scale of the MSLQ (12 items; $r_{xx'} = .79$) emphasizes planning, monitoring and regulating activities. Planning activities include goal setting and reviewing material to activate or to prime prior knowledge in order to facilitate organization and comprehension of information. Examples of monitoring activities include self-testing, asking questions and evaluating one's attention while reading. Regulating activities are used to check and to modify cognitive activities as a student proceeds with a task.

Supplemental Questionnaires: Resource Management Strategies

Additional supplemental questionnaires measuring resource management strategies were administered to the same subset of the Study II participants. Three of these questionnaires come from the MSLQ: (a) Regulating Time and Study Environment, (b) Effort Regulation, and (c) Help Seeking Strategies. The remaining two exploratory questionnaires constructed for this study are Willingness to Seek Help and Grade Seeking Strategies.

Regulating time and study environment. This set of questions (8 items; $r_{xx'} = .76$) was designed to measure how effectively students scheduled, planned and managed their study time and whether they had a regular place where they could concentrate on studying.

Effort regulation. Effort regulation is important to controlling attention in the face of distractions, uninteresting work, and competing tasks. Students who are able to self-manage effort and to achieve goals despite difficulties will have more time to spend using other learning strategies that contribute to their academic success. The Effort Regulation scale from the MSLQ (4 items; $r_{xx'} = .69$) contains items measuring persistence in overcoming obstacles to studying.

Help seeking strategies. The support of peers and instructors is an aspect of the environment that some students use to learn material and to facilitate achievement. The Help Seeking Strategies scale from the MSLQ (4 items; $r_{xx'} = .52$) was used to measure the degree to which students will ask for help. Help seeking is interesting because it reflects a desire and commitment to learn, but it also indicates that one is not able to learn the material alone. The former—that is, wanting to learn—would be expected to correlate with achievement, but the latter—admitting insufficient ability—would not. In fact, Pintrich et al. (1991) reported that 3 of the 4 items on this scale show nonsignificant (slightly negative) correlations with grades. To overcome the low reliability of the Pintrich et al. (1991) scale, 6 additional items were written to measure a student's willingness to seek help from a teacher or other students. The new Help Seeking scale contained a total of 10 items.

Grade seeking strategies. A new, 6-item scale of Grade Seeking Strategies was constructed by writing items designed to measure strategies that maximize a student's grades. Examples of these strategies include budgeting time to complete all questions on a test, seldom leaving test questions blank, and making assignments appear neat and well organized. This scale was constructed for purely exploratory reasons, and it was expected to overlap somewhat with the Strategic Approach scale from the Approaches to Studying Inventory.

Two booklets were constructed for each student. The first booklet contained the timed verbal ability measures. The second booklet contained the remaining primary and supplemental questionnaires described above.

Procedure

Data collection. Participants were administered the questionnaire booklets during class time. Classes were approximately 70 minutes long. The ability measures were administered using standardized instructions and the standard 7-minute time limits for each of the two subtests. When the time had expired, the booklets for the ability measures were collected and new booklets containing the other measures were distributed. The total time required for the entire assessment was one hour. A debriefing statement was used for students following the assessment (see Appendix B). All students were required to stay for the duration of the study. Students who finished early were instructed to spend the remainder of their time answering some open-ended questions about their attitudes towards school and science. The administration guide is presented in Appendix C.

Data analyses. Frequency histograms were generated for each variable so that the distributions of the variables could be examined graphically. Means, standard deviations, and Cronbach alpha reliabilities were also computed for each measure. Next, the intercorrelations of the task measures were computed, and a table of intercorrelations across all measures was prepared. Scatterplots of pairs of measures were prepared to show correlations and detect outliers. A principal components analysis of the intercorrelations among the measures was computed.

Results and Discussion

Descriptive Statistics

Frequency histograms for all continuous variables showed no substantial deviations from normality. Means, standard deviations, the 95% confidence interval for the means, reliabilities, and the number of items per scale appear in Table 6. For the grade variables, final grades can range from 0 to 100; 80 and over is considered an A, 70 to 79 is a B, and 60 to 69 is a C. The 95% confidence

Table 6

Means, Standard Deviations, Confidence Intervals, Reliabilities and Number of Items for Study II

Variable	Measure	Mean	*SD*	-95% Conf.	+95% Conf.	Alpha	# Items
SFPQ	Industriousness	48.50	8.34	47.40	49.60	.77	18
SCIMAST	Mastery Orientation	24.78	6.64	23.91	25.65	.91	9
SCIPERF	Performance Orientation	8.03	2.43	7.71	8.35	.75	3
SCIWORK	Work Avoidance Orientation	8.13	2.30	7.83	8.43	.69	3
INTTOT	Interest in Science Class	64.50	21.76	61.63	67.37	.92	16
INTPERS	Personal Interest in Science	15.85	7.33	14.89	16.82	.75	4
DEEP	Deep Approach	54.18	9.83	52.90	55.47	.83	16
SURFACE	Surface Approach	48.96	9.64	47.71	50.22	.76	16
STRATEG	Strategic Approach	54.02	10.54	52.65	55.40	.82	16
APATHET	Apathetic Approach	22.28	7.65	21.28	23.27	.84	8
CONFID	Academic Self-Confidence	14.53	3.55	14.07	15.00	.79	4
INTGOAL	Intrinsic Goal Orientation	17.74	5.49	17.02	18.45	.72	4
EXTGOAL	Extrinsic Goal Orientation	18.33	6.08	17.54	19.12	.74	4
ANX	Test Anxiety	21.90	7.30	20.95	22.85	.74	5
ACS_DEC	Action Control-Decision	5.75	2.83	5.37	6.13	.71	12
ACS_FAIL	Action Control-Failure	5.93	2.70	5.57	6.29	.67	12
SCICONT	Sci. Perceived Control	20.48	4.60	19.85	21.10	.66	4
SCISELFE	Sci. Self-Efficacy	36.43	11.29	34.85	38.01	.92	8
TSKSELFE	Task Self-Efficacy	14.46	4.19	13.88	15.04	.86	3
GRDSCI	Grade in Science	70.81	11.82	69.28	72.34	NA	1
AVGSCI	Avg. Grade in Science	70.58	9.58	69.33	71.83	NA	1
AVGGRD	Overall Avg. Grade	72.62	8.84	71.46	73.78	NA	1
MABVOC	MAB Vocabulary	14.97	4.93	14.33	15.60	.72	46
MABINFO	MAB Information	17.58	5.75	16.83	18.32	.82	34

intervals around the means were presented so that mean scores from the measures in Study II could be compared with those to be obtained in Study III.

Reliability Analyses

Cronbach alpha reliabilities are presented in Table 6. The reliabilities ranged from .67 (Action Control-Failure) to .92 (Science Interest). The lower reliabilities observed with the Action Control measures (.71 and .67) probably resulted from shortening the scales from 20 to 12 items each due to time constraints. Reliabilities for Deep, Surface, Strategic, and Apathetic Approaches to Learning were consistent with those observed in the pilot study. In sum, most of the conative measures included here showed internal consistency reliability.

Correlational Analyses

The correlations were adjusted for attenuation due to unreliability in the measures because it was the relationships among the true scores of the constructs that were of interest. Correlations for the conative, ability, and grade variables are presented in Table 7. Corrected correlations appear below the diagonal and uncorrected correlations appear above the diagonal. A single item was used to measure each self-reported grade variable, so reliabilities could not be calculated. Corrected correlations involving grades were thus corrected only for attenuation in the non-grade variable.

It is clear from the correlation matrix presented in Table 7 that the majority of correlations are moderately high and significant. In fact, among the conative variables, the means of the absolute values of the corrected correlations and uncorrected correlations are .45 and .34 respectively. Across all the correlations in Table 7, the means of the absolute values of corrected and uncorrected correlations are .36 and .29, respectively. Of the 210 uncorrected correlations, only 46 were nonsignificant, and of these, 36 were concentrated in the two MAB ability variables and the Action Control-Failure variable.

Ability correlations. As expected, the MAB Vocabulary and Information subtests were highly intercorrelated. Both subtests measure verbal ability and both showed a similar pattern of correlations with the other variables. Corrected correlations with self-reported grades ranged from .19 to .36, indicating that students with high ability scores reported higher grades in their science class and in other classes.

Table 7

Cronbach Alpha Reliabilities and Corrected Correlations Among the Measures From Study II (N = 234)

Variable	Description	SFPQ	SCIMAST	SCIPERF	SCIWORK	INTTOT	INTPERS	DEEP	SURFACE	STRATEG	APATHET	CONFID	INTGOAL
SFPQ	Industriousness	(.77)	.50	.29	-.47	.31	.22	.49	-.22	.53	-.46	.31	.48
SCIMAST	Mastery Orient.	.60	(.91)	.57	-.53	.66	.54	.67	-.24	.60	-.68	.40	.70
SCIPERF	Performance Orient.	.38	.69	(.75)	-.20	.30	.31	.41	-.01	.46	-.33	.23	.43
SCIWORK	Work Avoidance	-.64	-.67	-.28	(.69)	-.54	-.32	-.44	.40	-.43	.63	-.26	-.38
INTTOT	Interest in Sci. Class	.37	.72	.36	-.68	(.92)	.50	.48	-.29	.39	-.58	.36	.46
INTPERS	Personal Interest	.29	.65	.41	-.44	.60	(.75)	.33	-.23	.26	-.47	.23	.39
DEEP	Deep Approach	.61	.77	.52	-.58	.55	.42	(.83)	-.25	.69	-.50	.46	.62
SURFACE	Surface Approach	-.29	-.29	-.01	.55	-.35	-.30	-.31	(.76)	-.23	.55	-.40	-.31
STRATEG	Strategic Approach	.67	.69	.59	-.57	.45	.33	.84	-.29	(.82)	-.55	.47	.57
APATHET	Apathetic Approach	-.57	-.78	-.42	.83	-.66	-.59	-.60	.69	-.66	(.84)	-.41	-.52
CONFID	Acad. Self-Conf.	.40	.47	.30	-.35	.42	.30	.57	-.52	.58	-.50	(.79)	.42
INTGOAL	Intr. Goal Orient.	.64	.86	.59	-.54	.57	.53	.80	-.42	.74	-.67	.56	(.72)
EXTGOAL	Extr. Goal Orient.	.36	.66	.90	-.27	.40	.47	.56	.11	.58	-.44	.20	.68
ANX	Test Anxiety	-.09	-.04	.19	.27	-.24	-.16	.06	.65	-.04	.18	-.27	-.04
ACS_DEC	Action Control-Dec.	-.58	-.39	-.16	.41	-.35	-.25	-.36	.59	-.59	.52	-.36	-.50
ACS_FAIL	Action Control-Fail.	-.21	-.05	.06	.18	-.11	-.03	.00	.49	-.09	.13	-.27	-.16
SCICONT	Sci. Perceived Control	.04	.46	.33	-.19	.44	.36	.46	-.14	.31	-.36	.32	.45
SCISELFE	Sci. Self-Efficacy	.43	.69	.48	-.55	.65	.57	.56	-.50	.56	-.66	.65	.72
TSKSELFE	Task Self-Efficacy	.31	.51	.37	-.35	.49	.47	.54	-.40	.46	-.48	.47	.62
GRDSCI	Grade in Science	.38	.49	.42	-.42	.43	.39	.34	-.37	.45	-.50	.60	.42
AVGSCI	Avg. Grade in Sci.	.35	.41	.36	-.33	.30	.43	.30	-.46	.40	-.47	.51	.34
AVGGRD	Overall Avg. Grade	.39	.27	.31	-.29	.20	.15	.22	-.24	.34	-.29	.46	.24
MABVOC	MAB Vocabulary	-.05	-.04	.08	-.03	-.01	.11	-.04	-.26	-.16	.01	.23	-.01
MABINFO	MAB Information	-.11	.10	.11	-.09	.10	.33	.02	-.28	-.12	-.06	.26	.09

Table 7 (continued)

Variable	Description	EXTGOAL	ANX	ACS_DEC	ACS_FAIL	SCICONT	SCISELFE	TSKSELFE	GRDSCI	AVGSCI	AVGGRD	MABVOC	MABINFO
SFPQ	Industriousness	.27	-.07	-.43	-.15	.03	.36	.25	.33	.31	.34	-.04	-.09
SCIMAST	Mastery Orient.	.54	-.03	-.31	-.04	.36	.63	.45	.47	.39	.26	-.03	.09
SCIPERF	Performance Orient.	.67	.14	-.12	.04	.23	.40	.30	.36	.31	.27	.06	.09
SCIWORK	Work Avoidance	-.19	.19	.29	.12	-.13	-.44	-.27	-.35	-.27	-.24	-.02	-.07
INTTOT	Interest in Sci. Class	.33	-.20	-.28	-.09	.34	.60	.44	.41	.29	.19	-.01	.09
INTPERS	Personal Interest	.35	-.12	-.18	-.02	.25	.47	.38	.34	.37	.13	.08	.26
DEEP	Deep Approach	.44	.05	-.28	.00	.34	.49	.46	.31	.27	.20	-.03	.02
SURFACE	Surface Approach	.08	.49	.43	.35	-.10	-.42	-.32	-.32	-.40	-.21	-.19	-.22
STRATEG	Strategic Approach	.45	-.03	-.45	-.07	.23	.49	.39	.41	.36	.31	-.12	-.10
APATHET	Apathetic Approach	-.35	.14	.40	.10	-.27	-.58	-.41	-.46	-.43	-.27	.01	-.05
CONFID	Acad. Self-Conf.	.15	-.21	-.27	-.20	.23	.55	.39	.53	.45	.41	.17	.21
INTGOAL	Intr. Goal Orient.	.50	-.03	-.36	-.11	.31	.59	.49	.36	.29	.20	-.01	.07
EXTGOAL	Extr. Goal Orient.	(.74)	.26	-.10	.10	.37	.38	.32	.28	.26	.19	-.02	.02
ANX	Test Anxiety	.35	(.74)	.36	.38	.01	-.32	-.09	-.28	-.29	-.22	-.11	-.17
ACS_DEC	Action Control-Dec.	-.14	.50	(.71)	.40	-.06	-.36	-.27	-.25	-.25	-.22	.05	.09
ACS_FAIL	Action Control-Fail.	.14	.54	.58	(.67)	.02	-.15	-.07	-.11	-.19	-.10	-.03	-.07
SCICONT	Sci. Perceived Control	.53	.01	-.09	.03	(.66)	.44	.43	.10	.12	.03	-.05	.03
SCISELFE	Sci. Self-Efficacy	.46	-.39	-.45	-.19	.56	(.92)	.67	.59	.48	.32	.03	.17
TSKSELFE	Task Self-Efficacy	.40	-.11	-.35	-.09	.57	.75	(.86)	.36	.36	.20	.12	.25
GRDSCI	Grade in Science	.33	-.33	-.30	-.16	.12	.62	.39	NA	.78	.59	.19	.27
AVGSCI	Avg. Grade in Sci.	.30	-.34	-.30	-.23	.15	.50	.39	.78	NA	.63	.25	.33
AVGGRD	Overall Avg. Grade	.22	-.26	-.26	-.12	.04	.33	.22	.59	.63	NA	.16	.17
MABVOC	MAB Vocabulary	-.03	-.15	.07	-.04	-.07	.04	.15	.22	.29	.19	(.72)	.57
MABINFO	MAB Information	.03	-.22	.12	-.09	.04	.20	.30	.30	.36	.19	.74	(.82)

Note. Correlations below the diagonal were corrected for attenuation caused by unreliability in the measures. Cronbach alpha reliabilities appear in parentheses in the diagonal. Reliabilities for self-reported grades were not computed because these were measured by one item. Correlations were computed using pairwise deletion, so *N*s range from 214 to 234 due to missing data for some cases. For $N = 234$, $r_{05} = .13$, $r_{01} = .15$, and $r_{001} = .22$.

Table 7 shows that verbal ability was largely uncorrelated with the conative constructs. Although there were some significant correlations, these were relatively low. As one would expect, MAB Vocabulary and Information were both correlated with academic self-confidence (r_{adj} = .23 and r_{adj} = .26, respectively). Negative correlations were also found between Test Anxiety (ANX) and the Information (r_{adj} = -.22) and Vocabulary (r_{adj} = -.15) subtests and between Surface Approach and the ability variables (Vocabulary r_{adj} = -.26, Information r_{adj} = -.28). Thus, students who reported using learning strategies such as studying only what is required to pass and memorizing unrelated facts, and who reported anxiety about school work, tended to score lower on the ability tests. A positive correlation was found between the Information score and Personal Interest in Science (r_{adj} = .33), but not between Vocabulary and Personal Interest in Science (r_{adj} = .11), perhaps because several of the items in the Information subtest contain science content.

Discussion of ability correlations. One of the goals of this study was to explore the relationships between verbal ability and the conative constructs. Few previous studies have included standardized ability measures together with conative measures in a sample of high school students, so it was important to determine whether or not these conative measures would capture variance that was distinct from verbal ability. Verbal ability, as measured by the MAB Vocabulary and Information subtests, accounted for little of the variance in the conative measures. Academic Self-Confidence and Surface Approach were the conative variables most strongly correlated with verbal ability, and each of these shared only about 6% of the variance with ability. These data clearly indicate that conative constructs cannot be dismissed as surrogates for ability measures.

These data are consistent with those of Meece et al. (1988), even though their study differed from the present research in some important ways. Specifically, Meece et al.'s (1988) study involved a sample of 5th- and 6th-grade students, and it used school records of standardized achievement tests instead of the standardized ability measures administered here. Despite these differences, of the 8 conative-achievement correlations reported by Meece et al. (1988), 7 were below .30. Meece et al.'s (1988) strongest achievement-conative correlation involved perceived competence. Likewise, Study II found that two constructs reflecting perceived competence, Academic Self-Confidence and Self-Efficacy, showed the highest ability-conative correlations.

Grade correlations. In addition to the positive correlations found between grades and ability, self-reported grades also correlated with a number of the conative variables. The pattern of correlations was the same for all three of the grade variables. The highest correlations were observed between Academic Self-Confidence and grades (e.g., for grade in science, r_{adj} = .60, r = .53). Positive correlations between grades and Industriousness, Mastery Orientation, Performance Orientation, Science Interest, Personal Interest, Deep Approach, Strategic Approach, Academic Self-Confidence, and Intrinsic and Extrinsic Goal Orientations were observed. Negative correlations were observed between grades and Work Avoidance, Surface Approach, Apathetic Approach, Test Anxiety, Action Control-Decision and Action Control-Failure. This pattern of correlations is consistent with the theoretical overlap expected between these variables and grades.

Discussion of grade correlations. The correlations between the conative and grade variables are consistent with those obtained by Pintrich, Smith, Garcia, and McKeachie (1993) in a sample of 356 college students, although the correlations in this study tended to be higher. In both studies, Self-Efficacy and Intrinsic Goal orientation yielded among the highest positive correlations with grades and Test Anxiety the lowest. The higher correlations found here could be influenced by the greater variance in conative scores observed in this sample of high school students compared with Pintrich et al.'s (1993) college sample. The significant correlations with grades are evidence for the predictive validity of these conative measures. It is not surprising that students who approach science material with the intent of mastering and understanding it, who are interested in science, who believe in their academic ability, and who have high self-efficacy beliefs about learning science report better grades than students who avoid science whenever possible, intend only to reproduce material for tests, are anxious about their performance, and have difficulty maintaining their intentions to study science.

Anxiety correlations. Test Anxiety showed low to moderate correlations with most of the other conative variables, indicating that anxiety alone cannot account for the relationships observed among the conative variables. Test Anxiety did correlate highly with Surface Approach (r_{adj} = .65, r = .49), in part because the Surface Approach contains four items intended to measure fear of failure. However, even when these four items were removed, the correlation remained significant (r_{adj} = .48, r = .36).

Test Anxiety correlated moderately with Action Control-Decision (r_{adj} = .50, r = .36) and Action Control-Failure (r_{adj} = .54, r = .38). Action Control-Failure is intended to measure preoccupation with negative experiences in both achievement and other settings. Because Test Anxiety contains items that emphasize the worry component of test anxiety, the correlation with Action Control is not surprising. There were several other correlations involving Test Anxiety, but these were relatively low.

Industriousness correlations. Industriousness (SFPQ) is a personality construct combining items from the Personality Research Form (PRF) scales of Achievement, Endurance, and Play (reflected), all of which are intercorrelated. Industriousness can be interpreted as a measure of achievement motivation, at least insofar as it is embodied in the definitions of these three scales. Industriousness was highly correlated with all the variables in Table 7 except Test Anxiety and the ability variables. This indicates that the traditional construct of achievement motivation shares variance with many of the conative variables in this study.

Industriousness correlated most highly with Intrinsic Goal Orientation (r_{adj} = .64, r = 48), Mastery Orientation (r_{adj} = .60, r = 50), Deep Approach (r_{adj} = .61, r = 49), and Strategic Approach (r_{adj} = .67, r = 53). The most negative correlations occurred with Work Avoidance (r_{adj} = -.64, r = -.47), Apathetic Approach (r_{adj} = -.57, r = -.46), and Action Control-Decision (r_{adj} = -.58, r = -.43).

Discussion of Industriousness and Anxiety Correlations

As hypothesized, significant relationships were found between many of the newer and more speculative conative constructs and the established constructs of achievement motivation and anxiety. If most of the variance in a newer construct can be accounted for by an established construct, the rule of parsimony would dictate that the newer construct be considered superfluous. Here, the Industriousness scale served as a measure of achievement motivation. Achievement motivation was moderately highly correlated with Mastery Orientation, Work Avoidance, Deep Approach, Strategic Approach, Apathetic Approach, and Intrinsic Goal Orientation. Test Anxiety was correlated with the Surface Approach and the Action Control scales. While achievement motivation and anxiety account for a significant portion of the variance in these conative constructs, they still leave much unaccounted for.

Goal orientation correlations. As expected, Mastery Orientation was highly correlated with Intrinsic Goal Orientation (r_{adj} = .86, r = .70). The magnitude of these correlations suggests that these variables measure largely the same construct. Further evidence for this is found by examining the pattern of correlations between these two variables and the other variables in Table 7. Thus, a correlation was calculated between the Mastery Orientation column and Intrinsic Goal Orientation column in the square intercorrelation matrix of the conative variables from Study II. The resulting correlations was .98. This indicates that these two variables show virtually identical patterns of correlation with the other variables in the study.

Two other measures of goal orientation, Performance Orientation and Extrinsic Goal Orientation, were also highly correlated (r_{adj} = .90, r = .67). Both of these variables showed the same pattern of correlations with the other variables in Table 7. The correlation between these two columns was .98.

Also to be noted, the Mastery Orientation scale correlated .57 with Performance Orientation (r_{adj} = .69, r = .57, $p < .001$). Intrinsic Goal Orientation correlated .50 with Extrinsic Goal Orientation (r_{adj} = .68, r = .50, $p < .001$). Thus, students high in one type of motivation tend to be high in the other. For example, students motivated to master material for their own purposes are frequently also motivated to master it to please others.

Mastery Orientation was also highly correlated with Deep Approach Orientation (r_{adj} = .77, r = .67), Strategic Approach Orientation (r_{adj} = .69, r = .60), and Apathetic Approach to Learning Orientation (r_{adj} = -.78, r = -.68). Similarly, Intrinsic Goal Orientation was also highly correlated with Deep Approach Orientation (r_{adj} = .80, r = .62), Strategic Approach Orientation (r_{adj} = .74, r = .57), and Apathetic Approach to Learning Orientation (r_{adj} = -67, r = -.52). Thus, students high in intrinsic motivation who aim to master their classwork indicate that they (a) use more involved learning strategies, (b) show active interest in their classwork, (c) are better organized, and (d) are more aware of the assessment demands placed upon them.

Discussion of goal orientation correlations. Lepper (1988) presents a conceptual analysis of the similarities among the goal orientation constructs of (a) Intrinsic vs. Extrinsic Motivation, (b) Task Orientation vs. Ego Orientation, and (c) Learning Goals vs. Performance Goals. Study II provides empirical support for Lepper's conceptual analysis. Intrinsic Motivation from the Motivated Strategies for Learning Questionnaire (Pintrich et al., 1991) correlated highly with Mastery Orientation from the Science Activity Questionnaire (Meece et al., 1988). Likewise, Extrinsic Motivation was highly correlated with Performance Orientation. These strong relationships were found even though the Science Activity Questionnaire used a different item format (4-point Likert instead of 7-point Likert for the Motivated Strategies for Learning Questionnaire) and consisted of much shorter items and simpler vocabulary (presumably because the Science Activity Questionnaire was developed for elementary school students).

There are two implications of the convergence of the Science Activity Questionnaire and Motivated Strategies for Learning Questionnaire goal orientation measures. One implication is that research involving the goal orientation distinctions of several different researchers can be linked. The questionnaires measuring Mastery vs. Performance Orientation (Meece et al., 1988) and Intrinsic vs. Extrinsic Motivation (Pintrich et al., 1991) are capturing the same construct distinctions. Thus, research involving these measures ought to yield consistent results. These findings should in turn be consistent with research involving the questionnaires used by Ames (1984) and Nicholls et al. (1985), which measure Task vs. Ego Orientation with items that were adapted by Meece et al. (1988) for the Science Activity Questionnaire.

A second implication is that these questionnaires do not fully capture the theoretical distinctions among the constructs. For example, the intrinsic vs. extrinsic distinction is broader than the mastery vs. performance distinction because the latter involves competition or comparison of one's performance with that of others. The intrinsic vs. extrinsic distinction could involve extrinsic rewards or punishments that do not involve competition or comparison, such as when students receive tangible extrinsic rewards for their performance (Lepper & Greene, 1978). Thus, subtle theoretical distinctions among goal orientation constructs seem to have been lost when the constructs were operationalized.

Corrected correlations between the learning orientation measures and the performance orientation measures ranged in the .60s and .70s, much higher than correlations reported in previous research. Meece et al. (1988) reported a correlation of .13 between task mastery and ego/social goal orientations measured using the same Science Activity Questionnaire (SAQ) that was used here for Study II. Pintrich et al. (1991) report a correlation of .15 (r_{adj} = .22) between Intrinsic Goal Orientation and Extrinsic Goal Orientation in a sample 380 college students who completed the Motivated Strategies for Learning Questionnaire (MSLQ).

It is unclear what accounts for the discrepancy in the magnitude of these intercorrelations, given that the prior research used the same scales as used here. The SAQ includes only three items to measure Ego/Social Orientation. The MSLQ includes only four items for Extrinsic Goal Orientation. The reliabilities found for these scales were acceptable, but one might speculate that so few items would be insufficient to capture the performance orientation construct. An examination of the items reveals that they contain several themes, including (a) valuing high grades, (b) performing better than others, and (c) gaining recognition for good performance from the teacher or other students. The learning orientation items span the themes of (a) valuing learning, (b) enjoying challenge in science, (c) investing time and effort in science, (d) being involved in science, and (e) enjoying science material that arouses curiosity. Given that so few items are used to measure these broad item themes, it seems plausible that students who score highly on performance orientation might also score highly on learning orientation.

In summary, Study II found a large amount of overlap between learning and performance orientations, but not so much as to warrant collapsing these constructs. Improved measurement and tighter definition of these constructs would be helpful.

Correlations involving supplemental variables. Table 8 presents the correlations among the supplemental measures administered to a subset of the Study II sample. As before, correlations corrected for attenuation appear below the diagonal and uncorrected correlations appear above the diagonal. These supplemental measures were highly intercorrelated, with 16 of the 36 corrected correlations above .90. The correlations among the self-regulatory strategy variables averaged .88. These variables included Grade Seeking, Rehearsal, Elaboration, Organization, Critical Thinking, and Metacognitive Self-Regulation. To simplify the interpretation of these variables, they were summed to form a composite variable called "Cognitive and Metacognitive Strategies" (COGMETA).

Table 8

Means, Standard Deviations, Reliabilities and Correlations Among the Supplemental Measures From Study II (N = 92)

	Measure	MEAN	*SD*	GRDSEEK	HELPTOT	REHRSL	ELABOR	ORGANZ	CRITHNK	METAREG	ENVREG	EFRTREG
GRDSEEK	Grade Seeking Strategies	30.97	7.55	(.80)	.58	.83	.74	.80	.62	.80	.60	.68
HELPTOT	Help Seeking (Total Score)	46.13	9.42	.77	(.71)	.60	.56	.51	.51	.61	.49	.41
REHRSL	Rehearsal Strategies	19.50	5.39	1.00	.80	(.79)	.79	.81	.67	.80	.63	.62
ELABOR	Elaboration Strategies	27.95	7.35	.91	.73	.98	(.82)	.80	.81	.89	.67	.66
ORGANZ	Organization Strategies	23.81	6.84	.96	.65	.98	.95	(.86)	.69	.83	.61	.67
CRITHNK	Critical Thinking	22.77	6.06	.77	.67	.84	.99	.83	(.81)	.79	.45	.45
METAREG	Metacognitive Self-Reg.	52.97	12.91	.96	.78	.97	1.00	.97	.95	(.86)	.75	.75
ENVREG	Regulating Study Env.	34.96	9.00	.76	.66	.80	.84	.74	.57	.92	(.78)	.75
EFRTREG	Effort Regulation	17.70	5.37	.90	.58	.83	.86	.86	.59	.96	1.00	(.71)

Note. Cronbach alpha reliabilities appear in parentheses in the diagonal. Correlations below the diagonal have been corrected for unreliability. The sample size ranges 92 to 110 due to missing data. r_{05} approximately = .25 (for N = 92).

Similarly, the corrected correlations between Regulating the Study Environment and Effort Regulation were high (1.00), so these variables were summed to form a composite variable called "Resource Management" (RESMAN). The remaining variable, Help Seeking, was less highly correlated with the other supplemental variables and thus was not included in either the Cognitive and Metacognitive Strategies or Resource Management composite variables.

Discussion of correlations involving supplemental variables. The correlations among the supplemental variables in Study II showed a striking degree of overlap. Numerous corrected correlations above .90 were observed in the set of self-regulatory measures from Pintrich et al.'s (1991) MSLQ. The data reported here indicate that the theoretical distinctions made among these constructs are not supported empirically, at least in this sample of high school students. Students do not appear to distinguish among closely related learning strategies when they are presented with the questionnaire measures used here.

These data stand in contrast to Pintrich et al.'s (1993) conclusion in reference to the MSLQ that "the learning strategy scales represent an array of different cognitive, metacognitive, and resource management strategies that can be reliably distinguished from one another on both conceptual and empirical grounds" (p. 812). While there are empirical distinctions among the strategy measures, these data indicate that not all of the MSLQ strategy scales should be considered distinct from one another. Pintrich et al.'s (1993) own data support this point: the correlation between, for example, Effort Regulation and Time and Study Environment Management is reported to be .70. But when this correlation is corrected for unreliability, it is .97. Likewise, the correlation reported between Elaboration and Metacognitive Self-Regulation is .67. But this correlation becomes .87 when disattenuated.

Here, the supplemental measures were divided conceptually and empirically into three of Pintrich et al.'s more molar groups: cognitive and metacognitive strategies, help seeking strategies, and resource management strategies. Clearly, further research and improved measurement of these strategies will help draw sharper distinctions among them. Help seeking and resource management strategies in particular have been studied less frequently, but hold promise for future instructional research and evaluation because they may be especially amenable to intervention.

Principal Components Analysis

A principal components analysis was conducted for three reasons. First, many of these measures had not been administered together to a sample of students. Accordingly, it was important to understand the structure of their interrelationships. Second, combining the variables into a smaller number of component scores would permit easier and more parsimonious interpretation of the data. Third, principal components analysis uses both common and unique variance to form components. As Schönemann (1990) demonstrates, there can be criteria that are perfectly predictable from test scores via multiple regression, but completely unpredictable from common factors. Since predicting scores on a science achievement assessment was to be one goal of Study III, the component scores from principal components analysis were preferred. For these data, including both unique and common variance resulted in more interpretable components.

The uncorrected correlation matrix presented in Table 7 was analyzed by principal components and rotated to a varimax criterion of simple structure. Based on an inspection of the scree plot and component interpretability, seven components were retained and rotated by varimax. The analysis was conducted both with and without the MAB Information scale included because this measure was not administered in Study III and it was important to compare analyses based on the same set of paper-and-pencil measures for the two studies. Since the results were highly similar, the solution without MAB Information is presented in Table 9. By removing MAB Information, the same variables could be analyzed in both the Study II and III samples. MAB Information was extended into the component space using Dwyer's (1937) extension methods. The supplemental variables Help Seeking, Cognitive and Metacognitive Strategies, and Resource Management Strategies were also extended into the component space.

Interpretation of Components

Component I—Pursuit of Excellence. The first component was marked by high loadings on Industriousness, Deep Approach, Strategic Approach, and Intrinsic Goal Orientation. A close examination of these measures reveals that they share some common themes, reflecting a general concern for excellence and a desire for challenging work. Industriousness measures a willingness to work

Table 9

Principal Components Analysis of Study II Data (*N* = 200)

Variable	Measure	I	II	III	IV	V	VI	VII	h^2
SPFQ	Industriousness	.70	-.18	.22	-.18	.24	.18	-.05	.69
DEEP	Deep Approach	.71	.05	.08	.35	.27	.22	.01	.76
STRATEG	Strategic Approach	.71	-.11	.25	.20	.16	.27	-.16	.76
INTGOAL	Intr. Goal Orient.	.54	-.17	.07	.35	.30	.37	.05	.68
SURFACE	Surface Approach	-.22	.49	-.20	-.19	-.40	.31	-.29	.71
ANX	Test Anxiety	.18	.59	-.33	-.07	-.26	.35	.00	.69
ACS_DEC	Action Control-Dec.	-.39	.70	-.11	-.03	-.16	-.06	.11	.70
ACS_FAIL	Action Control-Fail.	-.02	.84	-.05	-.02	.05	.00	-.04	.71
CONFID	Acad. Self-Conf.	.45	-.12	.48	.45	.04	-.11	.18	.70
GRDSCI	Grade in Science	.13	-.07	.82	.15	.27	.14	.08	.82
AVGSCI	Avg. Grade in Sci.	.07	-.16	.81	.11	.21	.16	.18	.80
AVGGRD	Overall Avg. Grade	.19	-.05	.84	-.04	-.01	.07	.02	.75
SCICONT	Sci. Perceived Control	.03	.06	-.01	.79	.13	.17	-.12	.69
SCISELFE	Sci. Self-Efficacy	.23	-.21	.34	.58	.41	.21	.01	.76
TSKSELFE	Task Self-Efficacy	.24	-.11	.15	.67	.21	.19	.17	.65
SCIMAST	Mastery Orient	.44	-.02	.19	.25	.57	.43	-.04	.81
SCIWORKA	Work Avoidance	-.45	.05	-.15	.05	-.70	.07	-.01	.72
INTTOT	Interest in Sci. Class	.18	-.06	.16	.32	.71	.13	-.08	.69
INTPERS	Personal Interest	-.09	-.08	.13	.19	.68	.37	.10	.67
APATHET	Apathetic Approach	-.42	.13	-.22	-.16	-.67	-.09	.00	.74
SCIPERF	Performance Orient.	.21	.02	.24	.11	.12	.78	.06	.74
EXTGOAL	Extr. Goal Orient.	.21	.10	.11	.21	.15	.81	-.04	.79
MABVOCAB	MAB Vocabulary	-.07	.00	.15	-.01	.00	.01	.94	.91
Extension variables									
MABINFO	MAB Information	-.16	-.04	.20	.10	.06	.00	.54	
HELPTOT	Help Seeking	.37	.04	.01	.31	.08	.18	-.07	
COGMETA	Cog. & Meta. Strateg.	.56	-.19	.21	.37	.36	.31	-.12	
RESMAN	Resource Management	.48	-.23	.14	.02	.59	.06	-.21	
Eigenvalues		3.10	2.01	2.94	2.29	3.11	2.30	1.15	
Percent variance accounted for		.13	.09	.13	.10	.14	.10	.05	

Note. MABINFO, HELPTOT, COGMETA, and RESMAN were extended into the component space using the Dwyer (1937) method. The eigenvalues presented in the table are for the rotated components. The first seven eigenvalues for the unrotated components are 8.37, 2.56, 1.69, 1.40, 1.10, .92, .88. The highest loading for each variable is marked.

hard rather than play. High scorers maintain high standards and are willing to persevere in the face of difficulty to attain excellence. They respond positively to competition and will work towards accomplishing difficult or distant goals.

Both Deep Approach and Strategic Approach also loaded primarily on this component. Deep Approach measures self-reported use of a collection of "deeper," more elaborate learning strategies. It contains subscales for Intention to Understand, Active Interest, Relating Ideas, and Use of Evidence. On the other hand, Strategic Approach measures strategies designed to use resources efficiently to achieve success or good grades. Strategic Approach contains subscales for Intention to Excel, Alertness to Assessment Demands, Study Organization, and Time Management. Deep Approach thus emphasizes learning and understanding. Strategic Approach stresses achievement and performance. When both measures are interpreted as Pursuit of Excellence, the similarities between the two superficially different approaches become clear. If students are motivated to achieve excellence, they will be well served by both Deep and Strategic Approaches. It is important for students to understand the material to be learned, to see how ideas fit together, and to evaluate evidence carefully. But it is also important for them to be well organized, to use their time efficiently, and to understand how they will be evaluated. Both Deep and Strategic Approaches are in the service of the more general Pursuit of Excellence construct by a process of subsidiation (Murray, 1938).

Intrinsic Goal Orientation also loaded on this component. The items of this scale do seem to span similar content to the Deep Approach items. Students who choose to participate in tasks for challenge, curiosity, learning, and understanding also seek to achieve excellence in their work. Mastery Orientation, which was correlated with Intrinsic Goal Orientation, also showed a strong, but not its highest, loading on this component. One plausible explanation is that the Mastery Orientation scale (from the Science Activity Questionnaire) emphasizes the science context more strongly than does Intrinsic Goal Orientation. Hence, it loaded most highly on the component identified by science interest.

Murray (1938) introduced the concept of n-Achievement, which was later popularized by McClelland, Atkinson, Clark, & Lowell, 1953), who interpreted it as "competition with a standard of excellence." The Pursuit of Excellence dimension also includes aspects of the Weberian concept of Protestant work ethic (Weber, 1904/1958) and Competition With Others (Jackson, Ahmed, & Heapy, 1976); it is a general construct not confined to educational settings.

Component II—Evaluation Anxiety. Component II was marked by high loadings from Test Anxiety, Surface Approach, Action Control-Failure, and Action Control-Decision. Although the two action control scales loaded most highly here, Evaluation Anxiety seems to provide the more parsimonious and traditional interpretation. Action Control-Failure measures preoccupation with negative experiences, so it is similar to Test Anxiety, which measures preoccupation with possible failure in achievement settings. Action Control-Decision measures a different but related kind of preoccupation—that is, difficulty in taking action once a decision has been made. Surface Approach contains subscales measuring Intention to Reproduce, Passive Learning, Unrelated Memorizing, and Fear of Failure. The Fear of Failure scale contains items that are similar to those from the Test Anxiety scale.

Students obtaining high scores on this component are preoccupied with possible failure. These students report that they (a) procrastinate working on their assignments, (b) have difficulty grasping the "big picture" when studying, (c) aim to reproduce material for tests even though they don't understand it, and (d) feel upset or panicked when they are evaluated. For some students, these behaviors may be a natural consequence of being unprepared or confronted with material that is too difficult. Support for this idea comes from the negative zero-order correlations observed between the verbal ability measures and the Surface Approach and Test Anxiety scales.

Component III - Self-Reported Grades. The third component was defined by high loadings from the self-reported grade variables and a moderate loading from Academic Self-Confidence. The loading from Academic Self-Confidence provides supporting evidence for the validity of this measure. Students who report higher grades would be expected to report greater academic self-confidence, on average.

Component IV - Science Confidence. The fourth component was defined by high loadings from Science Learning Control Beliefs, Science Learning Self-Efficacy, and Science Task Self-Efficacy; hence it was labeled Science Confidence. High scorers on this component report that (a) their success in science is contingent on their own effort rather than on external factors, (b) they are confident they will understand the material presented in their science class, (c) they will receive excellent grades in science, and (d) they will be successful in learning and recalling science text presented by computer.

Component V—Science Interest vs. Science Avoidance. The fifth component was identified by positive loadings from the two interest variables and Mastery Orientation and by negative loadings from Work Avoidance and Apathetic Approach. All five of these variables were measured in the context of the student's science class, so this component was named "Science Interest vs. Science Avoidance." High scorers on this component view science as relevant to their current and future lives. They regard science class as enjoyable and look forward to the learning activities prepared by their teacher. They also describe science class as more interesting than most of their other classes. Low scorers are disaffected learners. They describe science class as boring and irrelevant. These students would rather not take science class at all, but feel forced to take it by others. They would like to avoid schoolwork in science and would prefer to take the path of least resistance.

It is important to note that Science Interest shows as a component separate from Pursuit of Excellence. The concept of interest has been relatively neglected by researchers on achievement motivation (e.g., Heckhausen, Schmalt, & Schneider, 1985; Weiner, 1992), who seem to imply that motivated students aim for high performance, regardless of the content domain (Schiefele, 1991).

Component VI—Performance Orientation. High loadings from Performance Orientation and Extrinsic Goal Orientation defined the sixth component. Consequently, it was named "Performance Orientation." High scorers on this component regard learning tasks as a means to an end, such as receiving high grades, rewards, or competing successfully with others.

Component VII—Verbal Ability. The seventh component was defined by MAB Vocabulary and the extension variable MAB Information. This component was interpreted as "Verbal Ability." Note that when MAB Information was included in the principal components analysis, both the MAB variables showed equally high loadings on this component.

Extension variables. The extension variables were loaded on the seven components in interpretable ways. Help Seeking loaded most highly on Pursuit of Excellence but the loading was only .37. If other measures of Help Seeking had been included, they might have defined a Help Seeking component. Cognitive and Metacognitive Strategies also loaded on Pursuit of Excellence, reflecting the expected theoretical overlap between use of these strategies and achievement motivation. Resource Management loaded on Science Interest vs. Science Avoidance. Students who were effective at managing their study environments and learning efforts tended to be more interested in the science material that was to be learned.

Second-Order Factor Analysis

Although the emphasis up to this point has been on the interpretation of primary orthogonally rotated principal components, it is also of considerable interest to determine the degree to which conative components are organized at a higher level. Such an analysis requires the evaluation of correlated components. Accordingly, the varimax rotated principal components matrix reported in Table 9 was analyzed by a variant of a procedure described by Schmid and Leiman (1957). The varimax matrix was subjected to an oblique rotation using promax (Hendrickson & White, 1964). This procedure is similar in its rationale to varimax, except that it relaxes the restriction of orthogonality by permitting oblique factors. The factor pattern matrix resulting from promax was very similar to that from varimax, yielding factors defined by the same variables and bearing the same interpretations. The factor correlation matrix generated from the promax solution is presented in Table 10. The strongest relationships involved Science Interest, marked by correlations with Science Confidence (r = .45), Self-Reported Grades (r = .40), and Pursuit of Excellence (r = .41). Verbal ability was most highly correlated with Self-Reported Grades, but showed low correlations with the remaining factors, consistent with the raw correlations among the measures. The strongest negative correlation was observed between Evaluation Anxiety and Self-Reported Grades (r = -.36).

The 7 x 7 first-order factor correlation matrix was in turn transformed by principal components to a matrix with 7 variables (the first-order factors) on 2 second-order principal components. These were rotated to a univocal varimax criterion (Jackson & Skinner, 1975) and are presented in Table 11. The first component was defined by Pursuit of Excellence, Self-Reported Grades, Science Confidence, and Science Interest. This component captures a confident,

Table 10

Correlations Among Oblique Factors Generated From the Promax Rotation of the Study II Data (*N* = 200)

Factor	I	II	III	IV	V	VI
I. Pursuit of Excellence						
II. Evaluation Anxiety	-.24					
III. Self-Reported Grades	.37	-.36				
IV. Science Confidence	.36	-.20	.32			
V. Science Int. vs. Science Avoid.	.41	-.34	.40	.45		
VI. Performance Orientation	.22	.22	.04	.23	.15	
VII. Verbal Ability	.08	-.17	.31	.19	.16	-.11

Table 11

Second-Order Factors Rotated to a Univocal Varimax Criterion From Study II Data (*N* = 200)

		Second-order I	Second-order II
I.	Pursuit of Excellence	.72	-.10
II.	Evaluation Anxiety	-.41	-.63
III.	Self-Reported Grades	.65	.36
IV.	Science Confidence	.73	-.07
V.	Science Int. vs. Science Avoid.	.76	.10
VI.	Performance Orientation	.39	-.76
VII.	Verbal Ability	.27	.53

interested, and achievement-focused approach to science learning. It was labeled "Pursuit of Excellence in Science." The second component was defined by negative Evaluation Anxiety and negative Performance Orientation, and, to a lesser extent, positive Verbal Ability. Students scoring highly on this component are not oriented to science or science achievement, nor do they view learning science as a means to some other end. They also report little anxiety, but do report higher than average grades. This component was labeled "Science Ambivalence."

Summary of Study II

In Study II, a broad set of conative and ability measures was administered to a sample of 234 Ontario high school students. The purpose of Study II was to explore the construct validity of this set of conative constructs as a guide for future research. Descriptive statistics, reliability analyses, correlational analyses and a principal components analysis were conducted on these data to explore characteristics of the measures and to evaluate interrelationships among the constructs. Conclusions from Study II are summarized as follows:

Psychometric properties of questionnaires. The questionnaires used in this study showed no substantial deviations from normality. Most of the questionnaires were reliable, with Science Interest and Science Self-Efficacy demonstrating the highest reliabilities (both .92) and Action Control-Failure and Science Perceived Control showing the lowest reliabilities (.67 and .66 respectively). Reliabilities for Deep, Surface, Strategic, and Apathetic Approaches to Learning were consistent with those found in Study I.

Significant correlations among conative measures. Of the 210 correlations among the conative and ability measures, the majority were found to be significant. There were 46 nonsignificant correlations. Of these, 36 were concentrated in the two MAB ability variables and the Action Control-Failure variable.

Verbal ability uncorrelated with conative measures. MAB Vocabulary and Information were largely uncorrelated with scores on the conative measures. The exceptions were Surface Approach, Test Anxiety, and Personal Interest in Science. Students who were test anxious or who reported using surface learning strategies (i.e., studying only what is required to pass, memorizing unrelated facts, and reporting anxiety about school work) tended to score lower on the ability measures. Students with high scores on Personal Interest in Science scored higher on MAB Information but not on MAB Vocabulary.

Self-reported grades correlated with several conative measures. The grade correlations were consistent with those of Pintrich et al. (1993). Positive correlations were observed between grades and Industriousness, Mastery Orientation, Performance Orientation, Science Interest, Personal Interest, Deep Approach, Strategic Approach, Academic Self-Confidence, and Intrinsic and Extrinsic Goal Orientations. Negative correlations were found between grades and Work Avoidance, Surface Approach, Apathetic Approach, Test Anxiety, and Action Control-Decision and Failure.

Convergence of MSLQ and SAQ goal orientation measures. Intrinsic Goal Orientation was highly correlated with Mastery Orientation (r_{adj} = .86, r = .70). Likewise, Extrinsic Goal Orientation was highly correlated with Performance Orientation (r_{adj} = .90, r = .67). This finding supports Lepper's (1988) argument that these constructs are similar.

High intercorrelations among cognitive and metacognitive strategy measures. High correlations were found among the supplemental measures of the use of various cognitive and metacognitive strategies. This suggests that students have difficulty distinguishing among these strategies on self-report measures. Three composite variables were formed from the supplemental measures: Cognitive and Metacognitive Strategies, Resource Management, and Help Seeking.

Principal components analysis. The Study II variables were subjected to a principal components analysis with varimax rotation. Seven components were retained and were identified as follows:

Component I	Pursuit of Excellence
Component II	Evaluation Anxiety
Component III	Self-Reported Grades
Component IV	Science Confidence
Component V	Science Interest vs. Science Avoidance
Component VI	Performance Orientation
Component VII	Verbal Ability

Verbal Ability, Pursuit of Excellence (achievement motivation) and Evaluation Anxiety, the basic dimensions of the McClelland-Atkinson theory of achievement motivation (McClelland et al., 1953), accounted for a large percentage of the variance among the conative measures. However, they did not account for all the variance. The additional components listed above were needed to account fully for these data.

Second-order factor analysis. Principal components analysis of oblique factors yielded two components which were labeled Pursuit of Excellence in Science and Science Ambivalence.

CHAPTER 5

STUDY III (COMPUTERIZED SCIENCE LEARNING STUDY)

Method

Study III was designed to determine whether individual differences in the conative constructs from Study II were associated with student differences in learning activities and with students' subsequent achievement on a science assessment.

Sample

A total of 82 students from one southwestern Ontario (Canada) high school participated in the computerized science learning task study. Participants were volunteers paid two dollars for their time. Table 12 presents background variables for Study III participants.

The sample was comprised of 34 males, and 48 females, ranging in age from 15 to 19 years, with a mean age of 16.5 years. Most students were in Grade 11. The ethnic composition of these students was Asian (6), Black (2), Canadian Indian (8), Hispanic (6), Other (13), White (47). The student body in this sample is predominantly White and is representative of southwestern Ontario's population of 15- to 19-year-olds. For most students, the first language spoken was English. Most students planned to go on to a technical school, community college, or university after graduation from high school.

Materials

Questionnaires. Study III used the same questionnaires as Study II, except the Information subtest from the MAB and the supplemental questionnaires (Sections 9 and 10) were not administered to make time for the computerized science task. Table 13 lists the questionnaires used in Study III. Refer to the method section in Study II for questionnaire descriptions.

Computerized Science Learning Task (CSLT). The Computerized Science Learning Task (CSLT) was developed in two phases. In Phase 1, the text and figures for the computerized task were prepared. In Phase 2, Microsoft Windows software was written for the task. It was subsequently tested with pilot subjects to ensure that it was free from defects. Each of these phases is described in detail below.

Table 12

Background Variables for the Study III Sample (*N* = 82)

Variable	Levels	Frequency	Variable	Levels	Frequency
Gender			Ethnicity		
	Male	34		Canadian Indian	8
	Female	48		White	47
				Black	2
Age				Asian	6
	15	4		Hispanic	6
	16	39		Other	13
	17	32			
	18	6	First language learned[a]		
	≥ 19	1		English	59
				French	3
Grade				French and English	14
	10	1		Other	6
	11	74			
	12	7	College plans[b]		
				Missing	1
				University	42
				Community college	22
				None planned	1
				Undecided	16

[a] Students were asked "What language(s) did you learn when you first began to talk?"

[b] Students were asked "After you graduate from high school, which of the following do you plan to do? (1) Go to University; (2) Go to a technical school or community college; (3) I don't plan to take any further schooling after high school; (4) Undecided."

Phase 1: Formulation of the computerized text and figures. The learning task was similar to the task used by Nolen (1988), but involved different content and was computerized to permit additional variables (such as time) to be recorded. The Computerized Science Learning Task (CSLT) used material adapted from several encyclopedia and science magazine articles. These articles described bacterial, viral, and protozoan diseases, and included figures and diagrams of microorganisms and their processes. The organization, content, and vocabulary of the text was carefully considered. Three criteria guided the selection of the science text.

First, the material explored science concepts students had not yet encountered in school. Second, the text and figures were designed to be interesting to students, presenting information relevant to their daily lives. Third, Nolen (1988) used difficult text and found poor recall performance and flat

Table 13

Questionnaire Variables for Study III

Description	Possible values	Items
1. Multidimensional Aptitude Battery; Jackson (1984); Multiple choice		
Vocabulary subtest	0-46	46
2. Six-Factor Personality Questionnaire; Jackson et al. (1996); 5-point Likert		
Industriousness scale	18-90	18
3. Approaches to Studying Inventory; Entwistle & Tait (1992); 5-point Likert		
Deep Approach to Learning scale	16-80	16
Surface Approach to Learning scale	16-80	16
Strategic Approach to Learning scale	16-80	16
Apathetic Approach to Learning scale	8-40	8
Academic Self-Confidence scale	4-20	4
4. Science Activity Questionnaire; Meece et al. (1988); 4-point Likert		
Learning (Task) Orientation for Science	9-36	9
Performance (Ego) Orientation for Science	3-12	3
Work Avoidant Orientation for Science	3-12	3
5. Motivated Strategies for Learning; Pintrich et. al (1991); 7-point Likert		
Intrinsic Goal Orientation	4-28	4
Extrinsic Goal Orientation	4-28	4
Test Anxiety	5-35	5
6. Science Interest Questionnaire; Mitchell (1993); 7-point Likert		
Personal Interest in Science	4-28	4
Situational Interest (in this year's science class)	6-42	6
Meaningfulness (in this year's science class)	4-28	4
Involvement (in this year's science class)	6-42	6
The total Science Interest score for this year's science class (sum of Situational Interest, Meaningfulness, and Involvement above)	16-112	16
7. Action Control Scale; Kuhl et al. (1991); Forced choice		
Action Control-Decision subscale	0-12	12
Action Control-Failure subscale	0-12	12
8. Motivated Strategies for Learning; Pintrich et al. (1991); 7-point Likert		
Perceived control over outcome in science class	4-28	4
Science Learning Self-Efficacy	8-56	8
Computerized Science Task Self-Efficacy	3-21	3

test score distributions, suggesting that the material was too difficult for her participants. For the present study, the concepts were presented clearly and simply, although some difficult words were intentionally left in the text to encourage students to look them up in a computerized dictionary.

Phase 2: Development of the CSLT software. After the science text and figures were prepared, Microsoft Windows software for the task was written using Borland's Delphi development language. The software started with detailed instructions to teach students how to use the program. Participants were instructed to press a button using the mouse to display each screen. The software recorded how long each screen was displayed in milliseconds. Participants could move among the screens by pressing buttons to move forward and backward. In addition to reading the text, participants could do the following: (a) look up words and phrases in a dictionary, (b) study figures depicting bacteria, viruses, protozoa and biological processes, (c) ask themselves comprehension monitoring questions or (d) play computer games. The comprehension monitoring questions allowed students to test their understanding of the material. Eliza (see Weizenbaum, 1992) and Asteroids (n.d.) were the two computer games students could play. Eliza was an entertaining psychotherapist who would answer students' questions about any subject. If Eliza couldn't recognize any keywords in the question, she responded with a witty retort or asked a clarifying question. Asteroids was a video game in which the objective of the game was to shoot and to destroy moving asteroids from a moveable spaceship.

The dependent variables recorded by the computer were the number of times and the amount of time spent (a) reading each screen of text, (b) examining the figures, (c) looking up words in the dictionary, (d) asking comprehension monitoring questions, (e) playing Eliza, and (f) playing Asteroids. The list of dependent variables is given in Table 14. Figures 1 through 6 show examples of the six different types of Computerized Science Learning Task (CSLT) screens. The procedure used to collect the data for Study III is described next.

Procedure

Data for each respondent were collected during class time in two 75-minute sessions. In the first session, participants were administered a subset of the questionnaires used in Study II (see Table 13). Administration of the Study III questionnaires closely followed the procedure detailed in Study II. In the second session, participants completed the Computerized Science Learning Task and were tested on their free and cued recall of the science material that had been presented to each respondent by computer.

Table 14

List of Dependent Variables From the Computerized Science Learning Task (CSLT)

Name	Description
PANTIME	The total time the participant spent examining the screens or "panels" that contained science instruction text
FIGTIME	The total time the participant spent examining the science instruction figures
DICTTIME	The total time spent using the dictionary
QUESTIME	The total time spent examining comprehension testing questions
ELIZTIME	The total time spent playing the computer game "ELIZA"
ASTTIME	The total time spent playing the computer game "ASTEROIDS"
PANNUM	The total number of times the participant viewed an instructional panel
FIGNUM	The total number of times the participant viewed a figure
DICTNUM	The total number of times the participant used the dictionary
QUESNUM	The total number of times the participant asked comprehension testing questions.
ELIZNUM	The total number of times the participant played "ELIZA"
ASTNUM	The total number of times the participant played "ASTEROIDS"
TOTTIME	The total time the participant spent on the task. (The sum of the first 5 time variables above.)
GAMETIME	The total time the participant spent playing games (The sum of ELIZTIME and ASTTIME above)
SCITIME	The total time the participant spent studying the science material (PANTIME + FIGTIME + DICTTIME + QUESTIME)

Administration of the Computerized Science Learning Task. The CSLT was administered in a classroom computer laboratory equipped with 25 computers running Microsoft Windows. Students were familiar with these computers because they had been using them in their classes. Students were told that their participation would involve learning and recalling several pages of science material on the computer. Students were instructed to take as much time as they needed to learn the concepts and processes described in the text and figures. They were told that after they finished studying the text, they would be asked some questions about what they had learned. Participants were given blank paper on which to take notes if they desired, but they were told that they would not be able to refer to the notes later. The verbal instructions given to participants about the

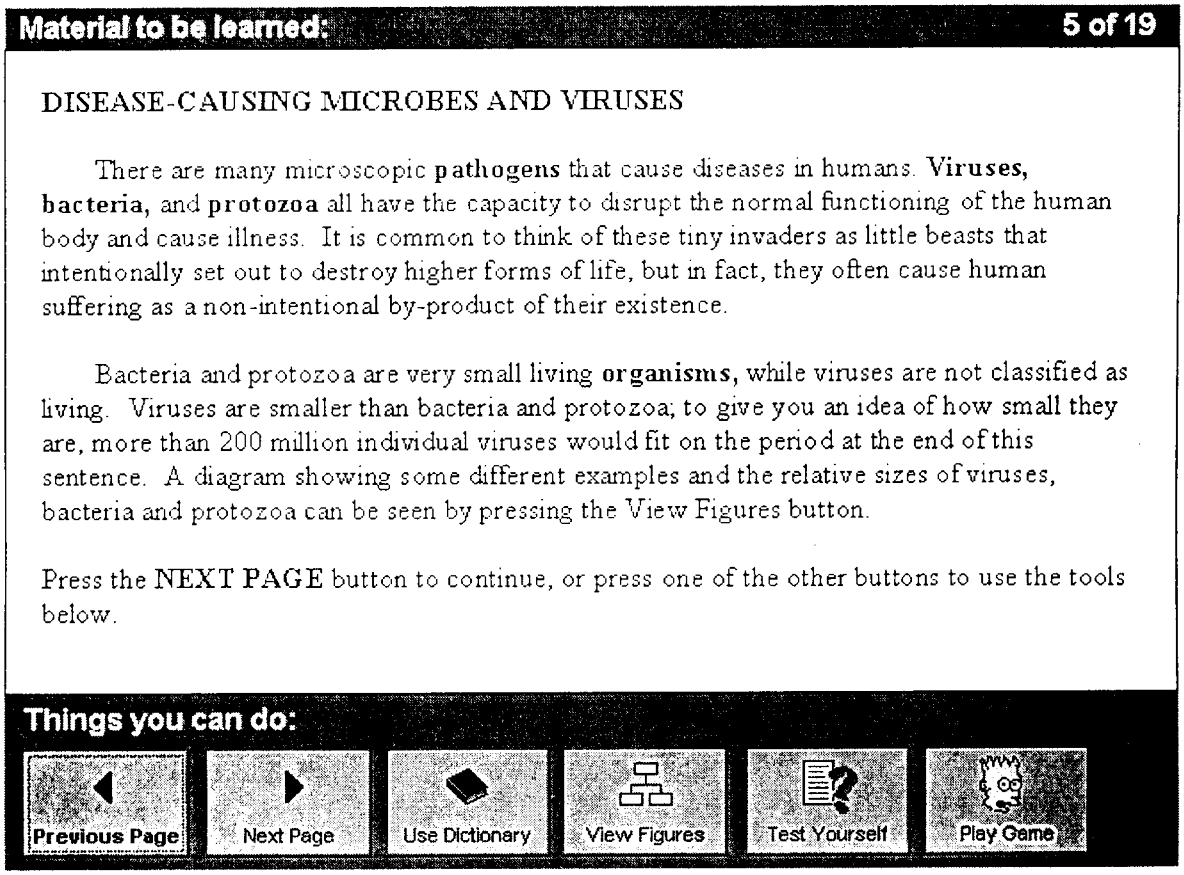

Figure 1. Text screen from the Computerized Science Learning Task (CSLT).

Computerized Science Learning Environment are presented in Appendix D. After completing the computer task, each student was presented with a paper-and-pencil test that contained free and cued recall questions about the science material presented by computer (see Appendix E).

Hypotheses for Study III

The purpose of Study III was to determine whether individual differences in the conative constructs were associated with student differences in learning activities and subsequent science achievement. Study III addressed the following hypotheses:

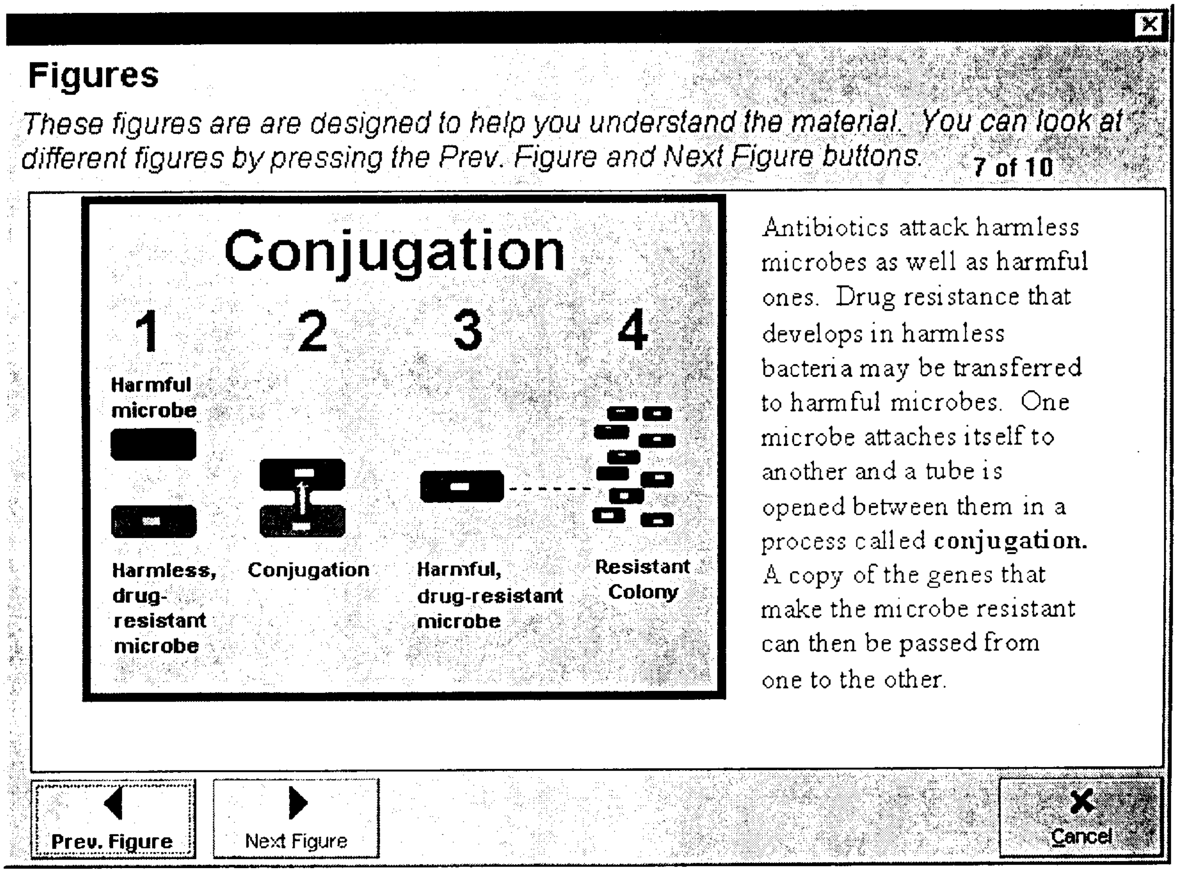

Figure 2. Figure screen from the Computerized Science Learning Task (CSLT).

Hypothesis 1—Construct validity of conative constructs. Newly proposed conative constructs will show significant relationships with established motivational constructs, including achievement motivation and test anxiety, but will possess substantial unique variance as well.

Hypothesis 2—Relationships between science achievement and conative constructs. The conative constructs will correlate with the science achievement measures independently of verbal ability.

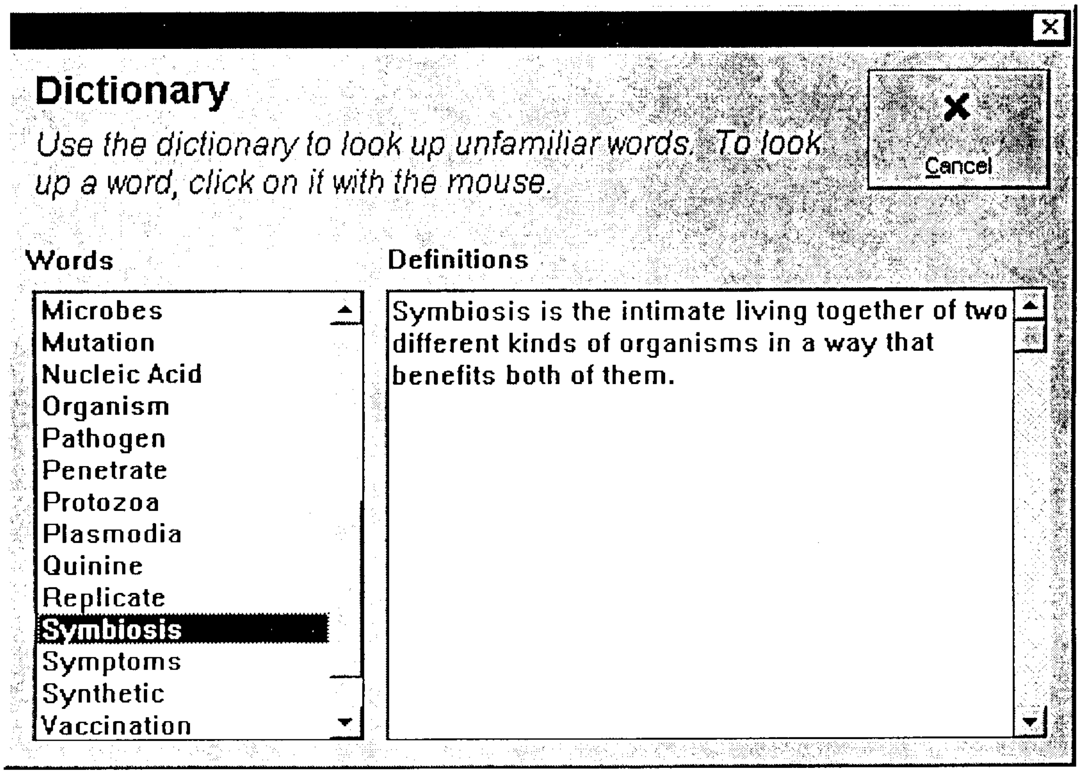

Figure 3. Dictionary screen from the Computerized Science Learning Task (CSLT).

Hypothesis 3—Relationships between science achievement and learning activities. Performance on a paper-and-pencil assessment of the science material presented in the computerized task will correlate positively with: (a) the frequency with which students engaged in science learning activities during the computerized science task and (b) the time spent learning science material. Performance on the assessment will correlate negatively with (a) the frequency students engage in game playing activities and (b) the time spent playing games.

Hypothesis 4—Relationships between conative constructs and learning activities. The conative constructs will correlate with (a) the frequency students engaged in science learning activities during the computerized science task and (b) the time spent learning science material.

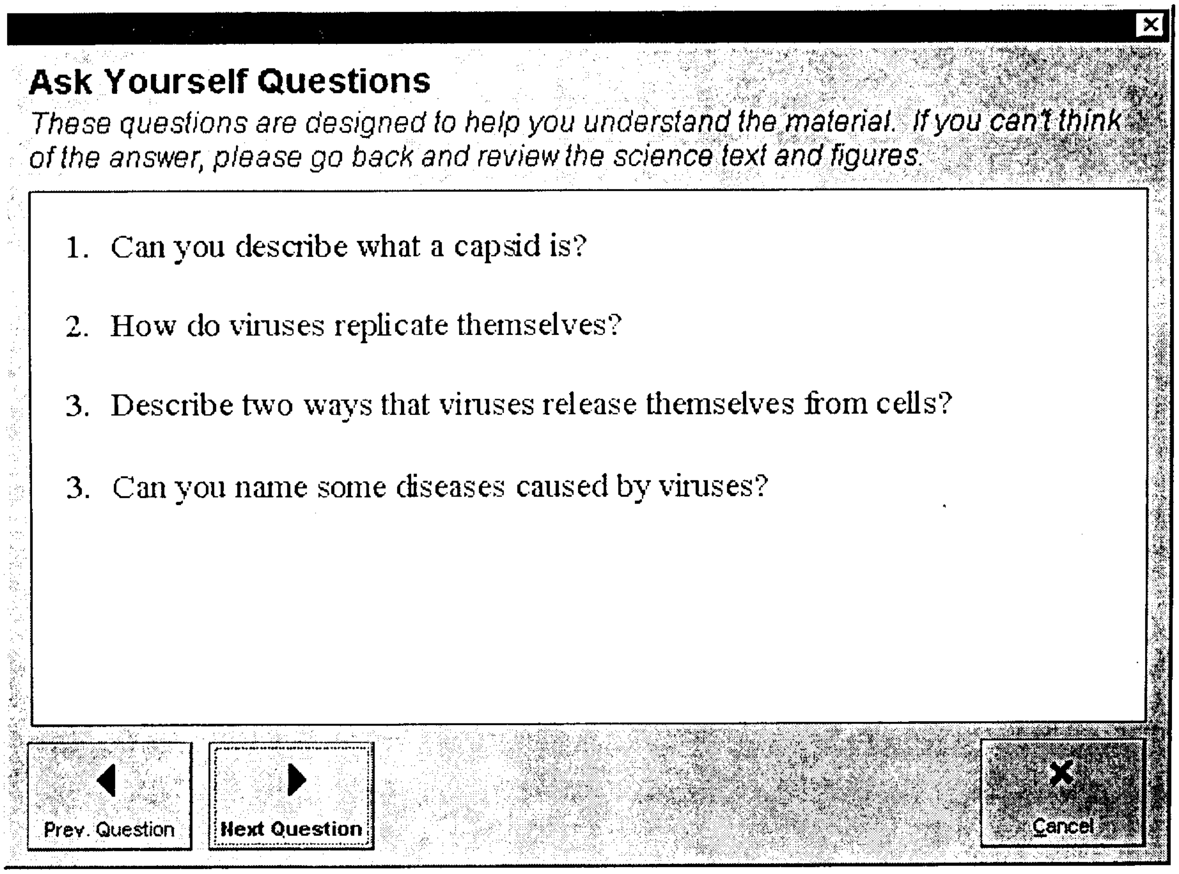

Figure 4. Questions screen from the Computerized Science Learning Task (CSLT).

Data Analyses

As in Study II, frequency histograms were generated to examine the distributions of the measures graphically. Means, standard deviations, confidence intervals about the means, and Cronbach alpha reliabilities were computed and compared to the corresponding statistics from Study II. The intercorrelations of the task measures were computed and a table of the intercorrelations across all measures was prepared. Scatterplots of pairs of measures were plotted to examine their interrelationships. A principal components analysis was computed, and its congruence was compared to the corresponding analysis from Study II. Principal components scores were then intercorrelated with the science achievement and the time and activity variables from the Computerized Science Learning Task.

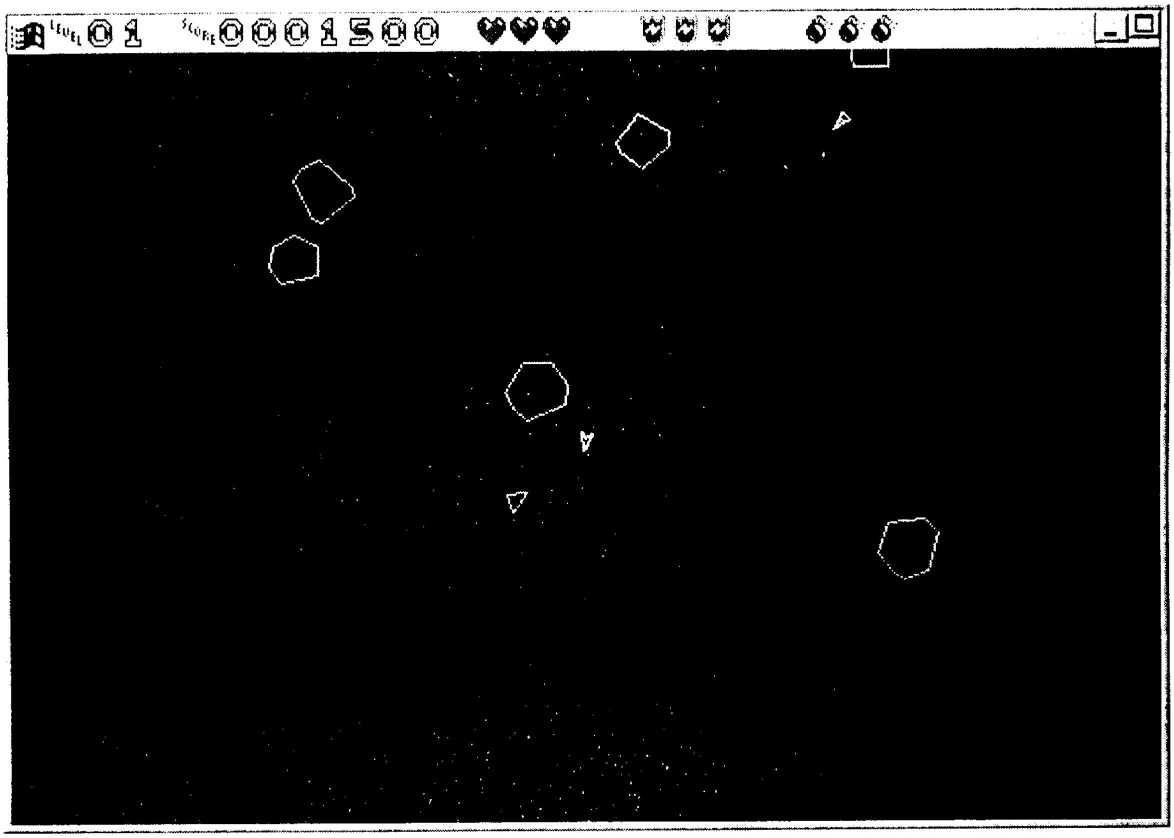

Figure 5. Asteroids screen from the Computerized Science Learning Task (CSLT).

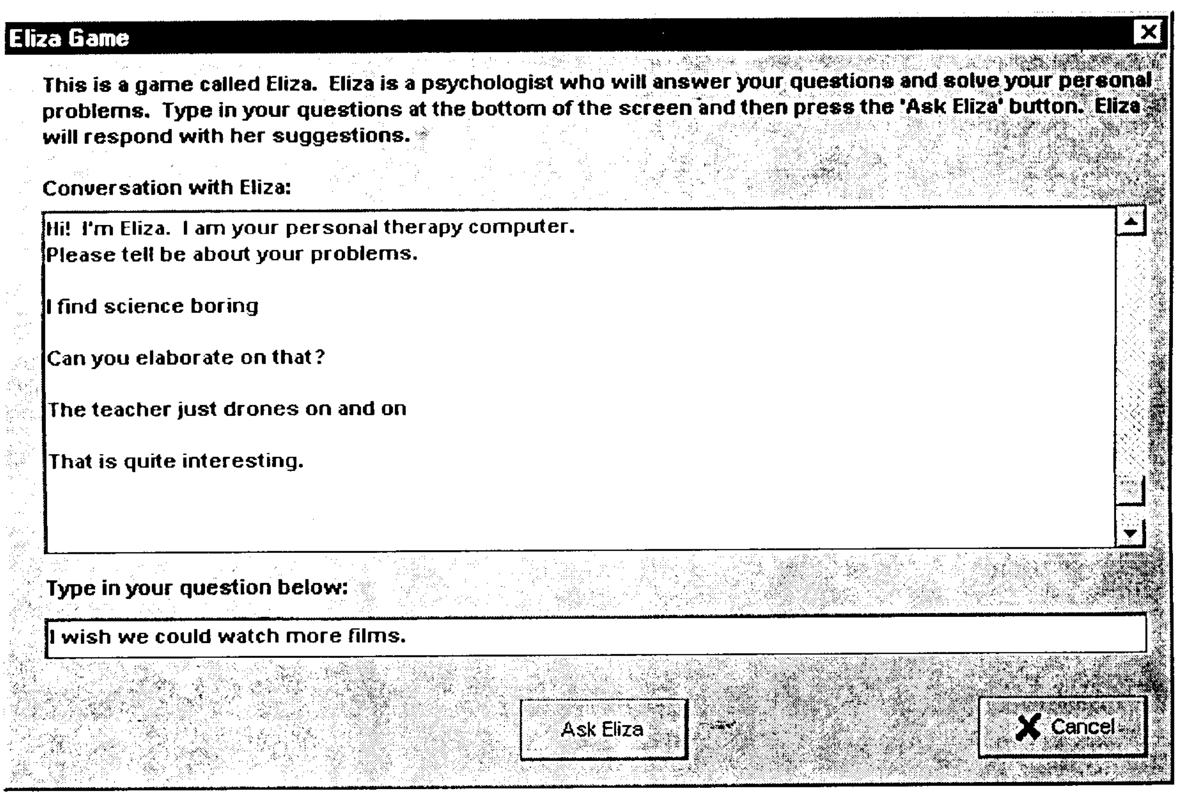

Figure 6. Eliza screen from the Computerized Science Learning Task (CSLT).

Results and Discussion

Descriptive Statistics

Frequency histograms for all questionnaire variables were plotted, and no substantial deviations from normality were found. Means, standard deviations, the 95% confidence interval for the means, reliabilities, and the number of items per scale appear in Table 15.

Reliability Analyses.

Cronbach alpha reliabilities were computed for each of the measures and appear in Table 15. The reliabilities ranged from .57 (Action Control-Failure) to .94 (MAB Vocabulary). The two Action Control measures demonstrated lower reliability (.57 and .61) than they had in Study II (.67 and .71). The remaining reliabilities were acceptable.

Correlations Among Conative Measures

The correlation matrix is presented in Table 16. Correlations among the questionnaire variables closely matched those from Study II. To compare the Study II and Study III correlations, a vector was formed from each matrix by adjoining adjacent columns. This resulted in two vectors each containing 253 correlations. To avoid any problems associated with the distributions of correlations, each of the correlations was assigned a rank. A Spearman rank order correlation was computed between the ranks. This yielded Spearman rho of .92, indicating that the patterns of the Study II and III correlation matrices were highly similar.

Another way of comparing the two matrices is to examine differences in individual correlations. Each Study III correlation was compared to its corresponding Study II correlation and the difference was tested for significance. Of the 253 correlations in each matrix, only 22 were significantly different, slightly more than the 13 differences expected by chance (α = .05). These differences and the associated p-values for Study II and III correlations are presented in Table 17.

Table 15

Means, Standard Deviations, Confidence Intervals, Reliabilities and Number of Items for Study III

Variable	Measure	Mean	*SD*	-95% Conf.	+95% Conf.	Alpha	# Items
SFPQ	Industriousness	49.35	7.88	47.62	51.09	.75	18
SCIMAST	Mastery Orientation	25.67	7.09	24.10	27.23	.92	9
SCIPERF	Performance Orientation	8.28	2.58	7.71	8.85	.78	3
SCIWORK	Work Avoidance Orientation	7.85	2.41	7.32	8.38	.72	3
INTTOT	Interest in Science Class	66.44	20.78	61.75	71.12	.91	16
INTPERS	Personal Interest in Science	16.23	7.41	14.58	17.87	.91	4
DEEP	Deep Approach	56.00	10.80	53.63	58.37	.86	16
SURFACE	Surface Approach	48.98	9.03	46.99	50.96	.73	16
STRATEG	Strategic Approach	54.91	10.64	52.58	57.25	.84	16
APATHET	Apathetic Approach	22.23	7.53	20.58	23.89	.83	8
CONFID	Academic Self-Confidence	14.45	3.02	13.79	15.12	.68	4
INTGOAL	Intrinsic Goal Orientation	18.16	6.03	16.83	19.49	.80	4
EXTGOAL	Extrinsic Goal Orientation	18.86	6.06	17.52	20.20	.75	4
ANX	Test Anxiety	22.34	7.07	20.76	23.91	.76	5
ACS_DEC	Action Control-Decision	5.48	2.40	4.94	6.01	.61	12
ACS_FAIL	Action Control-Failure	6.04	2.54	5.47	6.61	.57	12
SCICONT	Sci. Perceived Control	20.53	4.87	19.44	21.61	.71	4
SCISELFE	Sci. Self-Efficacy	35.35	10.54	33.01	37.69	.91	8
TSKSELFE	Task Self-Efficacy	14.20	4.51	13.19	15.21	.90	3
GRDSCI	Grade in Science	67.23	11.48	64.70	69.77	N.A.	1
AVGSCI	Avg. Grade in Science	69.41	9.36	67.30	71.52	N.A.	1
AVGGRD	Overall Avg. Grade	73.15	8.03	71.37	74.92	N.A.	1
MABVOC	MAB Vocabulary	15.83	5.57	14.61	17.05	.94	46

The majority of the differences were negative, indicating that where significant differences were found, Study III correlations tended to be larger than Study II correlations. In most cases, Study II and III correlations were consistent in direction. Test Anxiety and Self-Reported Grades were frequently involved in differences, even though the means and standard deviations for these variables were the same across the two studies.

Table 16

Cronbach Alpha Reliabilities and Correlations Among the Measures From Study III (N = 82)

Variable	Description	SFPQ	SCIMAST	SCIPERF	SCIWORK	INTTOT	INTPERS	DEEP	SURFACE	STRATEG	APATHET	CONFID	INTGOAL
SFPQ	Industriousness	(.75)	.54	.35	-.42	.58	.42	.55	-.21	.54	-.63	.32	.53
SCIMAST	Mastery Orient.	.65	(.92)	.60	-.39	.65	.70	.69	-.04	.54	-.70	.25	.79
SCIPERF	Performance Orient.	.46	.71	(.78)	-.16	.41	.27	.37	.19	.49	-.44	.10	.50
SCIWORK	Work Avoidance	-.57	-.48	-.21	(.72)	-.41	-.38	-.41	.33	-.28	.56	-.35	-.27
INTTOT	Interest in Sci. Class	.70	.71	.49	-.51	(.91)	.47	.43	-.03	.41	-.57	.19	.65
INTPERS	Personal Interest	.51	.77	.32	-.47	.52	(.91)	.48	-.11	.33	-.51	.24	.56
DEEP	Deep Approach	.68	.78	.45	-.52	.49	.54	(.86)	-.21	.60	-.58	.37	.62
SURFACE	Surface Approach	-.28	-.05	.25	.46	-.04	-.13	-.26	(.73)	.14	.38	-.29	-.06
STRATEG	Strategic Approach	.68	.61	.61	-.36	.47	.38	.71	.18	(.84)	-.51	.42	.43
APATHET	Apathetic Approach	-.80	-.80	-.55	.72	-.66	-.59	-.69	.49	-.61	(.83)	-.43	-.55
CONFID	Acad. Self-Conf.	.45	.32	.14	-.50	.24	.31	.48	-.41	.56	-.57	(.68)	.23
INTGOAL	Intr. Goal Orient.	.68	.92	.68	-.36	.76	.66	.75	-.08	.52	-.67	.31	(.80)
EXTGOAL	Extr. Goal Orient.	.57	.84	1.00	-.41	.69	.58	.59	.28	.71	-.68	.14	.74
ANX	Test Anxiety	.13	.30	.60	.18	.34	.07	.11	.66	.24	-.10	-.32	.56
ACS_DEC	Action Control-Dec.	-.44	-.32	-.10	.45	-.31	-.17	-.41	.46	-.70	.62	-.68	-.30
ACS_FAIL	Action Control-Fail.	-.17	.08	.28	.08	.10	-.04	.01	.48	-.01	.15	-.32	.12
SCICONT	Sci. Perceived Control	.40	.49	.46	.07	.41	.36	.59	.06	.41	-.39	.22	.46
SCISELFE	Sci. Self-Efficacy	.40	.66	.46	-.20	.54	.58	.53	-.11	.55	-.56	.60	.69
TSKSELFE	Task Self-Efficacy	.45	.71	.50	-.27	.57	.72	.58	-.14	.47	-.62	.52	.70
GRDSCI	Grade in Science	.42	.46	.51	-.37	.37	.37	.25	-.12	.39	-.47	.36	.40
AVGSCI	Avg. Grade in Sci.	.30	.35	.26	-.45	.21	.44	.22	-.29	.02	-.42	.17	.18
AVGGRD	Overall Avg. Grade	.58	.20	.28	-.38	.31	.16	.36	-.16	.29	-.48	.41	.09
MABVOC	MAB Vocabulary	.07	.02	-.02	-.07	-.11	.13	.14	-.34	-.14	.02	.08	-.02

Table 16 (continued)

Variable	Description	EXTGOAL	ANX	ACS_DEC	ACS_FAIL	SCICONT	SCISELFE	TSKSELFE	GRDSCI	AVGSCI	AVGGRD	MABVOC
SFPQ	Industriousness	.43	.10	-.30	-.11	.29	.33	.37	.36	.26	.50	.06
SCIMAST	Mastery Orient.	.70	.25	-.24	.06	.40	.60	.65	.44	.34	.19	.02
SCIPERF	Performance Orient.	.81	.46	-.07	.19	.34	.39	.42	.45	.23	.25	-.02
SCIWORK	Work Avoidance	-.30	.13	.30	.05	.05	-.16	-.22	-.31	-.38	-.32	-.06
INTTOT	Interest in Sci. Class	.57	.28	-.23	.07	.33	.49	.52	.35	.20	.30	-.10
INTPERS	Personal Interest	.48	.06	-.13	-.03	.29	.53	.65	.35	.42	.15	.12
DEEP	Deep Approach	.47	.09	-.30	.01	.46	.47	.51	.23	.20	.33	.13
SURFACE	Surface Approach	.21	.49	.31	.31	.04	-.09	-.11	-.10	-.25	-.14	-.28
STRATEG	Strategic Approach	.56	.19	-.50	-.01	.32	.48	.41	.36	.02	.27	-.12
APATHET	Apathetic Approach	-.54	-.08	.44	.10	-.30	-.49	-.54	-.43	-.38	-.44	.02
CONFID	Acad. Self-Conf.	.10	-.23	-.44	-.20	.15	.47	.41	.30	.14	.34	.06
INTGOAL	Intr. Goal Orient.	.57	.44	-.21	.08	.35	.59	.59	.36	.16	.08	-.02
EXTGOAL	Extr. Goal Orient.	(.75)	.42	-.11	.18	.38	.45	.50	.44	.23	.26	-.02
ANX	Test Anxiety	.56	(.76)	.22	.28	.28	.18	.16	.11	-.09	-.01	-.28
ACS_DEC	Action Control-Dec.	-.16	.32	(.61)	.27	-.01	-.21	-.22	-.09	.00	-.08	.15
ACS_FAIL	Action Control-Fail.	.28	.43	.46	(.57)	.07	-.12	.00	-.18	-.15	-.10	.04
SCICONT	Sci. Perceived Control	.52	.38	-.02	.11	(.71)	.49	.56	.19	.22	.04	-.04
SCISELFE	Sci. Self-Efficacy	.54	.22	-.28	-.17	.61	(.91)	.69	.52	.38	.16	-.10
TSKSELFE	Task Self-Efficacy	.61	.19	-.30	.00	.70	.76	(.90)	.32	.44	.11	.05
GRDSCI	Grade in Science	.51	.13	-.12	-.18	.23	.55	.34	(NA)	.49	.36	.03
AVGSCI	Avg. Grade in Sci.	.27	-.10	.00	-.15	.26	.40	.46	.49	(NA)	.34	.26
AVGGRD	Overall Avg. Grade	.30	-.01	-.10	-.10	.05	.17	.12	.36	.34	(NA)	.15
MABVOC	MAB Vocabulary	-.02	-.33	.20	.04	-.05	-.11	.05	.03	.26	.15	(.94)

Note. Correlations below the diagonal were corrected for attenuation caused by unreliability in the measures. Cronbach alpha reliabilities appear in parentheses in the diagonal. Reliabilities for self-reported grades (GRDSCI, AVGSCI, and AVGGRD) were not computed because these were based on one item. Correlations were computed using pairwise deletion, so *N*s range from 76 to 82 due to missing data for some cases. r_{05} approximately = .23 (for N = 82).

Table 17

Differences Between Study II and Study III Correlations

Variable 1	Variable 2	Diff.	Study II *r*	Study III *r*	*p*-value
Interest in Science Class	Test Anxiety	-.48	-.20	.28	.001
Test Anxiety	Grade in Science	-.39	-.28	.11	.01
Surface Approach	Strategic Approach	-.37	-.23	.14	.01
Surface Approach	Sci. Self-Efficacy	-.33	-.42	-.09	.01
Performance Orientation	Test Anxiety	-.32	.14	.46	.01
Mastery Orientation	Test Anxiety	-.28	-.03	.25	.05
Industriousness	Interest in Science Class	-.27	.31	.58	.01
Personal Interest in Science	Task Self-Efficacy	-.27	.38	.65	.01
Test Anxiety	Sci. Perceived Control	-.27	.01	.28	.03
Industriousness	Sci. Perceived Control	-.26	.03	.29	.05
Interest in Science Class	Surface Approach	-.26	-.29	-.03	.05
Surface Approach	Intrinsic Goal Orientation	-.25	-.31	-.06	.05
Interest in Science Class	Extrinsic Goal Orientation	-.24	.33	.57	.05
Mastery Orientation	Task Self-Efficacy	-.20	.45	.65	.05
Interest in Science Class	Intrinsic Goal Orientation	-.19	.46	.65	.05
Academic Self-Confidence	Grade in Science	.23	.53	.30	.05
Grade in Science	Overall Avg. Grade	.23	.59	.36	.05
Grade in Science	Avg. Grade in Science	.29	.78	.49	.001
Avg. Grade in Science	Overall Avg. Grade	.29	.63	.34	.01
Academic Self-Confidence	Avg. Grade in Science	.31	.45	.14	.01
Strategic Approach	Avg. Grade in Science	.34	.36	.02	.01

Note. This table shows all the correlations found in Study III that were significantly different from their Study II counterparts. The first two columns (marked Variable 1 and Variable 2) indicate the pair of variables that formed the correlation. Diff. refers to the difference formed by subtracting each Study III correlation from its corresponding Study II correlation.

Principal Components Analysis of Study II and Study III Data

It is normally inappropriate to conduct an exploratory principal components analysis on data from a sample of 82. However, a principal components analysis was conducted despite this small sample size for two reasons. First, this analysis had already been conducted on the larger Study II sample. If the Study II components were replicated in Study III, this would provide evidence that the Study II components would generalize to other samples of students. Second, one of the aims of using principal components was as a means of data reduction. By reducing the set of the 23 variables common to Study II and III to a smaller number of orthogonal components, relationships between the components and the learning activity and science achievement outcome variables could be more easily interpreted.

A principal components analysis of the 23 variables common to Study II and Study III was computed using the Study III data. The resulting component loading matrix was rotated by varimax. The Study III principal components analysis could be considered a replication of the Study II analysis (and vice versa). Consequently, it was considered appropriate to evaluate the degree of congruence between the principal components solutions from the two studies.

It is well known that varimax rotations of two matrices containing the same variables will not necessarily yield an optimal level of congruence. This is partly because varimax rotation employs a somewhat arbitrary algorithm for maximizing a power of the component loadings within a given sample. Also, sample-specific properties of the error variance might operate to affect the ordering and patterning of the component loadings. Accordingly, a procedure was employed in which the component solution from one study (Study II) was rotated to maximize its congruence in a least squares sense with the varimax rotated solution for the alternative study (Study III). Similarly, the component matrix from Study III was rotated so that its rotated solution was maximally congruent with the varimax solution for Study II. In both cases the orthogonal procrustes procedure of Schönemann (1966) was employed. The procrustes-rotated component loading matrix for Study III is presented in Table 18.

Because procrustes rotation has been criticized for the possibility that it capitalizes on chance (Horn, 1967; Humphries, Ilgen, McGrath, & Montanelli, 1969), a procedure developed by Paunonen (personal communication, 1996) was employed for determining the degree to which a given procrustes rotation departs from expectations based on chance. This procedure involves the rotation of the component matrix to 1000 randomly-designated targets. Within each component, the scales expected to have high values based on the designated target were permuted 1000 times. These new randomly ordered targets in turn served as the target for the 1000 procrustes rotations. A total of 1000 sets of congruence coefficients (Harman, 1976, pp. 343-346) were in turn computed between the two component matrices, one set for each of the 1000 rotations to a random target. Next, means and standard deviations of the congruence

Table 18

Principal Components Analysis of Study III Data (N = 82) Rotated Based on an Orthogonal Procrustes Targeted Rotation Using the Component Matrix From Study II as the Target

Variable	Measure	I	II	III	IV	V	VI	VII
SPFQ	Industriousness	.54	-.22	.20	.10	.35	.33	.17
DEEP	Deep Approach	.61	.06	.14	.43	.38	.11	.19
STRATEG	Strategic Approach	.74	-.04	.25	.30	-.01	.26	-.24
ACS_DEC	Action Control-Dec.	-.59	.47	-.04	-.09	-.15	.22	.29
SURFACE	Surface Approach	-.05	.51	-.10	-.06	-.40	.39	-.39
ANX	Test Anxiety	.02	.46	-.10	.06	.04	.60	-.36
ACS_FAIL	Action Control-Fail.	.20	.65	-.28	-.13	-.04	.19	.19
CONFID	Acad. Self-Conf.	.47	-.19	.51	.32	.07	-.33	-.13
GRDSCI	Grade in Science	-.07	-.21	.72	.15	.20	.43	-.07
AVGSCI	Avg. Grade in Sci.	.01	-.09	.68	.14	.42	.19	.27
AVGGRD	Overall Avg. Grade	.38	.01	.67	-.19	.03	.20	.27
SCICONT	Sci. Perceived Control	.14	.16	.01	.75	.09	.24	.04
SCISELFE	Sci. Self-Efficacy	.12	-.12	.31	.67	.32	.25	-.22
SCIMAST	Mastery Orient	.35	.09	.19	.34	.64	.40	-.05
SCIWORKA	Work Avoidance	-.43	.17	-.30	.32	-.54	.00	-.08
INTTOT	Interest in Sci. Class	.35	-.08	.02	.11	.55	.48	-.07
INTPERS	Personal Interest	.10	.07	.25	.30	.70	.16	.04
APATHET	Apathetic Approach	-.50	.20	-.33	-.13	-.56	-.21	.01
INTGOAL	Intr. Goal Orient.	.30	.11	.01	.36	.63	.38	-.12
SCIPERF	Performance Orient.	.30	.23	.32	.17	.08	.66	-.06
EXTGOAL	Extr. Goal Orient.	.37	.23	.26	.16	.28	.65	-.07
TSKSELFE	Task Self-Efficacy	.23	-.54	-.14	.14	-.22	.54	.39
MABVOCAB	MAB Vocabulary	-.02	.23	.27	.07	.06	-.25	.75

Note. The first seven eigenvalues for the unrotated components are 8.10, 2.90, 1.65, 1.31, 1.20, 1.07, .97. The highest loading for each variable is marked.

coefficients between the component loadings of the two component matrices were computed and compared with those derived from the original analysis in which the targeted rotations were compared. This comparison permitted a significance test between the component congruence coefficients derived from the targeted rotation and those based on rotations to random targets, thus permitting an evaluation of the null hypothesis that the components derived from Study II and Study III are congruent only within the limits expected by chance.

Computation of congruence coefficients between the respective factors derived from Study II and Study III supports what is apparent from inspection, namely, that they are highly similar, ranging from .74 to .93. These are presented in Table 19. Also presented are the results of a procrustes rotation to a set of 1000 random targets based on a permutation of each component in the target matrix. All seven components yielded congruences different from those based on random targets at the .05 level.

The analysis to compare component similarity was also conducted in the opposite direction; that is, the rotated factor matrix derived from Study III served as the target for rotating the factor matrix from Study II. Results showed similar levels of congruence and significance and are not presented.

Discussion of Study II and Study III Principal Components Analysis

Study III replicated the seven principal components found in Study II on a different sample of high school students. This supported Hypothesis 1 by showing that the more speculative conative constructs included in this study could not be accounted for by the more established constructs of achievement motivation, anxiety, and ability. It also suggests that the correlational structure found in Study II will generalize to other, similar samples of students. Given the similarity between the Study II and Study III data, an additional principal

Table 19

Congruence Coefficients Obtained for Targeted and Randomly-Rotated Components

Component	Targeted rotation	Random rotation (Mean)	Random rotation (*sd*)
Component I	.93	.54	.12
Component II	.85	.54	.15
Component III	.93	.58	.12
Component IV	.86	.61	.09
Component V	.91	.56	.14
Component VI	.86	.63	.09
Component VII	.74	.43	.12

Note. For each of the seven components, congruence coefficients for the targeted rotation are more than two standard deviations outside the mean congruence coefficients for the random rotations ($p < .05$).

components analysis with varimax rotation was conducted on the combined Study II and III data (*N* = 277). This analysis also yielded the same seven components and is presented in Appendix F.

Computerized Science Learning Task (CSLT) Variables

Descriptive statistics. Descriptive statistics for the dependent variables from the Computerized Science Learning Task are presented in Table 20. Of the original 82 subjects, 27 could not participate in the CSLT portion of the study due to other school-related commitments; therefore, *N* for the CSLT variables was 55. Frequency histograms were plotted for each of the CSLT variables. The variables had normal distributions, with the exceptions of DICTNUM (number of words looked up in the dictionary) and QUESTIME (amount of time spent viewing comprehension monitoring questions), both of which were slightly negatively skewed. Square root transformations of these variables were created, but did not substantially affect the correlations or other statistics, so results are reported using the original DICTNUM and QUESTIME variables.

Table 20

Means, Standard Deviations, and Confidence Intervals for CSLT Variables

Variable	Description	Mean	*SD*	-95% Conf.	+95% Conf.
PANNUM	Number of times science screens viewed	30.05	16.47	25.60	34.51
FIGNUM	Number of times figures were viewed	6.84	6.47	5.09	8.58
DICTNUM	Number of words looked up in dict.	11.49	15.76	7.23	15.75
QUESNUM	Number of self-test questions asked	2.91	4.56	1.68	4.14
ELIZNUM	Number of times Eliza was played	27.22	39.32	16.59	37.85
ASTNUM	Number of times Asteroids was played	1.87	1.69	1.42	2.33
PANTIME	Total time spent on the science text	694	343	601	786
FIGTIME	Total time spent on the figures	102	121	69	134
DICTTIME	Total time spent looking up words	88	145	49	127
QUESTIME	Total time spent on self-test questions	31	42	20	43
ELIZTIME	Total time spent playing Eliza	250	285	173	327
ASTTIME	Total time spent playing Asteroids	315	389	209	420
TOTTIME	Total time spent on task	1479	375	1378	1581
GAMETIME	Total time spent playing games	565	510	427	703
SCITIME	Total time spent learning science	915	464	789	1040

Note. All times are reported in seconds.

Correlations among CSLT variables. The correlations among the CSLT variables are presented in Table 21. Some of the correlations originate from the nature of the task itself. For example, in the time available, students could elect to play games or study science, but investing more time in one activity left less time remaining for the other activity. Hence, the -.71 correlation between the amount of time spent playing games (GAMETIME) and the amount of time spent studying science (SCITIME) should be interpreted with this in mind. The correlations presented in Table 21 are not corrected for unreliability. It was not possible to estimate reliabilities for these variables because each participant's sequence of activities in the task could be highly idiosyncratic. The correlations did, however, form meaningful patterns. Learning related activities formed a positive manifold. For example, the amount of time spent studying science text correlated .44 with the amount of time spent examining the figures.

Science Achievement Assessment

Frequency distributions for the assessment of science achievement (SCITEST) were plotted and were found to be slightly negatively skewed. A new, normally-distributed variable (SQRTSCI) was created by taking a square root transformation of SCITEST. The science assessment had a high ceiling, with a maximum possible score of 102, although students were not expected to reach this score. Scores ranged from 2 to 86, with a mean score of 31.82 and standard deviation of 22.90. The mean of SQRTSCI was 5.26 with a standard deviation of 2.05. The assessment was highly reliable, with a Cronbach alpha reliability of .89 computed across the 20 questions comprising the test.

Relationships Between Science Achievement and the Aptitude Variables

Both SCITEST and SQRTSCI were correlated with each of the aptitude variables, and both yielded a similar pattern of correlations. Both corrected and uncorrected correlations are presented in Table 22. Most of the correlations were significant, with those involving Industriousness (r_{adj} = .73), Average Grade in Science (r_{adj} = .69), Deep Approach (r_{adj} = .62), Mastery Orientation (r_{adj} = .61), and Personal Interest (r_{adj} = .59) among the highest positive correlations. Surface Approach (r_{adj} = -.65), Work Avoidance Orientation (r_{adj} = -.67), and Apathetic Approach (r_{adj} = -.70) showed the highest negative correlations. Seven of the conative correlations were larger than the correlation between MAB Vocabulary and Science Achievement (SCITEST) (r_{adj} =.52).

Table 21

Uncorrected Correlations Among the Task Measures From Study III (N = 55)

Variable	Description	TOTTIME	GAMETIME	SCITIME	PANTIME	FIGTIME	DICTTIME	QUESTIME	ELIZTIME	ASTTIME	PANNUM	FIGNUM	DICTNUM	QUESNUM	ELIZNUM
GAMETIME	Time playing Games	.48													
SCITIME	Time Spent on Science	.27	-.71												
PANTIME	Time on Text Panels	.21	-.68	.92											
FIGTIME	Time on Figures	.16	-.44	.62	.44										
DICTTIME	Time using Dictionary	.15	-.29	.44	.14	.12									
QUESTIME	Time on Questions	.38	.03	.27	.26	-.01	-.03								
ELIZTIME	Time playing ELIZA	.33	.65	-.45	-.42	-.35	-.19	.05							
ASTTIME	Time playing Asteroids	.39	.83	-.60	-.59	-.33	-.25	.00	.13						
PANNUM	Number Panels viewed	.34	.07	.19	.19	.03	.06	.33	.30	-.13					
FIGNUM	Number Figures viewed	.15	-.35	.50	.32	.86	.13	.07	-.25	-.28	.19				
DICTNUM	No. times Dict. used	.34	-.13	.42	.18	.18	.73	.11	.01	-.17	.32	.24			
QUESNUM	No. times Quest. used	.43	.19	.14	.08	-.02	.03	.85	.20	.10	.41	.11	.24		
ELIZNUM	No. times ELIZA played	.26	.63	-.48	-.52	-.28	-.06	-.01	.79	.24	.27	-.09	.09	.17	
ASTNUM	No. times Aster. played	.20	.68	-.58	-.57	-.32	-.24	-.07	.28	.68	.12	-.19	-.05	.05	.34

Note. r_{05} approximately = .32 (for N = 55).

Table 22

Correlations Between the Science Achievement Assessment and the Aptitude Variables

Variable	Description	r_{adj} SCITEST	r_{adj} SQRTSCI	r SCITEST	r SQRTSCI	$r_{partial}$ SCITEST
SFPQ	Industriousness	.73	.72	.60	.59	.51
AVGSCI	Avg. Grade in Science	.69	.69	.65	.65	.47
DEEP	Deep Approach	.62	.56	.54	.49	.40
SCIMAST	Mastery Orientation	.61	.61	.55	.55	.49
INTPERS	Personal Interest in Science	.59	.58	.53	.52	.40
INTGOAL	Intrinsic Goal Orientation	.56	.52	.47	.44	.40
EXTGOAL	Extrinsic Goal Orientation	.55	.54	.45	.44	.40
MABVOC	MAB Vocabulary	.52	.52	.48	.48	-.23
SCIPERF	Performance Orientation	.49	.48	.41	.40	.37
AVGGRD	Overall Avg. Grade	.49	.47	.46	.44	.21
INTTOT	Interest in Science Class	.44	.44	.40	.40	.41
SCICONT	Sci. Perceived Control	.43	.43	.34	.34	.34
GRDSCI	Grade in Science	.38	.39	.36	.37	.32
SCISELFE	Sci. Self-Efficacy	.31	.28	.28	.25	.31
STRATEG	Strategic Approach	.22	.19	.19	.16	.23
CONFID	Academic Self-Confidence	.21	.15	.16	.12	.10
TSKSELFE	Task Self-Efficacy	.09	.09	.08	.08	.09
ACS_FAIL	Action Control-Failure	-.18	-.17	-.13	-.12	-.13
ANX	Test Anxiety	-.19	-.22	-.16	-.18	.03
ACS_DEC	Action Control-Decision	-.24	-.20	-.18	-.15	-.23
SURFACE	Surface Approach	-.65	-.67	-.52	-.54	-.26
SCIWORK	Work Avoidance Orientation	-.67	-.67	-.54	-.54	-.41
APATHET	Apathetic Approach	-.70	-.69	-.60	-.59	-.51

Note. Correlations appearing in the two columns marked by r_{adj} were corrected for attenuation caused by unreliability in the conative and science achievement measures. $r_{partial}$ refers to the Science Achievement Test (SCITEST) with MAB Vocabulary variance partialled out by regression procedures. r_{05} approximately = .32 (for $N = 55$).

Another view of the relationships between science achievement and the aptitude variables can be observed in the correlations between Science Achievement (SCITEST) and component scores calculated based on the combined Study II and III principal components analysis (see Table 23). These components are orthogonal, so each of these correlations can be interpreted as

Table 23

Correlations Between the Science Achievement Assessment and the Principal Components Scores

Variable	Description	SCITEST	SQRTSCI
Component I	Pursuit of Excellence	.19	.15
Component II	Evaluation Anxiety	.03	.03
Component III	Self-Reported Grades	.33	.34
Component IV	Science Confidence	.00	-.02
Component V	Science Interest vs. Science Avoidance	.65	.66
Component VI	Performance Orientation	.36	.37
Component VII	Verbal Ability	.50	.52

Note. The scoring coefficients for the principal components scores were calculated using combined Study II and III data. r_{05} approximately = .32 (for N = 55).

reflecting the unique shared variance between the component and science achievement. The results were similar for Science Achievement (SCITEST) and the square root transformation of Science Achievement (SQRTSCI), so the results involving the untransformed variable will be discussed here.

The highest correlation was found between Science Interest vs. Science Avoidance and Science Achievement (r = .65). Students who regarded science as interesting, enjoyable, and meaningful were much better at recalling computer-presented science material. Students who wished to avoid science work and who regarded science as irrelevant, boring, and uninteresting performed poorly on the science achievement assessment. There have been relatively few studies that investigated recall performance for passages varying in interest. Even fewer studies have measured both personal interest (long-standing, stable, individual interest) and situational interest (interestingness of specific situations) in a common sample of students (Hidi, 1990; but see Renninger, 1990). Higher recall performance for personally interesting passages has been found previously with elementary students (Estes & Vaughan, 1973), high school students (Schiefele, 1992) and college students (Fransson, 1977; Schiefele & Krapp, 1988).

The data reported here are consistent with these studies. The zero-order correlations involving interest showed that both Personal Interest in Science (r_{adj} = .59) and Situational Interest in Science Class (r_{adj} = .44) correlated with

Science Achievement. However, these two constructs were not highly intercorrelated (r_{adj} = .52, r = .47). This suggests that Personal Interest in Science and Situational Interest in Science Class are different interest constructs, both of which bear on science achievement.

The next highest correlation was found between the verbal ability component and Science Achievement (SCITEST) (r = .50). This correlation is not surprising, given the well-established relationship between verbal ability and the recall of text.

The Performance Orientation component correlated .36 with Science Achievement. In this sample, students who were motivated to impress others or achieve high grades performed well on the science test. The zero-order correlations between Science Achievement and Extrinsic Orientation (r_{adj} = .49) and Performance Orientation (r_{adj} = .55) were also moderate. A performance orientation has been associated with superficial engagement in classroom activities (Elliott & Dweck, 1988). Nolen (1988) found that task-oriented students used "deeper" learning strategies, whereas ego-oriented students used strategies that were effective for short-term retention of information for a test. Given the short learning time in Study III, it is not surprising that students scoring highly on Performance Orientation performed better on the science assessment. The use of "rehearsal" strategies associated with a performance orientation may have been effective for learning the material presented in the computerized task.

The principal components analysis did not define a learning goal orientation component. Nonetheless, Study III found moderate zero-order correlations between Science Achievement and the two learning goal orientation measures, Mastery Orientation (r_{adj} = .61) and Intrinsic Goal Orientation (r_{adj} = .56). In summary, the data reported in Study III show that both learning and performance goal orientations are correlated with Science Achievement, but that these orientations themselves are substantially intercorrelated.

The Self-Reported Grades component correlated .33 with Science Achievement. Students who reported performing well in their science and other classes scored higher on the science recall measure. Nonsignificant correlations were found between Science Achievement and the three remaining components: Pursuit of Excellence (r = .19), Evaluation Anxiety (r = .03), and Science Confidence (r = .00). However, zero-order correlations involving many of the variables that defined these components were significantly correlated with Science Achievement (see Table 22).

In summary, Hypothesis 2 was supported. Scores on the conative constructs were correlated with Science Achievement. Principal components scores defined by the conative variables, particularly Self-Reported Grades, Science Interest vs. Avoidance, and Extrinsic Orientation, were correlated with Science Achievement. These components were orthogonal to the Verbal Ability component, which also correlated with Science Achievement. These data provide empirical support that the conative variables are correlated with Science Achievement independently of verbal ability.

Correlations Between Science Achievement and the CSLT Variables

Support was found for Hypothesis 3, which posited relationships between Science Achievement and the CSLT variables. These data are presented in Table 24. As expected, students who spent more time learning the science material by reading the science text and studying the figures performed better on the science test. Students who chose to play games performed less well. The total amount of time students spent on the CSLT was uncorrelated with their performance. Surprisingly, the amount of time spent viewing computer-presented comprehension testing questions was not correlated with performance on the science test.

The activity variables were also correlated with Science Achievement. The number of figures viewed correlated .41 with Science Achievement. The number of times students played Eliza (r = -.35) or Asteroids (r = -.44) also correlated with Science Achievement. Unlike its corresponding time variable, the number of science panels viewed was not significantly correlated with Science Achievement (r = .08). This was probably because students who played games returned to science panels between games. The pattern of data found here supports Hypothesis 3.

The strongest relationships involved the two aggregate time variables, time spent studying science (r = .52) and time spent playing games (r = -.50). The implication of these findings is that the learning choices students made during the computerized learning task, particularly in how they allocated their time, had a profound impact on their subsequent performance on the science test.

Table 24

Correlations Between the Science Achievement Assessment and the CSLT Variables

Variable	Description	SCITEST	SQRTSCI
SCITIME	Total time spent learning science	.52	.53
PANTIME	Total time spent on the science text	.49	.50
FIGTIME	Total time spent on the figures	.45	.44
FIGNUM	Number of times figures were viewed	.41	.38
SCINUM	Number of science-related activities	.22	.19
DICTNUM	Number of words looked up in dict.	.19	.18
DICTTIME	Total time spent looking up words	.13	.15
PANNUM	Number of times science screens viewed	.08	.05
QUESTIME	Total time spent on self-test questions	.00	.00
TOTTIME	Total time spent on task	-.04	-.04
QUESNUM	Number of self-test questions asked	-.05	-.07
TOTNUM	Total science and game activities	-.14	-.18
ASTTIME	Total time spent playing Asteroids	-.35	-.36
ELIZNUM	Number of times Eliza was played	-.35	-.37
GAMENUM	Total number of game activities	-.36	-.39
ELIZTIME	Total time spent playing Eliza	-.42	-.43
ASTNUM	Number of times Asteroids was played	-.44	-.46
GAMETIME	Total time spent playing games	-.50	-.51

Note. r_{05} approximately = .32 (for N = 55). SCITIME is the sum of PANTIME, FIGTIME, DICTTIME, and QUESTIME. GAMETIM is the sum of ASTTIME and ELIZTIME. TOTTIME is the sum of SCITIME and GAMETIM.

Correlations Between the Aptitude Variables and Aggregate CSLT Variables

Hypothesis 4 stated that there would be relationships between students' aptitude and their activities and allocation of time during the task. These relationships were evaluated by correlating the aggregated CSLT variables (SCITIME, SCINUM, GAMETIME, and GAMENUM) with the aptitude variables. The correlations are presented in Table 25 and support Hypothesis 4. Students with high scores on Deep Approach to Learning, Intrinsic Goal Orientation, Perceived Control Over Science, Industriousness and Interest in Science, among others, spent more time studying science and less time playing games. Students

Table 25

Correlations Between the Aptitude Variables and Selected CSLT Activity Variables.

	Corrected correlations				Uncorrected correlations			
	SCITIME	SCINUM	GAMETIME	GAMENUM	SCITIME	SCINUM	GAMETIME	GAMENUM
DEEP	.51	.56	-.42	-.18	.47	.52	-.39	-.17
INTGOAL	.47	.39	-.38	-.19	.42	.35	-.34	-.17
SCICONT	.46	.40	-.53	-.34	.39	.34	-.45	-.29
SFPQ	.45	.50	-.31	-.14	.39	.43	-.27	-.12
INTTOT	.43	.40	-.35	-.07	.41	.38	-.33	-.07
SCIMAST	.36	.29	-.35	-.21	.35	.28	-.34	-.20
EXTGOAL	.36	.42	-.47	-.22	.31	.15	-.41	-.19
AVGSCI	.34	.18	-.37	-.36	.34	.18	-.37	-.36
STRATEG	.33	.49	-.27	.03	.30	.45	-.25	.03
INTPERS	.24	.28	-.28	-.13	.23	.27	-.27	-.12
GRDSCI	.23	.09	-.24	-.19	.23	.09	-.24	-.19
AVGGRD	.23	.18	-.28	-.08	.23	.18	-.28	-.08
TSKSELFE	.21	.11	-.30	.06	.20	.10	-.28	.06
SCISELFE	.20	.43	-.23	-.12	.19	.41	-.22	-.11
SCIPERF	.16	.05	-.42	-.31	.14	.04	-.37	-.27
ANX	.13	-.07	-.16	-.24	.11	-.06	-.14	-.21
CONFID	.12	.51	.02	.30	.10	.42	.02	.25
MABVOC	-.04	-.08	-.09	-.04	-.04	-.08	-.09	-.04
ACS_FAIL	-.23	-.32	.04	-.23	-.17	-.24	.03	-.17
SURFACE	-.27	-.15	.21	.13	-.23	-.13	.18	.11
ACS_DEC	-.35	-.41	.10	-.26	-.27	-.32	.08	-.20
SCIWORK	-.37	-.19	.27	.02	-.31	-.16	.23	.02
APATHET	-.46	-.35	.49	.22	-.42	-.32	.45	.20

Note. Correlations were corrected for attenuation due to unreliability in the measurement of the aptitude variables only (except grades). Reliability estimates for the activity variables could not be computed because students' experience with the CSLT did not involve separate "trials" or items. r_{05} approximately = .32 (for N = 55).

high in Apathetic Approach and Work Avoidance showed the opposite pattern; that is, they played more games and spent less time studying science. Performance on MAB Vocabulary was uncorrelated with any of the time or activity variables from the computerized science task.

The correlations between the principal components scores and the time and activity variables are presented in Table 26. Pursuit of Excellence, which had not been correlated with Science Achievement, correlated with time spent studying

Table 26

Correlations Between the Principal Components Scores and Selected CSLT Activity Variables

Variable	Description	Uncorrected correlations SCITIME	SCINUM	GAMETIM	GAMENUM
Component I	Pursuit of Excellence	.36	.34	-.20	-.08
Component II	Evaluation Anxiety	-.04	-.05	-.03	-.22
Component III	Self-reported Grades	.12	.11	-.13	-.20
Component IV	Science Confidence	.22	.32	-.31	-.20
Component V	Science Interest vs. Science Avoidance	.26	.19	-.23	-.18
Component VI	Performance Orientation	.38	.06	-.48	-.37
Component VII	Verbal Ability	.02	-.10	-.20	-.10

Note. The scoring coefficients for the principal components scores were calculated using combined Study II and III data. r_{05} approximately = .32 (for N = 55).

science (r = .36). Students who valued hard work rather than play, enjoyed challenge, and maintained high standards in their work invested more time in studying science. Performance Orientation was correlated with time spent studying science (r = .38), and negatively correlated with both the frequency of game playing (r = -.37) and the amount of time spent playing games (r = -.48). This finding was surprising because a Performance Orientation is often considered maladaptive as it is associated with lower levels of cognitive engagement. Here, students with high scores on Performance Orientation invested more time studying science and less time playing games. Perhaps students seeking to achieve high scores on the science assessment decided that playing games would be counterproductive, so they avoided them. The set of relationships involving science achievement, learning task activities, and the seven component scores is depicted graphically in Figure 7.

The implication of these findings is that the conative variables predicted whether students chose to spend their time studying or playing games, but verbal ability did not. This is an important source of validity evidence for the conative measures because it makes it difficult to argue that ability can account for these relationships.

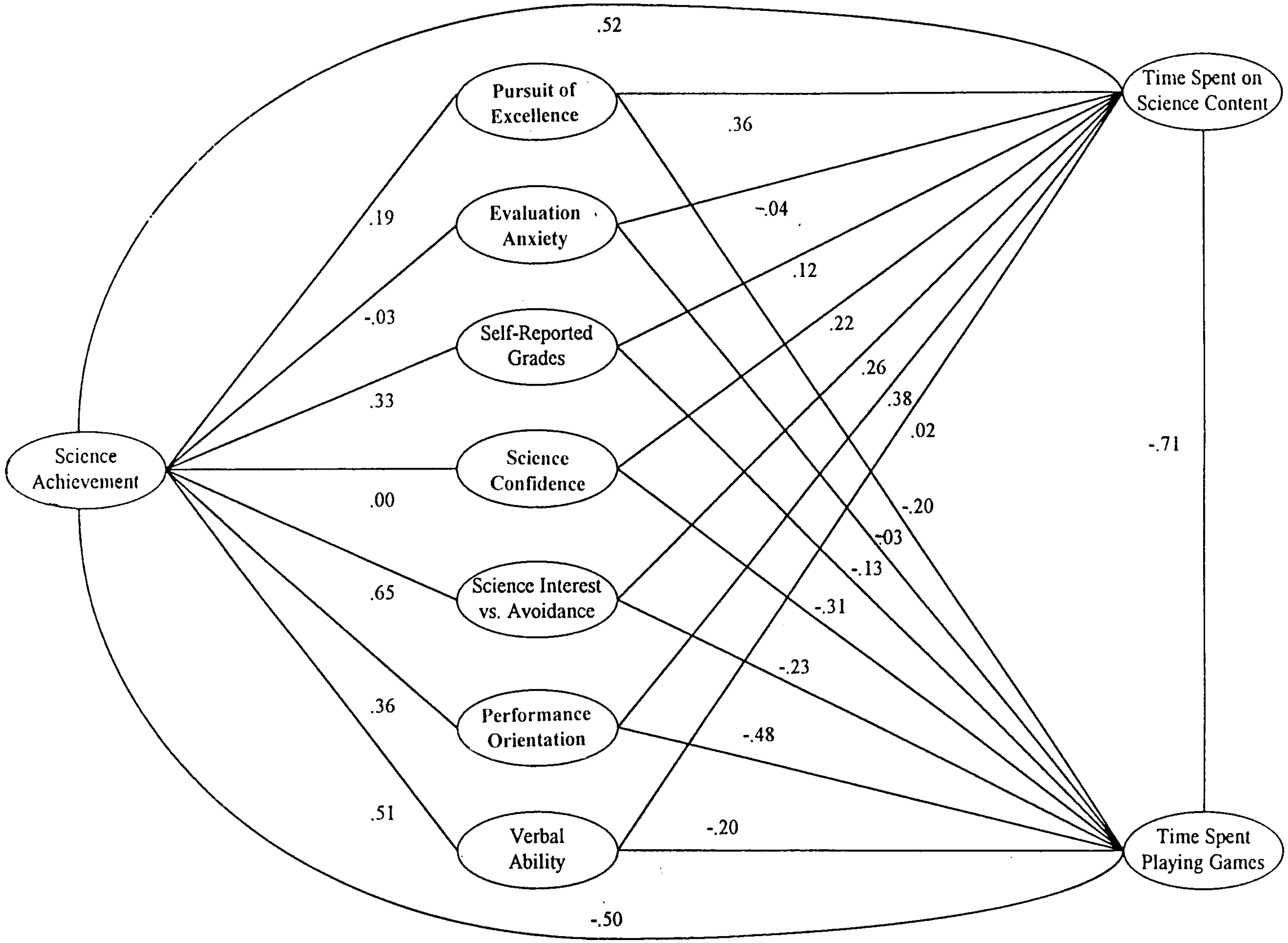

Figure 7. Correlations among science achievement, learning task activities and the seven aptitude component scores. $N = 47$.

Summary of Study III

The conative measures used in Study II were administered to a sample of 82 Ontario (Canada) high school students. One ability measure (MAB-Information subtest) and the supplemental measures used in Study II were omitted from Study III so students could complete the Computerized Science Learning Task (CSLT).

In the CSLT, 55 students participated and were tested on their free and cued recall of science material, which described bacterial, viral, and protozoan diseases. This material consisted of science text, figures, diagrams, word definitions, and comprehension testing questions, all related to disease-causing micro-organisms. In addition to studying the science material, these students could choose to play one of two computer games: Eliza (the computer psychotherapist) and Asteroids. The availability of these games allowed for the investigation of whether the students spent their time learning science material or playing games.

Descriptive statistics, reliability analyses, correlational analyses, and principal components analyses were conducted on the data. An analysis of the similarity between the Study II and Study III principal components was also undertaken. Conclusions summarized from Study III are as follows:

Descriptive statistics. No substantial deviations from normality were found in the conative and ability measures. Two of the learning activity variables, DICTNUM and QUESTIME, were slightly skewed left. Square root transformations of these variables removed the skew, but the transformation did not affect how these variables correlated with the other variables in Study III. The science assessment (SCITEST) was also skewed left but this also did not substantially affect the results. The means of the variables were largely consistent between Studies II and III.

Reliability analyses. Most of the measures demonstrated acceptable levels of reliability. Reliabilities for only two measures (Action Control-Failure and -Decision) were lower in Study III than in Study II.

Correlational analyses. Correlations among the questionnaire variables in Study III closely matched those from Study II. The pattern of relationships in particular was similar across the two studies. When correlational differences were found, they tended to be differences in the magnitude of the correlations, with correlations from Study III slightly larger than those from Study II. Study III replicated the finding from Study II of weak relationships between verbal ability and the conative measures.

Principal components analysis. A principal components analysis of the aptitude variables was conducted using a procrustes rotation to the Study II component loadings. This resulted in a principal components solution in Study III that was very similar to the one found in Study II. The correlation matrices from the two studies showed high levels of congruence, suggesting that the Study II and III findings will generalize to other similar samples of students.

Conative constructs and science achievement. A number of the conative constructs were significantly correlated with science achievement, supporting Hypothesis 2. Among the zero-order correlations, the highest involved Industriousness, Average Grade in Science, Deep Approach, Mastery Orientation, and Personal Interest in Science. Apathetic Approach, Work Avoidance Orientation, and Surface Approach entered into the most negative correlations. Among the principal components, Science Interest vs. Science Avoidance and Performance Orientation were most highly correlated with science achievement.

Conative constructs and learning activities. Conative variables were significantly associated with (a) the time students spent studying the science material, (b) the number of science-related screens students viewed, (c) the time students spent playing games, and (d) the number of times games were played. Motivational variables including Deep Approach, Intrinsic Goal Orientation, Industriousness, Mastery Orientation, Extrinsic Goal Orientation, Work Avoidance and Apathetic Approach entered into the strongest correlations. These relationships cannot be attributed to ability because the correlations between MAB Vocabulary and the science task activity variables were not significant.

Science achievement and learning activities. The activities of students during the computer-based science instruction were significantly related to their subsequent performance on the science achievement assessment. Significant positive correlations were obtained between the Science Achievement Assessment (SCITEST) and activity variables such as the time spent studying the science text, the time spent viewing figures, and the number of times students viewed the figures. Significant negative correlations were found between SCITEST and both the number of times students played games and the amount of time they spent playing games. Total time spent on the task was uncorrelated with SCITEST—what mattered was whether students spent their time learning or playing games.

CHAPTER 6
CONCLUSIONS AND IMPLICATIONS

This dissertation explored the construct validity of a broad set of conative constructs and studied their relation to computer-based science learning and science achievement. Studies I and II found strong support for the existence of conative constructs independent from established constructs including achievement motivation, test anxiety, and verbal ability. In Study III, a computer-based science learning environment was developed that permitted students to learn science material from text, figures, a dictionary, and comprehension testing questions. Students could also elect to spend their time playing one of two computer games. Substantial individual differences were found in the amount of time students spent studying science versus playing games. Scores on the conative and ability measures were associated with time spent studying vs. playing and with subsequent performance on a science achievement assessment.

Measurement Issues

For the most part, the measures used in these three studies were reliable and well designed, but there were a number of exceptions. The measure of Mastery Orientation derived from Crandall, Katkovsky, and Crandall's (1965) Intellectual Achievement Responsibility Scale used in Study I demonstrated unacceptably low reliability, and it was not used in Studies II and III. Several other scales possessed acceptable reliabilities but were measured with few items. From Meece et al.'s (1988) Science Activity Questionnaire, Work Avoidant Orientation and Performance Orientation were each measured with only three items. Mastery Orientation from the same questionnaire was measured with nine items. The relative strength of the associations between each of these three scales and achievement, strategy use, and other learning outcomes are often compared to determine which orientation ought to be cultivated in school. One would be more comfortable with these comparisons if each scale was measured by roughly the same number of items.

Overlapping Constructs

A number of constructs appeared to overlap substantially. Evidence for closely related constructs came from the correlation matrices in all three studies and from the principal components analyses in Studies II and III. The following constructs have been defined as independent from one another but were found in the present studies to have high communalities, which point to redundancies in how the conative domain has been described:

From Study I, Deep Approach (Entwistle & Tait, 1992) and Mindfulness (Salomon, 1987) were highly intercorrelated.

From Studies II and III, Intrinsic Goal Orientation from Pintrich et al.'s (1991) Motivated Strategies for Learning Questionnaire (MSLQ) was highly correlated with Mastery Orientation for Meece et al.'s (1988) Science Activity Questionnaire (SAQ). Both of these scales were negatively correlated with Work Avoidant Approach and Apathetic Approach.

Similarly, Extrinsic Goal Orientation from the MSLQ was highly correlated with Performance Orientation from the SAQ.

Work Avoidant Orientation (Meece et al., 1988) and Apathetic Approach from the Approaches to Studying Inventory (Entwistle & Tait, 1992) appear to measure largely the same construct.

The supplemental cognitive and metacognitive strategy measures administered to a subset of the Study II participants were highly intercorrelated. Apparently, students have difficulty distinguishing among these strategies, and indeed they might be more similar at the process level than previously thought.

Multidimensionality of the Conative Constructs

As hypothesized, the principal components analyses showed that the conative constructs included in Studies II and III went beyond the more established constructs of ability, achievement motivation, and anxiety. Evidence for these broad constructs was found, but so was evidence for Science Interest vs. Science Avoidance, Performance Orientation, Science Confidence, and Self-Reported Grade Achievement. The patterns of correlations observed in the three studies were meaningful and interpretable. One aspect of the correlations was particularly striking. The conative constructs were almost wholly independent from cognitive abilities. Few correlations were observed between the ability measures and the conative ones. Thus, students who are not motivated to learn or who lack interest in the material to be learned will not realize in many cases the potential afforded by their cognitive ability. Remedial programs that emphasize cognitive ability and teaching learning strategies will need to take the conative variables into account if they wish to maximize students' chances for educational success.

Despite the interpretability of the correlations, several surprises were found in the principal components analysis. For example, no learning goal orientation component was found. Intrinsic Goal Orientation loaded on Pursuit of Excellence but Mastery Orientation loaded on Science Interest vs. Science Avoidance. This was surprising given the amount of research attention devoted to the construct variously referred to as mastery orientation, task orientation, intrinsic orientation, or learning goal orientation. Perusal of the item content showed that the two learning goal orientation scales contained a mixture of items that were achievement-related, such as enjoying challenge and reporting a willingness to work hard rather than play, and items that were interest-related, such as being involved in science and enjoying curiosity-arousing science material. Achievement motivation and interest are arguably more fundamental, better established constructs, so these data challenge whether or not a construct of learning goal orientation can be justified as independent from these other, more basic constructs.

On the other hand, Performance Orientation did define its own component. Thematically, Performance Orientation also contained item content traditionally associated with achievement motivation, such as seeking measurable success (e.g., high grades), seeking recognition, and valuing competitiveness (e.g., performing better than others on tests). These content areas may take on particular meaning in educational contexts, distinct from their more general achievement motivation counterparts. Performance Orientation may be justified as a separate construct because it is defined in educational contexts.

The Performance Orientation component was highly correlated with both the science achievement assessment and the time and activity variables from the Computerized Science Learning Task. From these data, an argument can be made that fostering a performance orientation in students is desirable because it will lead them to spend more time studying and less time playing games, and result in higher achievement. This may be too strong a generalization, given that a performance orientation may have other negative consequences associated with it, but it does point out the need to consider the situations in which these constructs are relevant. In Study III, there were constraints on the time available for learning. Time spent playing games left less time remaining for learning the science material. Given this treatment, performance-oriented students were more effective than their non-performance-oriented counterparts. The implication here is twofold. First, researchers who advocate that "schools might foster a task orientation rather than the other orientations" (Nicholls et al., 1985, p. 688) ought to consider the implications of such a comprehensive recommendation. That is, for some students, in some situations, this will be maladaptive. Second, the relationships between conative constructs and educational outcomes may be particularly susceptible to situational influence. This suggests that they are best studied using aptitude-treatment interaction methodology (Cronbach & Snow, 1981).

Like Performance Orientation, Science Interest vs. Science Avoidance was also correlated with students' science achievement (r = .65). Students who regarded science as enjoyable and meaningful were much better at recalling the computer-presented material about microbes and diseases. There are three major findings related to interest from Studies II and III. First, the magnitude of the correlation between science interest and science achievement was surprising, given that interest is seldom included in studies that investigate motivation. Clearly, these data support Schiefele, Hausser, and Schneider's (1979) contention that achievement motivation theories (e.g., Weiner, 1980) are educationally limited because they imply that students ought to strive for high performance or learning, regardless of the content area (Schiefele, 1991). Second, interest theory distinguishes between Personal Interest (long-standing, stable, individual interest) and Situational Interest (interest in situational stimuli). Both of these constructs were correlated with science achievement, yet they were not highly intercorrelated themselves. This makes them promising candidates for future educational research, particularly because they are likely to be more amenable to educational intervention than are motivational orientations (Schiefele, 1991). Third, while interest correlated with science achievement, it was not significantly correlated with the time or learning activity variables from the science task (although some of the correlations approached significance). This supports the findings of Schiefele (1991), which suggest that interest may operate by increasing a student's level of cognitive engagement or "depth" of processing in the time available. Interested students appear to use "deep" strategies (Entwistle, 1988) such as elaboration, critical thinking, information seeking, and searching for main ideas.

The present substantive findings regarding the multidimensionality of the conative domain for science learning highlight an important theoretical and methodological issue. Good practice in construct validation requires that one go beyond the search for convergent validity to explore and evaluate plausible alternative hypotheses (Cambell & Fiske, 1958; Cronbach & Meehl, 1955; Loevinger, 1957). Thus, one not only asks what behavior is encompassed within the domain of a construct like mastery orientation, but explores questions such as "mastery orientation is 'nothing but' achievement motivation with a new label." This type of reasoning, when applied to a set of related constructs, requires a multivariate approach in which measures of a set of constructs are evaluated using alternative methods in a multivariate extension of the Campbell and Fiske multitrait-multimethod matrix. Such an approach can provide a perspective on conceptual confusion and redundant measurement, providing a more parsimonious set of constructs and more precise measurement.

Computer-Based Instructional Environments and the World Wide Web

The data reported here also have implications for the design of computerized learning environments for use in both research and applied settings. For research purposes, the computer-based environment used in Study III permitted time-on-task to be measured accurately and unobtrusively. Had an experimenter administered the learning materials by paper-and-pencil and using a stopwatch, the results might have been tainted by the salience of the timing and other possible sources of experimenter influence. The computer also provides a controlled learning environment in that every student is presented with the same material. It also allows for flexibility because students can choose to interact with the learning material at their own pace or in idiosyncratic ways. Finally, the computer is efficient in its use of the experimenter's time for collecting data, permitting more data to be collected in a set amount of time.

For use in applied settings, learning environments such as the one used in Study III have a number of implications. The computer-based instructional environment used here was closely patterned after Internet browsers such as those developed by Netscape and Microsoft. Students could move back and forth between text, figures, and other content. They could also choose not to study the science material but instead entertain themselves with distracting computer games. There is every indication that students will spend more time learning from environments that are similar to the one presented in Study III than they have in the past. The number of users of the World Wide Web has been increasing rapidly, as has the amount of information available on it, including learning material. Students will increasingly find themselves in situations where distractions can be found only a mouse-click away. The conative measures studied here identified students who would and who would not stay focused on task relevant activities—something that could not be predicted from verbal ability.

The benefits of computer environments for research on student learning extend beyond the more obvious ones of controlled experimentation and realism in a computer age. A computer environment permits going beyond adapting content difficulty to student ability. Computer environments offer the promise of being adapted to accommodate individual differences in conative and affective aptitudes. Student science interests could be assessed and used to select content attuned to individual interest profiles. For students differing in performance orientation, the computer could vary the salience of evaluative feedback to provide recognition for good performance. For apathetic learners, the computer could identify maladaptive patterns of computer use. For example, students might spend too little time on important material or they might be inattentive to the learning task, signaled by prolonged periods without student-computer interaction. These activity patterns could be brought to the attention of the student or teacher for intervention. In summary, adapting computerized environments to conative and affective aptitudes offers a rich set of possibilities that warrant investigation in their own right.

Recommendations for Future Research and Educational Activities

Need for generalizability of findings. Although there are several important implications to be drawn from the results of the present studies, they suggest further investigations that would increase the generalizability of these findings. In particular, there are three domains in which the generalizability of findings could be explored further: *populations of students*, *measures and constructs*, and *duration of learning experience*.

The analyses in Studies II and III pertain to a large sample of Canadian high school students. While Canadian students share much in common with their counterparts in the United States, this sample may not be representative of American high school students. In particular, there were fewer African American and Hispanic students in the Canadian high schools. The Canadian sample did, however, include a mix of rural and urban students. Thus, research is needed to explore the relationships found in these studies with more diverse samples of students, including those sampled from more diverse age and experiential levels. Indeed, cross-cultural researchers might examine the extent to which motivational styles vary as a function of national, linguistic, and cultural differences.

It is impossible in any one study to survey all the possible conative variables that could be studied. This study included a relatively broad set of prominent conative measures. It could be complemented by other broad surveys as well as by studies that take alternative approaches to variable sampling.

The variations in the use of learning strategies and time spent studying science in this research were limited by the short duration (approximately 30 minutes) of the science task, but science learning in the real world usually takes place over more extended periods. The sustained interest and work of basic scientists is legendary, but the underlying motivation for such work has been little studied. Further research that emphasized learning over much longer periods might thus identify different relationships with the conative variables. However, in educational environments students must often learn material quickly and recall it on subsequent tests and other situations within a short time frame. Learning of this sort appears to be more similar to the learning situation presented in Study III.

Conative constructs and science achievement. The conative constructs and measures studied in this investigation show much promise for future educational research and intervention. With few exceptions, the measures were highly reliable and possessed good distributional properties. Particularly promising are some of the more speculative constructs, including those related to Science Interest, Approaches to Learning and Studying, and Performance

Orientation. These constructs showed significant relationships with learning activities and science achievement independent from verbal ability. The strong relationships between these constructs and both science achievement and the time and activity variables suggest future research might be directed towards helping students to develop these conative aptitudes in their own right (Snow, 1992).

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APPENDIX A

DEBRIEFING FORM FOR STUDY I

Debriefing Statement

Thank you for your participation in this study. We greatly appreciate your help and your evaluations of these questionnaires.

Individuals differ in their motivation for school work, their approaches to learning and studying, and their ability to work on problems without interruption or distraction. Educational researchers have developed theories and questionnaires that are designed to measure these differences, but they often narrowly focus on only one or two of these kinds of distinctions. This study is part of a series of studies investigating differences in student motivation for learning and studying. Its purpose is to compare a large number of different theories and questionnaires that have been identified as important to success in school. Below is a description of each of the sections that you filled out in the questionnaire booklet. It is hoped that you will read these descriptions and become aware of some of the ways differences in motivation can affect your own studying and learning behavior. A reference section is provided at the end in case you want to get further information about these questionnaires.

Section 1: Approaches to Studying Questionnaire

This questionnaire is designed to measure several characteristic ways in which students approach learning situations. One of the principal distinctions measured is between deep and surface approaches, described by Marton and Säljö (1976) and Entwistle (1981, 1987a, 1987b), and their coworkers (Entwistle & Ramsden, 1983; Marton, Hounsell, & Entwistle, 1984). Central to this distinction is the degree to which the intention and commitment to learning is characteristic of students. Students who adopt a deep approach regard the text or problem material to be learned as instrumental to understanding the underlying meaning found in the material. These students are characterized by little concern for others' evaluations of their performance, active interest in the learning material, and attempts to evaluate the evidence presented, relating it to other topics in order to draw conclusions. For students who adopt a deep approach, learning is viewed as a process of constructing meaning and understanding in the world.

In contrast, students who adopt a surface approach regard the particular learning material as what needs to be learned, and they tend not to link it to a larger conceptual framework. A surface approach often results when students' performance will be evaluated and they are motivated to satisfy the demands of others. Learning is viewed as emphasizing the transmission of the content of the learning materials into the head of the learner, with a focus on memorization and passive knowledge acquisition to permit reproduction of the material on tests and evaluations.

A third approach, the strategic approach, combines elements of both the deep and surface approaches. Here learners are primarily concerned with impressing their teachers and obtaining positive performance evaluations. Consequently, there is a sensitivity among these students to the assessment demands and a concern for organized studying and efficient time management. Students who adopt a strategic approach tend to conserve their effort when possible, but to adopt a deeper approach when this is necessary to obtain good grades.

A fourth approach, the apathetic approach, characterizes students who are not engaged by the material or interested in its content. These students do not really know why they have to learn the material, put forth minimal effort, and tend not to be too concerned with others' evaluations of their performance. A fifth scale included in the questionnaire measured academic self-confidence.

Section 2: Entity vs. Incremental Theory of Intelligence

People have implicit beliefs or theories about intelligence. An "entity" theory maintains that intelligence is something about the self that the individual cannot change. An "incremental" theory regards intelligence as something malleable that can be developed through the individual's efforts. People with entity theories tend to have "performance" goals when it comes to learning. Performance-oriented students seek to document their ability. Performance-oriented students are often characterized by avoidance of challenge and impaired performance in the face of failure, especially when they have low academic self-confidence (Elliot & Dweck, 1988). They pursue performance goals, seeking to maintain positive judgments of their ability and avoid negative judgments (Nicholls & Dweck, 1979).

In contrast, students with "incremental" theories of intelligence are more oriented toward learning and "mastery" goals, i.e., developing their intelligence. Mastery-oriented students seek challenging tasks and maintain effective striving under failure (Dweck & Leggett, 1988). They pursue learning goals in achievement situations and put forth effort to increase their competence (Nicholls & Dweck, 1979). Understanding which theory a student holds about intelligence is one way that we can determine whether a student has a performance or a mastery orientation.

Section 3: Intellectual Achievement Responsibility Questionnaire

A second way of measuring performance vs. mastery orientation involves using the Intellectual Achievement Responsibility Scale you filled out in Section 3 (IAR; Crandall, Katkovsky, & Crandall, 1965). Past research (Dweck, 1975) has shown that the major difference between the mastery and performance orientations was in the respective tendency to neglect or emphasize effort in determining failure. Mastery-oriented students regard effort as the major cause of failure and increase their effort when faced with task difficulty or failure. Performance-oriented students, on the other hand, regard failure as a consequence of inadequate ability and view additional effort as unhelpful.

The IAR questionnaire also measures the degree to which you take credit for your successes and accept blame for your failures. Studies with younger students who accept responsibility for their successes and failures have shown that these students tend to demonstrate higher academic achievement.

Section 4: Mindfulness Questionnaire

The mindfulness questionnaire is designed to measure to what extent you enjoy and characteristically use effort-demanding mental processes (Salomon, 1987). Mindfulness is closely related to the Deep Approach to learning described in Section 1, and the same comments that appeared there also apply here. Several of the questions in the mindfulness questionnaire had random words in them (cup, horse, apple), and you got a higher mindfulness score if you mentioned these at the end of the questionnaire. You also received a higher score if you identified the nonsense item (I would rather have fun than a good time).

Section 5: Action Control Scale

The Action Control Scale was used to assess action vs. state orientation following the research of Kuhl (1981, 1991; also see Kuhl and Kraska, 1989). According to action control theory, when an individual perceives that an intended action (such as studying) is difficult to carry out, volitional control processes will be used to maintain intended actions and inhibit distractions (such as partying or watching TV). The ease or difficulty you have in carrying out your intentions is related to the degree to which you are Action or State oriented. For example, suppose it's Thursday night and you intend to get your homework done early so you can go away for the weekend, but your friends are going out and you would like to go out tonight too. You may perceive that the intention to do the homework will be difficult to carry out, and there are various things you could do to protect this intention from the preference to go out tonight. You can use an environmental control strategy, and go to the library to reduce the number of distractions. You might use motivational control strategies to try to think about how much fun you will have this weekend if you can go away and how boring it will probably be if you go out tonight.

Action-oriented individuals tend to take immediate action to carry out their intentions. They are characterized by having situationally appropriate intentions and an awareness of a means of transforming their current situation into some desired future state. In contrast, state-oriented individuals are marked by intentions that are either unrealistic or should be postponed. The state-oriented individual is often fixated on "past, present, or future states, for example, on a past failure to attain a goal, on the present emotional consequences of that failure, or on the desired goal state itself" (Kuhl & Kraska, 1989, p. 366).

Each item on the Action Control Scale specifies a situation followed by an action-oriented and a state-oriented response. It is scored for three types of action vs. state orientation—failure related, decision related, and performance related—and does not yield a combined score.

The failure orientation scale contains items assessing preoccupation with negative experiences. High scores on this scale indicate that you tend not to get preoccupied with failures or other experiences. For example, if you do poorly on an assignment and can't stop thinking about it, you would likely have a low score on this scale. High scores indicate that you are more action oriented when faced with failure.

The decision-related scale measures difficulty in taking action once a decision has been made. It does not measure the inability to terminate the decision process. This scale is referred to as the hesitation scale. For example, suppose you decide that you are going to stay home tonight and do your homework, but then you drag your feet getting started. You would probably receive a low store on this scale.

The performance-related scale measures the ability to persist at self-initiated and pleasant activities without shifting prematurely to alternative activities. It is sometimes referred to as the volatility scale and can be interpreted as measuring an over-functioning of the action initiation system. For example, you would get a high score on this scale if you often stopped doing things that you found enjoyable and switched to other activities.

Section 6: Similarities

The previous questionnaires were designed to measure motivational and volitional (will power) differences among students. In contrast, the similarities test is more like a traditional ability test. It was included to determine whether there is a relationship between some of the motivational variables and one type of cognitive ability.

Thanks again for your help. References are provided below if you wish to look into any of these motivational theories and measures.

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APPENDIX B

DEBRIEFING FORM FOR STUDIES II AND III

Information About the Study of Student Motivation for Science Learning

The reason for completing these questionnaires was explained at the start: psychologists want to compare theories about why some students enjoy and succeed in science class, and why other students so not.

Now, here is a short description of the questionnaires you completed today:

Booklet 1: *Vocabulary*

The test at the start of the session is called Vocabulary. It is supposed to test your knowledge and understanding of words. Some psychologists think that how much you know and understand already might explain your study habits and your attitudes related to science.

Booklet 2: *The Industriousness Factor* (Section 3)

The questions that you answered all have to do with your industriousness—your habits and attitudes about working and studying. Some psychologists think that differences in the trait of industriousness might explain why some students work harder in, and do better in, their science classes.

Approaches to Studying Inventory (Section 4)

Science Activity Questionnaire (Section 5)

These questionnaires asked you about how and why you study science. They are supposed to find out what your approach is to learning about science. Do you try to learn all about what you are taught in class? Do you study mainly so you can get high marks? Do you simply try to get by with a minimum of work?

Achievement and Stress Questionnaire (Sections 6, 7, 8, & 11)

This questionnaire tries to discover whether worrying hurts your performance on tests, or whether it actually helps you. Some people do poorly on tests when they feel stress, but some people do better when they experience stress.

Booklet 3: *Open-Ended Questions* (Section 12)

These questions are supposed to find out what you think of these questionnaires and what you generally think about school and science class.

As you can see, some of these questionnaires are quite similar. By having you complete all of them, psychologists hope to develop a good theory about why some students are more motivated in science class. As a result of this, it might be possible someday to make science classes more interesting and enjoyable for the students who take them.

Thank you for your help!

APPENDIX C

ADMINISTRATION GUIDE FOR STUDIES II AND III

Procedure

0. Read these instructions at least once before you do anything else.

1. Take everything with you in the car: booklets, some pencils or pens, and a stopwatch.

2. When you get to the school, get out of the car with all materials needed for the first session. Go to the principal's office and tell somebody who works there who you are and why you are there. If you do not know the number of the room where you will be making students fill out questionnaires, find out now.

3. Go to that room or to some other specified place to meet the teacher. Give the teacher the "teacher information form." Find out from the teacher what any non-consenting students should be told to do during the session.
   The teacher, presumably, will introduce you to the class, but they probably might as well go elsewhere (if they would like to) during the session. If he/she does go away, find out where he/she will be; you might need to know this in case things get out of hand. Have the teacher check in at the classroom after about fifty minutes to see how things are going, since the session might end early. If it does end early, the students can be returned to the teacher's custody.

4. Hand out the consent form. Have the students read it. Have the students sign it. If they don't want to sign it, compel them to do what the teacher had specified before.

5. Hand out the demographic form. Have the students complete it.

6. Hand out the booklets. Give every student one copy each of Booklet 1, Booklet 2, Booklet 3, and Booklet 4. MAKE SURE THAT EACH STUDENT GETS BOOKLETS THAT ALL HAVE THE SAME I.D. NUMBER. Also, give out pencils as is necessary.

7. Administer the MAB, which is Booklet 1, as per the instructions on the first page of each of the two sections. Emphasize that students must work only on the current section; they can't work on vocabulary when they should be doing information, or vice versa. Also emphasize that the students should answer every question. When time is up for the MAB, tell the students to put that booklet (Booklet 1) to the corner of the desk.

8. Paraphrase aloud the introduction sheet. Emphasize to the students that, although many of the questionnaires will seem very, very similar, it is important for them to answer all of them carefully.

9. Tell the students to look at Booklet 2. Tell them that, within Booklet 2, they will find several questionnaires. Ask them to read the instructions for the first questionnaire, and then to complete it. Ask them to repeat this process until they have completed all the questionnaires in the book. Unlike the MAB sections, these sections can be completed without specific time restrictions, and students can go on to the next section as soon as they are finished. When the students have all finished all of Booklet 2, have them put it aside also.

10. Tell the students to look at Booklet 3. In this booklet are the open-ended questions, to which students physically write their answers. When everyone is finished, have them put this booklet aside.

11. If there are at least 8 minutes before the end of the class session, have the students start on Booklet 4. If not have them put Booklet 3 inside Booklet 2, and put those inside Booklet 1. Collect the booklets, including the unfinished Booklet 4. If they do complete Booklet 4, then this is one more booklet to be put inside the other booklets. Whether they complete Booklet 4 or not, when you have collected the booklets (and some decent fraction of the pencils), transfer command of the students to their rightful teacher.

12. Thank the class and the teacher. Don't forget the teacher information form.

13. Maybe put the returned booklets back in the car. Get the new ones.

14 Do whatever you have to do during the break between sessions. Maybe visit the principal's office again to find out the next location. When the next session starts, do the same things all over again.

15. Visit the principal's office on the way out. Thank the people there for participating. Don't leave any materials behind.

APPENDIX D

COMPUTERIZED LEARNING ENVIRONMENT INSTRUCTIONS FOR STUDY III

Student Motivation for Science Learning

Computerized Learning Environment Preamble:

- The purpose of the study is to understand what students think of the computerized learning environment, and to evaluate your learning from it.
- You will be given forty minutes to learn the material in the computerized learning environment.
- After the computerized portion is finished, you will be given a short questionnaire about what you think of the computerized learning environment.
- Finally, you will be given a test about the material that you have learned in the computerized learning environment. The test will take about 20 minutes.
- When you turn in the test to me, I will give you a two-dollar bill as a token of our appreciation for your participation in the study.
- Please write your name in the upper right-hand corner of the paper beside your keyboard. I have provided this paper for you to take notes if you wish. You may take notes from the computerized learning environment, but you may not use these notes during the test.
- The computerized learning environment has a section called "test yourself." It has sample questions for you to review the material if you wish. However, you cannot write any answers back to it.
- I would like to encourage you to freely explore the computerized learning environment. You can click on different icons to visit different places. For example, you can open up a dictionary in order to look up the meaning of highlighted words. Or you can open a file that contains figures about the material to be learned. There are also two computer games. At any time you can take a break and play a computer game.
- Does anyone have any questions? So, let's get started. Good luck!

APPENDIX E

SCIENCE RECALL MEASURE FROM STUDY III

Test on Disease Causing Microbes

First Name: ________________________ Last Name: __________________________

1. Please define as many of the following as your can:
   a) interferon

   b) "budding" as it relates to viruses

   c) febrile

   d) capsid

   e) quinine

   f) antibodies

   g) malaria

   g) bacteria

2. Which of the three microbes described in the text is smallest in size? Which is the largest?

3. Name at least four of the nine most deadly diseases:

First Name: ________________________ Last Name: _________________________

4. Name three diseases caused by viruses:

5. Why are viruses difficult to treat with drugs?

6. How do viruses replicate?

7. How do bacteria harm the body?

8. Describe how mutation helps bacteria become resistant to drugs. Use a drawing if you desire.

9. Describe how conjugation helps bacteria become resistant to drugs. Use a drawing if you desire.

First Name: ________________________ Last Name: __________________________

10. What has led to malaria becoming more common in parts of the world?

11. What can doctors and patients each do to help prevent bacteria from becoming resistant to drugs?

12. Describe how a vaccine helps prevent disease.

13 One a scale of 1 to 10 with 10 being most difficult, how difficult was this test?

Very Easy								**Very Difficult**	
1	2	3	4	5	6	7	8	9	10

14. Other comments:

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APPENDIX F

SUPPLEMENTAL TABLE

Table F-1

Principal Components Analysis of Combined Study II and III Data (*N* = 277)

Variable	Measure	I	II	III	IV	V	VI	VII	h^2
SPFQ	Industriousness	.67	-.15	.21	-.13	.30	.21	.00	.67
DEEP	Deep Approach	.66	.06	.09	.35	.34	.22	.07	.74
STRATEG	Strategic Approach	.69	-.11	.24	.22	.17	.32	-.18	.76
INTGOAL	Intr. Goal Orient.	.42	-.11	.08	.32	.44	.40	.01	.65
SURFACE	Surface Approach	-.19	.45	-.19	-.14	-.39	.40	-.30	.70
ANX	Test Anxiety	.10	.54	-.26	-.03	-.16	.48	-.14	.65
ACS_DEC	Action Control-Dec.	-.45	.68	-.06	-.02	-.16	-.03	.10	.71
ACS_FAIL	Action Control-Fail.	.02	.83	-.10	.00	.03	.03	.03	.71
CONFID	Acad. Self-Conf.	.42	-.12	.52	.44	.07	-.17	.05	.70
GRDSCI	Grade in Science	.06	-.10	.82	.13	.26	.17	-.01	.81
AVGSCI	Avg. Grade in Sci.	.04	-.16	.79	.07	.27	.15	.20	.80
AVGGRD	Overall Avg. Grade	.30	-.00	.77	-.08	-.01	.07	.13	.72
SCICONT	Sci. Perceived Control	.03	.09	.02	.77	.17	.18	-.08	.67
SCISELFE	Sci. Self-Efficacy	.16	-.21	.35	.60	.42	.20	-.05	.76
TSKSELFE	Task Self-Efficacy	.31	-.16	-.05	.51	.09	.20	.36	.57
SCIMAST	Mastery Orient	.35	-.02	.20	.25	.64	.43	-.04	.82
SCIWORKA	Work Avoidance	-.45	.03	-.17	.12	-.67	.11	-.06	.71
INTTOT	Interest in Sci. Class	.20	-.03	.14	.28	.70	.15	-.07	.65
INTPERS	Personal Interest	-.10	-.07	.17	.18	.72	.28	.10	.68
APATHET	Apathetic Approach	-.40	.13	-.27	-.13	-.68	-.09	.03	.74
SCIPERF	Performance Orient.	.19	.03	.26	.12	.16	.77	.05	.74
EXTGOAL	Extr. Goal Orient.	.18	.09	.15	.18	.26	.78	-.02	.78
MABVOCAB	MAB Vocabulary	-.06	.03	.17	-.03	-.01	-.01	.91	.85
Extension variables									
MABINFO	MAB Information	-.18	.04	.22	.10	.05	-.02	.55	
HELPTOT	Help Seeking	.35	-.01	.01	.31	.12	.19	-.06	
COGMETA	Cog. & Meta. Strateg.	.50	.21	.25	.40	.41	.25	-.13	
RESMAN	Resource Management	.47	.25	.15	.05	.59	-.00	-.22	
Eigenvalues		2.80	1.87	2.85	2.01	3.41	2.45	1.20	
Percent variance accounted for		.12	.08	.12	.09	.15	.11	.05	

Note. MABINFO, HELPTOT, COGMETA, and RESMAN were extended into the component space using the Dwyer (1937) method. The eigenvalues presented in the table are for the rotated components. The first seven eigenvalues for the unrotated components are 8.11, 2.65, 1.63, 1.27, 1.10, .84, .97. To make the components match those from Study II, the presentation order of the sixth and seventh components was switched and the second component was reflected. The highest loading for each variable is underscored.