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ABSTRACT

The relationships among prior knowledge, learning strategy use, interest, learning goals, and conceptual understanding were studied with 72 fifth graders from 3 science classrooms. In September 1996 students completed a knowledge test designed to assess their prior knowledge and conceptual understanding of ecological concepts (plant and animal relationships and interdependencies). In early December, students completed a self-report measure of learning goals, interest, and strategy use, and the knowledge test in that order. Prior knowledge, strategy use, interest, and learning goals were positively related to each other and to conceptual understanding. Prior knowledge accounted for 29% of the total variance in conceptual understanding after the contributions of strategy use, interest, and learning goals were controlled. After controlling for prior knowledge, interest explained 7%, learning goals 6%, and strategy use explained 4% of the total variance in conceptual understanding. With the exception of prior knowledge, individual contribution of each of the other predictor variables to conceptual understanding was no longer significant when contributions of the other predictors were controlled. After controlling for prior knowledge, learning goals and interest accounted for 37% and 17% of the total variance in strategy use, respectively. After controlling for either interest or learning goals, prior knowledge did not account for a significant portion of the variance in strategy use. The mutual support of these processes in knowledge acquisition is discussed. Two appendixes contain the study instruments. (Contains 6 tables and 71 references.) (Author/SLD)

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Predicting Conceptual Understanding with Cognitive and Motivational Variables

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Abstract

We examined the relationship between prior knowledge, learning strategy use, interest, learning goals, and conceptual understanding. Subjects were 72 fifth grade students from 3 science classrooms. In mid-September (fall-1996), students completed a knowledge test designed to assess their prior knowledge and conceptual understanding of ecological concepts (plant and animal relationships and interdependencies). In early-December, students completed a self-report measure of learning goals, interest, and strategy use, and the knowledge test in that order. Prior knowledge, strategy use, interest, and learning goals were positively related to each other and to conceptual understanding. Prior knowledge accounted 29% of the total variance in conceptual understanding after the contributions of strategy use, interest, and learning goals were controlled. After controlling for prior knowledge, interest explained 7%, learning goals explained 6%, and strategy use explained 4% of the total variance in conceptual understanding. With the exception of prior knowledge, individual contribution of each of the other predictor variables to conceptual understanding was no longer significant when contributions of the other predictors were controlled. After controlling for prior knowledge, learning goals, and interest accounted for 37% and 17% of the total variance in strategy use, respectively. After controlling for either interest or learning goals, prior knowledge did not account for a significant portion of the variance in strategy use. The mutual support of these processes in knowledge acquisition is discussed.

The need to understand how cognitive and motivational variables are related to each other and to the quality of human learning has been widely expressed in recent research literature (e.g., Lepper, 1988; Pintrich, Marx, & Boyle, 1993; Pintrich & Shrauben, 1992; Schunk & Meece, 1992; Tobias, 1994). In this study, we examined the relative contribution of prior knowledge, learning strategies, interest, and learning goals to each other and to conceptual understanding. The aforementioned cognitive and motivational variables are considered to facilitate students' development of a subject matter (e.g., Alexander, 1992; Alexander, Kulikowich, & Jetton, 1994; Chi, DeLeeau, & Lavancher, 1994; Deci, 1992; Dweck & Leggett, 1988; Graesser, Golding, & Long, 1991; Pressley & McCormick, 1995; Weinstein & Mayer, 1986; Wigfield & Eccles, 1992).

Although a number of investigators (e.g., Alexander, Kulikowich, & Jetton, 1995; Archer, 1988; Cavallo & Shaffer, 1994; Chan, 1995; Guthrie, Van Meter, Hancock, McCann, Anderson, & Alao, in press; Meece, Blumenfeld, & Hoyle, 1988; Nolen, 1988; Schiefele, 1996) have found that prior knowledge, use of learning strategies, interest, and learning goals are related to each other and to different indicators of conceptual understanding (e.g., text comprehension, propositional knowledge, procedural knowledge), few investigators have explored the contribution of each factor to conceptual understanding (see Alexander et al., 1994; Schiefele, 1991; and Tobias, 1994, for complete reviews). One purpose of this study was to examine the relative contribution of prior knowledge, use of learning strategies, interest, and learning goals to conceptual understanding.

Another important yet little understood area of research is the relative contribution of each factor to conceptual understanding beyond and above the relative contributions of the other sets of factors. For instance, will strategy use, interest, learning goals, and prior knowledge predict a significant amount of the variance in conceptual understanding after the contributions of the other sets of factors are controlled? As mentioned earlier, these factors are interrelated. Students interested in the material to be learned are more likely to adopt learning goals, and employ higher-level strategies (e.g., elaboration of ideas, connection among ideas) to link new information to their prior or subject matter knowledge than students who are not interested in the material to be learned. In addition, interest and learning goals are potential facilitators of use of higher-level strategies. Moreover, interest, learning goals, and strategy use are correlated with prior knowledge (Schiefele, 1991; Tobias, 1994).

The above information suggests that we need to investigate the unique and joint effects of prior knowledge, stategy use, interest, and learning goals to conceptual understanding. For example, the unique effects of each factor on conceptual understanding would be demonstrated if the contributions of two or more of these factors to conceptual understanding remain significant after the contributions of other factors are controlled. On the other hand, the joint effects of each factor on conceptual understanding would be demonstrated if the contributions of two or more of these factors to conceptual understanding do not remain significant after the contributions of the other factors are controlled. This would mean that the association of each factor to each other and to conceptual understanding cannot be teased apart. Furthermore, it would imply that cognitive and motivational factors converge to promote human learning and development. For these reasons, the second purpose of this study was to explore the relative contribution of each factor to conceptual understanding after the contributions of the other factors are controlled.

In addition, the relative contribution of interest, learning goals, and prior knowledge to reported use of higher-level learning strategies (e.g., connection among ideas, elaboration of ideas) also needs to be discerned. Will interest and learning goals each explain a significant portion of variance in strategy use after prior knowledge is controlled and vice versa? Most of the studies on the relationship between these variables have not addressed this issue. This line of research has primarily been used to document the zero order correlations amongst these variables (see Ames, 1992; and Blumenfeld, 1992, for complete reviews). The final purpose of this study was to examine the relative contribution of interest, learning goals, and prior knowledge to use of learning strategies.

Conceptual Understanding

Conceptual understanding can be characterized in terms of breadth and depth (Chi et al., 1994; Chinn & Brewer, 1993; diSessa, 1993; Keil, 1989; Mayer, 1992; Novak, 1985; Pine & West, 1986). Breadth refers to the extent that knowledge is distributed and represents the major sectors of a specific domain. For instance, food chains and webs, predator-prey relations, energy pyramid, community, biomes, carrying capacity, and energy cycle are major aspects of ecosystems. A student who knows the meaning and definitions of each of the aforementioned ecological concepts is an example of an individual whose knowledge samples and represents the major sectors of an ecosystem.

Depth refers to the knowledge of scientific principles that describes the relationships among concepts (Entwistle, 1995; Nickerson, 1985; Perkins & Blythe, 1994). A student who can: (a) construct a food chain using knowledge of the relationships between populations of producers and consumers from different trophic levels; and (b) explain the interactions among the food chain elements with ecological concepts (i.e., feeding order and energy flow) is an example of a student who has a depth of understanding of the food chain and its elements (Gallegos, Jerezano, & Flores, 1994). Breadth and Depth are related to each other and are important aspects of conceptual understanding. In this study, conceptual understanding was defined as knowledge of basic ecological concepts and the ability to use ecological principles to construct and explain the interactions within a food chain.

<u>Prior Knowledge and Conceptual Understanding</u>

Prior or subject matter knowledge has been identified as an important variable contributing to the acquisition of conceptual understanding (Driver, Asoko, Leach, Mortimer, & Scott, 1994; Kintsch, 1988; Novak, 1988). Prior knowledge is expected to facilitate the acquisition of conceptual understanding by enhancing students' abilities to: (a) assimilate and integrate new information; and (b) distinguish relevant from irrelevant information. Students with prior knowledge of ecological concepts are in a better position to acquire conceptual understanding of those concepts than students without such knowledge.

In addition, research points the importance of prior knowledge as a significant predictor of conceptual understanding (Kintsch, 1988). Prior knowledge also contributes substantially to different indicators of conceptual understanding. For example, BouJaoude (1992) found that prior knowledge of burning and chemical change concepts accounted for 36% of the total variance in high school students' ability to diagnose and correct misunderstandings about the concepts of burning and chemical change. Similarly, Glasson (1989) found that prior knowledge of life, earth, and physical science concepts accounted for 9% of the variance in middle school students' understanding of concepts related to simple machines (levers and pulleys) and 20% of the variance in their ability to generate solutions to physical science algorithmic problems.

On the other hand, most of the studies on the contribution of prior knowledge to different indicators of conceptual understanding did not control for the effects of strategy use, and motivation (interest or learning goals). It is not clear whether the contribution of prior knowledge to conceptual understanding will remain significant after the effects of strategy use and motivation are controlled. Furthermore, most of the studies on the contribution of prior knowledge to different indicators of conceptual understanding have been conducted with mostly middle, high school, and college students. It is not clear whether the results of previous studies can be generalized to elementary school students. For these reasons, we investigated the relationship between fifth grade students' prior knowledge of ecological concepts and the food chain, and their understanding of those concepts. We also examined the total amount of variance in conceptual understanding that can be accounted for by prior knowledge after the contributions of strategy use, interest, and learning goals were controlled.

Strategy Use and Conceptual Understanding

Use of learning strategies is important to the acquisition of conceptual understanding (Anderson, 1980). For example, students use learning strategies to study, learn, remember, and understand different academic concepts (see Pressley, Goodchild, Fleet, Zajchowski, & Evans, 1989, for a review). However, not all types of learning strategies are expected to promote the acquisition of conceptual understanding. For this reason, it is important to distinguish basic from higher-level learning strategies.

In contrast to basic strategies (e.g., rehearsal, memorization) that students use to remember facts and details, higher-level strategies (e.g., monitoring of comprehension, connection among ideas, elaboration of ideas) are used to understand main ideas and concepts (Entwistle & Ramsden, 1983). Use of higher-level strategies is expected to facilitate the acquisition of conceptual understanding (Brown, Bransford, Ferrara, & Campione, 1983; Entwistle & Ramsden, 1983; Graesser et al., 1991). For example, a student who tries to figure out how information on different ecological concepts (e.g., community, food chain, energy pyramid) are connected is more likely to understand that the size of a population in a community will depend on how much energy is available to that population (the community-energy pyramid relationship) than a student who simple memorizes the different ecological concepts.

Use of higher-level learning strategies is the focus of this investigation. In addition to being related to prior knowledge, interest, and learning goals (other correlates of conceptual understanding), frequent use of higher-level strategies is associated with active classroom engagement and students' academic achievement (Meece et al., 1988; Pokay & Blumenfeld, 1990). Moreover, use of higher-level strategies contribute substantially to different indicators of conceptual understanding. Chan (1995) found that use of higher-level reading strategies explained 18% of the variance in ninth grade students' reading comprehension scores. Fletcher and Bloom (1988) found that use of higher-level strategies accounted for 31% of the variance in college students' recall of propositions from narrative texts. Further, BouJaoude (1992) found that use of higher-level strategies explained 14% of the variance in high school students' ability to correct misunderstandings about chemistry concepts.

Similar to the studies on prior knowledge, most of the studies on the relative contribution of strategy use to conceptual understanding have been conducted with middle, high school, and college students. The exception is Chan (1995) who found that use of higher-level strategies did not explain a significant amount of variance in fifth grade students' reading comprehension scores. In addition, other studies on the relative contribution of use of higher-level strategies to indicators of conceptual understanding did not control for the effects of prior knowledge, interest, and learning goals. Whether the contribution of use of higher-level strategies to conceptual understanding will remain significant after the effects of the aforementioned variables are controlled remain a puzzle. In this study, we examined: (a) the relationship between fifth grade students' prior knowledge, use of higher-level strategies, interest, and learning goals and their conceptual understanding of ecological science concepts; and (b) the relative contribution of use of higher-level strategies to conceptual understanding after prior knowledge, interest, and learning goals were controlled.

Interest and Conceptual Understanding

The importance of interest to the acquisition of meaningful learning or conceptual understanding has long been recognized by educational psychologists (e.g., Dewey, 1913; James, 1950; Thorndike, 1935). The belief was that interest directs attention; improves memory; allows students to identify with the material to be learned; and promotes the understanding of various academic concepts. Although different conception of interest has been proposed over the years (see Hidi, 1990; and Schiefele, 1991), more contemporary researchers define interest as a personal and a situational phenomenon (Krapp, Hidi, & Renninger, 1992).

Personal interest is unique to the individual; it is an enduring preference for a specific subject, topic, concepts, or an activity. Situational interest is elicited within a particular context, it is short lived, and is common among individuals. Both personal and situational are related to each other and to concept comprehension (see Hidi, 1990, for a complete discussion). Personal interest is the focus of this investigation. In addition to being related to students' comprehension of various academic concepts (math, science, reading), personal interest is also correlated with prior knowledge, and use of higher-level learning strategies (see Schiefele, 1991; and Tobias, 1994, for reviews).

Interest in the material to be learned also contributes substantially to different indicators of conceptual understanding (e.g., conceptual knowledge, propositional knowledge, reading comprehension). Results of several studies conducted in the past two decades on interest (e.g., Baldwin, Peleg-Bruckner, & MCClintock, 1985; Chambers & Andre, 1997; Schiefele, 1996; Shimoda, 1994) suggests that: (a) readers with high-topic interest tend to process the meaning of their texts more deeply than readers with low-interest; (b) students with high-topic interest are the ones who use higher-level learning strategies to understand the material to be learned; and (c) students with high-topic interest usually perform better on complex and deep comprehension questions than their counterparts with low interest. The aforementioned questions require students to recall the relations between facts, combine and compare various aspects of the text, and to apply the acquired information to novel situations. These positive results have been observed at the elementary, middle, high school, and college levels.

With the exception of studies conducted by Schiefele and his colleagues (see Schiefele, 1991, for a review), most of the studies on the contribution of interest to aspects of conceptual understanding did not control for the effects of students' prior knowledge. Furthermore, previous investigations on the contribution of interest to aspects of conceptual understanding have not simultaneously controled for the effects of prior knowledge, use of higher-level strategies, and learning goals. To better understand the contribution of interest to student learning, we examined: (a) the relationship between fifth grade students' prior knowledge, use of higher-level strategies, interest, and learning goals and their conceptual understanding of ecological science concepts; and (b) the relative contribution of interest to conceptual understanding after prior knowledge, use of higher-level strategies, and learning goals were controlled.

Learning Goals and Conceptual Understanding

Research on achievement goal orientations suggests that a learning goal orientation is important to the acquisition of conceptual understanding (see Ames, 1992; Blumenfeld, 1992; and Dweck & Leggett, 1988, for complete reviews). In contrast to performance goal orientation in which learning is undertaken with an intention to demonstrate high ability or avoid negative evaluation, learning goal orientation involves an intention to understand the material to be learned (Meece et al., 1988). The latter intention oreintation is the focus of this investigation.

Learning goals are predictors of achievement behaviors and student learning outcomes (Anderman & Young, 1994; Cavallo & Shafer, 1994; Nolen, 1988). In addition, learning goals have been found to foster mastery-oriented approaches to learning and studying that are associated with conceptual understanding. For example, several researchers (e.g., Archer, 1988; Nolen & Haladyna, 1990; Pintrich & DeGroot, 1990) have found that students who are committed to learning goals sought to master their work independently; persisted in the face of obstacles or difficulties; prefer challenging learning tasks; have positive attitudes toward learning; and used and reported using higher-level learning strategies to understand their school assignments. Furthermore, several achievement goal theorists (e.g., Ames & Ames, 1984; Nicholls, Cheung, Lauer, & Patashnick, 1989) have demonstrated that students with learning goals are more likely to maintain positive motivation in school. These results suggest that students who are committed to learning goals are more likely to acquire conceptual understanding than students who are not as committed to these goals.

On the other hand, the relative contribution of learning goals to conceptual understanding remains a puzzle. Since learning goals are correlated with use of higher-level strategies and are expected to be positively related to interest and prior knowledge (see Schiefele, 1991), it is important to understand the relative contribution of learning goals to conceptual understanding after the contributions of the aforementioned variables are controlled. For these reasons, we examined: (a) the relationship between fifth grade students' prior knowledge, use of higher-level strategies, interest, and learning goals and their conceptual understanding; and (b) the relative contribution of learning goals to conceptual understanding after prior knowledge, use of higher-level strategies, and interest were controlled. In summary, to better understand how cognitive and motivational variables are related to each other and to the quality of conceptual knowledge, the three research questions were:

1. Will strategy use, interest, and learning goals each predict conceptual understanding after prior knowledge is controlled?

2. Will strategy use, interest, learning goals, and prior knowledge predict conceptual understanding when the other sets of variables are controlled?

3. Will interest and learning goals each predict strategy use after prior knowledge is controlled and vice versa?

Method

Subjects

Participants were seventy-two fifth grade students from three science classrooms. Number of students from each class were 27 (38%), 25 (35%), and 20 (27%). The classrooms were parts of two elementary schools in a mid-Atlantic state. Both schools were located in lower middle class neighborhoods. Of the 72 students who participated in the study, 42 were boys (58%) and 30 were girls (42%). Of these, 35 were Caucasian (49%), 18 were African American (25%), 11 were Hispanic (15%), and 8 were Asian American (11%). Parental consent was obtained for all of the students. All of the students completed the cognitive and motivational measures. The school district did not track students for science classes at the two elementary schools involved in the study. Thus, the sample of students included a range of student achievement levels.

Measures

Knowledge Test. An 18-item knowledge test was designed to assess students understanding of ecological science concepts (plant and animal relationships and interdependencies). The first fifteen items are multiple-choice and matching questions. These items tapped students' ability to identify and recognize different ecological science concepts. Items 2, 3, 7, 12, and 15 were designed to assess students' knowledge of photosynthesis and energy transfer: the process of photosynthesis, factors needed for photosynthesis (sunlight, carbon dioxide), transformation of the sun's energy, mechanisms needed for photosynthesis, and recognition of the sun's potential, respectively. Items 6, 8, 11, 4, 10, and 14 were designed to assess their knowledge of ecosystems: definition of habitat, recognition of an ecosystem is an important food-chain, biomes as life supporting environment, the definition of ecosystem, function of the ecosystem, relationships between ecosystems and the sun's energy, respectively. Items 1, 5, and 13 were designed to assess their knowledge of the relationships among organisms: definition of community (plants and animals), and carrying capacity (predator-prey relations), respectively. Items 9 tapped their knowledge of organisms and their environment (animals and biomes). Items 16, 17, and 18 were designed to assess their knowledge of the food chain, more specifically, students' ability to use different plants and animals to construct terrestrial food-chains, and their ability to explain why their constructed food chains were correct using food-chains principles and concepts (i.e. predator-prey relations). Item 16 required students to construct two food-chains; one with (Man, Grass, Sheep, Cow, and sun), and the other with a (Snake, Eagle, Corn, and Rat). Items 17 and 18 required students to provide explanations for their constructed food-chains.

Test items were derived from three different sources. Some of the items were derived from science textbooks designed for fifth graders (Barudaldi, Ladd, & Moses, 1981; Cohen, Del Giorno, Harlan, McCormack, & Staver, 1986; Sund, Adams, Hackett, & Moyer, 1983). Previous environmental science knowledge tests that were designed to assess fourth and fifth grade students' knowledge of the food-chain and ecosystems (Martin County Schools, Jensen Beach, Florida, 1976) was the second source. In addition, other items were derived from previous knowledge tests designed to assess fourth, fifth, and sixth grade students' knowledge of living and nonliving things (Gallegos, Jerezano, & Flores, 1994; Singh, Cyr, & Serber, 1980). Content validity of the constructed knowledge test was further established with the help of two fifth grade science teachers. Cronbah's alpha coefficient for the 18 knowledge test items was .71. The knowledge test items are included in Appendix A.

Prior knowledge and Conceptual understanding. Students' September knowledge test score was the measure of prior knowledge. Students' December knowledge test score served as the measure of conceptual understanding. The maximum score for the knowledge test was 30 points. Students' prior knowledge scores ranged from 27 to 3 points, with a mean score of 12.27 (SD 4.83). Conceptual understanding scores ranged from 29 to 5, with a mean score of 14.76 (SD 4.90).

Scoring and Coding the Knowledge Test

Students received one point for each of the multiple choice questions they answered correctly; and a score of zero for those they answered incorrectly. The food chains constructed by students were coded into one of four categories developed by Gallegos et al (1994) to code food chains constructed by fourth, fifth, and sixth grade students. Descriptions of the four categories, adapted from Gallegos et al (1994, p.261), appear below:

A. correct answers, when they began with the producer and had a correct predator-prey relation.

B. inverted answers, when they began with the highest trophic level animal.

C. erroneous answers, when the predator-prey relation failed in at least one member of the food chain.

D. no answer.

For example, one of the food-chain tasks required students to construct a food-chain with a: snake, eagle, corn, and rat. A correct answer model = the corn, rat, snake, and eagle, respectively. The model began with the producer (corn) and the correct predator-prey relational sequence. The corn is eaten by the rat; the rat is eaten by the snake; and the snake is eaten by the eagle. An inverted model = the eagle, snake, rat, and corn, respectively. The model began with the highest trophic level animal (the eagle). An erroneous model may begin with the snake, eagle, rat, and corn, respectively. The predator-prey relation failed in at least one member of the food chain (i.e., rat--corn). In this situation, the model is implying that the rat is eaten by the corn. Students who failed to construct the model received a no answer score. A rank score was assigned to the categories in the following manner: 5 points for the correct model; 3 points for the inverted model; 1 point for an erroneous model; and 0 points when students failed to construct a model. The same rank score was used by Gallegos et al (1994).

A coding rubric developed by Guthrie et al (1997) to code third-and-fifth-grade students' responses on a writing task was adapted to code explanations provided by students for why they think that their constructed food chains were correct. The original coding rubric was based on a 6-point scale. The rubric was used to classify students' explanations of how ponds are different from deserts. The established interrater agreements for adjacent and exact scores for the writing task are 96% and

80%, respectively.

In this study, students' explanations were sorted into five categories or levels. The example(s) provided under each category are students' explanations for the food-chain model they constructed with a: snake, eagle, corn, and rat.

Level 5

At this level students clearly explicated the (predator-prey relations) that linked features of their constructed food chains; and understood that the producer is the initiator of their constructed food chain. Example: "I think its right because my food chain starts out with the corn witch is eaten by the rat and the rat is eaten by the snake and the snake is eaten by the eagle." In this example, the student acknowledged that the producer (corn) is the initiator of his constructed food chain and correctly explained the predator-prey relations that linked the features of the constructed food chain.

Level 4

At this level students wrote an explicit relationships between the producer and other animals in their constructed food chains, but no information is provided on how the producer is the initiator of their constructed food chain. For example, they only used parameters such as who eats whom. Examples: "I think my food chain is correct because a eagle can eat a snake, a snake can eat a rat, and a rat can eat corn." "I think my food chain is right because the rats eat corn snake eats rat and eagle eats snake." In both example, the students only used parameters such as who eats whom.

Level 3

At this level students wrote explicit relationships that linked features of their constructed food chains. However, the information provided about the relations are correct for only two or three features. Example: "rats eat corn, snake eats rat, and then eagle eats rat." The relationship between the snake and eagle was left out.

Level 2

At this level students wrote about different features of their constructed food chains but no relationships were explicitly stated, or scientifically inaccurate relationships. For example, the predator-prey relations was erroneous. Examples: "I think my food chain is correct because usually the bigger animal eats the smaller animal." "Because snakes and eagles are my favorite animals and I read about them."

Level 1

At this level students presented no information. Explanations were incoherent, or completely irrelevant to the topic of food chain. Students might have also presented information not in-line with their constructed food chain. Example: "It is because I know it is." Answer was completely irrelevant to the topic of food chain.

Interrater Agreement for the Coding Rubrics. Interrater agreement is an index of reliability suggested for coding rubrics or rules (see Suen, 1988, for a review). It is an estimate of similarity of ratings between two or more raters. More specifically, we used the degree or percentage of agreement that independent raters obtain after using a criterion-based standard or coding rubrics.

To understand the strength of the coding rules and to establish interrater agreement, two graduate students each independently coded 10 transcripts. Coders did not know the identity of the students whose transcripts were being coded. The percentage of agreement between coders was calculated for the strength of drawing and writing tasks using: (number of agrees) divided by the number of agrees + number of disagrees. For the drawing tasks (questions 27 and 29), 100% agreement (exact scores) was achieved. For the writing tasks, 98% and 96% agreement (exact scores) was achieved for questions (28 and 30), respectively.

THE LISQ. The Learning goals, Interest, and Strategy Use Questionnaire (LISQ) was designed to assess students' intentions to try to learn and understand ecological science concepts (food chain, ecosystem), their interest in science and ecological science concepts, and their use of learning strategies (See Appendix B). The LISQ items were derived from previous learning goals, interest, and strategy use instruments of established validity (construct and face) and reliability (internal, predictive, and discriminant) (e.g., Wigfield & Guthrie, 1997; Hollenbeck, Klein, O'leary, & Wright, 1989; Mitchell, 1993; Pintrich, Garcia, & Mckeachie, 1993; Schiefele, 1991). More specifically, the items from previous instruments were reworded to focus students attention on science class and ecological science concepts.

Learning Goals: This scale contained items that implied that students' goal was to learn and understand ecological science concepts. Item numbers (4, 6, 9, 2, 1, 3, and 16) were the LISQ items designed to assess students' learning goals (e.g., "I will try hard to understand how plants make their own food," and "I don't mind reading more books to learn about animals that eat plants"). The response associated with these items was based on a four-point scale anchored by strongly agree and strongly disagree, high score on this scale is indicative of high commitment to the goal of learning ecological science concepts (see Meece et al., 1988, for more information) (the 7- items' coefficient alpha = .80).

Interest: This scale contained items that implied that students' were interested in science and science concepts. Item numbers (10, 12, 11, 13, 8, 7, and 14) were the LISQ items designed to assess students' interests in science and ecological science concepts (e.g., "I wish our school had more stuff on plants and animals," and "Science is my favorite subject"). Responses to each item was based on a four-point scale (4 = strongly agree to 1 = strongly disagree) high score on this scale is indicative of high level of interest in science and science concepts (the 7-items' coefficient alpha = .81).

Strategy Use: This scale had items that assessed students' use of higher-level strategies (e.g., monitoring, elaboration). Item numbers (5, 17, 18, 19, 20, 21, 22, and 23) were the LISQ items designed to assess students' use of learning strategies (e.g., "When I study for a science test, I try to see how my readings fit with what I had learned before in science," and "In science class, I try to see how what we are learning fits with what I know"). The response scale associated with these items was based on a four-point likert scale anchored by strongly agree to strongly disagree, high score on this scale is indicative of high use of higher level strategies. Although these items formed one factor in a factor analysis, a subset was highly intercorrelated, and was used. These had a reliability of .50, which was adequate for this study.

Procedures

The study was conducted in two main phases. In the first phase, students completed an 18-item knowledge test. As mentioned earlier, the test was designed to assess students' knowledge of ecological science concepts (plant and animal relationships and interdependencies). Students completed the knowledge test in their science classrooms during the third week of school (mid-September) in fall (1996). Knowledge test administration took between 25-35 minutes. In the second phase, the Learning goal, Interest, and Strategy Use Questionnaire (LISQ) and knowledge test in that order were administered to students in (early-December) during the latter part of the semester.

LISQ administration took between 10-15 minutes. To ensure that students' ability to read the knowledge test and questionnaire items did not affect the reliability of the their responses, each of the knowledge test and questionnaire items was read with the students. This procedure also ensured that all of the students completed the the knowledge test and questionnaire items at the same time. Before responding to the questionnaire items, students were told that "There are no right or wrong answers to these questions. Circle the number that you agree with the most. Circle only one number for each sentence."

In order to determine the curriculum content, teachers were interviewed after both phases of the study were completed. Teachers' interviews showed that 4-6 hours were dedicated to the teaching of ecology. The content objectives emphasized ecology and included (a) understand principles of energy transfer in a food chain; and (b) describe how living and nonliving things interact in an ecosystem. Students were informed about the importance of ecological concepts, such as, "learning about ecological concepts enables one to better able to solve environmental issues that affect the survival of our society." The concept of food chain was introduced with a conceptual model that showed the interactions among the food chain elements. Students also constructed food chains and labeled its different parts. Ecological concepts such as community, ecosystem, predator, prey, consumers, producers, and carrying capacity were synthesized to help students understand how living and nonliving things interact in an ecosystem. Information on half of the knowledge items were taught to the students. Items 1, 4, 5, 6, 10, 13, and 16 were identical to the items used by the teachers to assess students' knowledge of the ecology (see the Knowledge test's measure section for a description of these items).

Factor Analysis

Because of the purpose of this study, it was necessary to provide evidence for existence of only one factor in each scale and support that a single construct was being measured. For example, it is plausible that the learning goals and interest scales may be measuring the same construct. Students who are interested in learning different science concepts may also be highly committed to learning these concepts. On the other hand, interest and learning goals can be distinguished from one another. A student may be interested in science but may not be committed to the goal of learning science concepts and ideas, or put forth the effort needed to understand science concepts. Commitment to learning implies effort over time, while interest was conceptualized as a general liking for science and ecological science concepts. In short, the three LISQ scales needed to be distinguished from each other. To provide evidence for the existence of only one factor in each scale, exploratory factor analysis was performed. Existence of only one factor in each scale was supported (Table 1).

Insert Table 1 about here

Results

Descriptive Statistics

As mentioned earlier, the study was conducted in two main phases. In phase one, students completed the knowledge test in their science classrooms during the third week of school (mid-September) in fall (1996). In phase two, students completed the Learning goal, interest, and strategy use questionnaire (LISQ) and the knowledge test in that order in early December. Phase one knowledge test scores served as students' prior knowledge of ecological science concepts. Phase two knowledge test scores was operationalized as students' conceptual understanding of the ecological science concepts.

Similar to previous studies (i.e., Meece et al., 1988), students' mean score on the learning goals measure was operationalized as their commitment to learning ecological science concepts. Students' mean score on the interest measure was operationalized as their interest in science and ecological science concepts. Students' mean score on the strategy use measure was operationalized as their use of higher-level strategies. Table 2 shows the means and standard deviations for all of the measured variables: prior knowledge, interest, learning goals, strategy use, and conceptual understanding.

Since the interest, learning goals, and strategy use scales were all based on a four-point scale, students' ratings of each scale items are noteworthy. The strategy use items received the highest ratings ($M = 3.23$); followed by the learning goal items ($M = 3.07$); and the interest items ($M = 2.60$).

The knowledge test used to assess students' prior knowledge and conceptual understanding was based on a thirty-point scale. Based on this scale, students' prior knowledge and conceptual understanding mean scores ($M = 12.27$ and $M = 14.76$, respectively) were low. These results suggested that most of the students in this study had a low understanding of ecological science concepts.

Insert Table 2 about here

Scores on all measures were examined for gender differences. No significant gender differences were observed. Table 3 shows the intercorrelations among the variables. Review of this table indicated that the motivational and cognitive measures were positively related. Prior Knowledge was not significantly correlated with interest (r = .20); Learning goals (r = .17); or strategy use (r = .15). However, prior knowledge was significantly correlated with conceptual understanding (r = .61, $p < .001$). Interest was significantly correlated with learning goals (r = .59, $p < .001$); moderately correlated with strategy use (r = .44, $p < .001$); and moderately correlated with conceptual understanding (r = .40, $p < .001$). Learning goals was strongly correlated with strategy use (r = .60, $p < .001$); and moderately correlated with conceptual understanding (r = .34, $p < .01$). Strategy use was significantly correlated with conceptual understanding (r = .28, $p < .01$).

Insert Table 3 about here

Answers to Research Questions

To understand the relative effects of prior knowledge, learning strategies, interest, and learning goals to each other and to conceptual understanding, hierarchial regression analyses were performed. Hierarchial regression analyses are used to identify the relative effects of variables assumed to be affecting a phenomenon under study (Pedhazur, 1982; Pedhazur & Schmelkin, 1991). The relative effects of variables are determined by entering them in the regression analysis in a sequence, one variable at a time and noting at each step the increment in R^2 due to the variable being entered. The increment in R^2 allows a researcher to understand the variance accounted for by each variable while controlling for the effects of other variables (Pedhazur & Schmelkin, 1991). The order of sequence in which the variables are entered into the analysis depended on the question being asked.

Question 1

Will strategy use, interest, and learning goals each predict conceptual understanding after prior knowledge is controlled? To address this question, three hierarchial multiple regression analyses were performed. The dependent variable was conceptual understanding. In the first analysis, independent variables were entered in the order of prior knowledge and strategy use. Since the goal was to understand the contribution of strategy use to conceptual understanding after prior knowledge was controlled, strategy use was entered into the regression analysis after prior knowledge. Results of the multiple regression analysis showed that strategy use predicted a significant amount of the variance in conceptual understanding when prior knowledge was controlled. Strategy use accounted for 4% of the total variance in conceptual understanding. $\underline{R}^2$ change was significant at ($p < .027$), as indicated in Table 4.

In the second analysis, the independent variables were entered in the order of prior knowledge and interest. Interest predicted a significant amount of the variance in conceptual understanding when prior knowledge was controlled. Interest accounted for 7% of the total variance in conceptual understanding. Increment in $\underline{R}^2$ was significant at ($p < .004$), as indicated in Table 4.

In the third analysis, the dependent variable was conceptual understanding. Independent variables were entered in the order of prior knowledge and learning goals. Learning goals predicted a significant amount of the variance in conceptual understanding when prior knowledge was controlled. Learning goals accounted for 6% of the total variance in conceptual understanding. $\underline{R}^2$ change was significant at ($p < .01$). The results are shown in Table 4.

Insert Table 4 about here

Question 2

Will strategy use, interest, learning goals, and prior knowledge predict conceptual understanding when the other variables are controlled? Specifically, will prior knowledge predict conceptual understanding after interest, learning goals, and strategy use are controlled?; will strategy use predict conceptual understanding when prior knowledge, learning goals and interest are controlled?; will learning goals predict conceptual understanding when prior knowledge, interest, and strategy use are controlled?; and will interest predict conceptual understanding when prior knowledge, learning goals, and strategy use are controlled?

To address these questions, three hierarchial multiple regression analyses were performed. The dependent variable was conceptual understanding. In the first analysis, independent variables were entered in the order of interest, learning goals, strategy use, and prior knowledge. Multiple regression analysis showed that prior knowledge predicted conceptual understanding when the contributions of interest, learning goals, and strategy use were taken into account. Prior knowledge accounted for 29% of the total variance in conceptual understanding. $\underline{R}^2$ change was significant at $p<.001$, as indicated in Table 5. In the first analysis, independent variables were entered in the order of prior knowledge, learning goals, interest, and strategy use. Multiple regression analysis showed that strategy use did not predict a significant amount of the variance in conceptual understanding when prior knowledge, learning goals, and interest were controlled (Table 5).

In the second analysis, independent variables were entered in the order of prior knowledge, interest, strategy use, and learning goals. Multiple regression analysis showed that learning goals did not predict a significant amount of the variance in conceptual understanding when prior knowledge, interest, and strategy use were controlled (Table 5). In the third and final analysis, independent variables were entered in the order of prior knowledge, learning goals, strategy use, and interest. Multiple regression analysis showed that interest did not predict a significant amount of the variance in conceptual understanding when prior knowledge, learning goals, and strategy use were controlled (Table 5). These results suggested that prior knowledge, learning goals, interest, and strategy use were correlated with each other and to conceptual understanding (see Discussion section, for more information).

Insert Table 5 about here

Question 3

Will interest, and learning goals predict strategy use after prior knowledge is controlled? To address this question, two hierarchial multiple regression analyses were performed. The dependent variable was strategy use. In the first analysis, independent variables were entered in the order of prior knowledge and interest. Multiple regression analysis showed that interest predicted a significant amount of the variance in strategy use when prior knowledge was controlled. Interest accounted for 17% of the total variance in strategy. Increment in $\underline{R}^2$ was significant at ($p < .003$), as indicated in Table 6.

In the second analysis, the independent variables were entered in the order of prior knowledge and learning goals. Multiple regression analysis showed that learning goals predicted a significant amount of the variance in strategy use when prior knowledge was controlled. Learning goals accounted for 37% of the variance in strategy use. Increment in $\underline{R}^2$ was significant at ($p < .001$), as indicated in Table 6.

In a third analysis, the independent variables were entered in the order of learning goals, interest, and prior knowledge. Multiple regression analysis showed that prior knowledge did not predict the variance in strategy use after learning goals and interest were accounted for. $\underline{R}^2$ change was not statistically significant. Results are shown in Table 6.

Insert Table 6 about here

Discussion

The need to understand how cognitive and motivational variables are related to each other and to knowledge acquisition has been widely expressed in recent literature. In this study, we examined the relative contribution of prior knowledge, learning strategies, interest, and learning goals to conceptual understanding. In what follows, we will discuss the main findings; provide information on the conclusions that can be drawn from the data of this study; and make suggestions for future studies.

In reference to the first question, the results of this study suggest that prior knowledge, interest, learning goals, and strategy use are important to knowledge acquisition. These variables were all statistically correlated with conceptual understanding of ecological science concepts. More importantly, each variable accounted for a significant portion of variance in conceptual understanding.

In reference to the second question, prior knowledge accounted for a significant portion of the variance in conceptual understanding after the contributions of interest, learning goals, and strategy use were controlled. Independent of the latter variables, prior knowledge accounted for 28% of the total variance in conceptual understanding. By enhancing students' abilities to: (a) assimilate and integrate information; and (b) distinguish relevant concepts or information from irrelevant ones, prior knowledge can facilitate the acquisition of conceptual understanding independent of interest, learning goals, and strategy use.

On the other hand, neither interest, learning goals, nor strategy use accounted for a significant portion of variance in conceptual understanding after the contributions of the other predictors were controlled. For example, strategy use did not predict a significant portion of the variance in conceptual understanding after the contributions of prior knowledge, learning goals, and interest were accounted for. Interest did not predict a significant portion of the variance in conceptual understanding after the contributions of prior knowledge, learning goals, and strategy use were accounted for. Finally, learning goals did not predict a significant portion of the variance in conceptual understanding after the contributions of prior knowledge, interest, and strategy use were accounted for.

Since prior knowledge was the only factor independent of the others to account for a significant portion of variance in conceptual understanding, the interdependence hypothesis between the key study variables was supported. In other words, interest, learning goals, and strategy use were correlated with each other to such an extent that none of them made unique, independent contribution to conceptual understanding. This does not imply that the construct are identical or that the measures were tapping the same variables. To the contrary, factor analysis revealed that all constructs were separable. Correlation among them were for the most part moderate. However, they all contributed shared variance in conceptual understanding. The total R was .68, showing the set explained 46 percent of the variance in conceptual knowledge, which is substantial. It should be noted that perfectly reliable measures could possibly have shown unique contributions of each variable. However, the evidence suggests that student who had high interest were likely to gain high levels of conceptual knowledge. However, the high interest student also had high learning goals and high strategy use, their superior knowledge can not simply be attributed to relatively high levels of interest, learning goals, and strategy use. None can be discounted.

If the predictor variables were not correlated with each other and to conceptual understanding, the proportion of the variance that each predictor variable accounted for would have remained the same regardless of the order in which each predictor was entered into the regressional analyses. However, the proportion of the variance in conceptual understanding accounted for by strategy use, interest, and learning goals was not constant across different orders (Table 4). A close inspection of Table 4 indicates that the proportion of the variance attributed to prior knowledge, strategy use, interest, and learning goals varied, to a greater or lesser extent, depended on the stage at which each variable was entered into the regressional analyses.

In reference to the third and final question, learning goals, interest, and strategy use were all statistically correlated. Students who were interested in science and ecological science concepts are more likely to commit themselves to the goal of learning ecological science concepts, and are also more likely to use higher-level strategies to learning their ecological concepts. These findings are also compatible with other research that has reported positive associations amongst interest, learning goals, and use of higher-level strategies (e.g., Anderman & Young, 1994; Nolen, 1988; Meece et al., 1988; Schiefele, 1991; Pintrich & DeGroot, 1990) and can be taken as additional evidence that motivation and cognition are meaningfully linked.

After prior knowledge was accounted for, interest and learning goals accounted for 17% and 34% of the total variance in strategy use, respectively. Interest and learning goals were associated with frequent use of higher-level strategies independent of prior knowledge. Interest and learning goals are important predictors of frequent use of higher-level strategies (Nolen, 1988; Schiefele, 1991). Prior knowledge did not predict the variance in strategy use after learning goals and interest were accounted for. Prior knowledge of ecological concepts, interest, and learning goals are important to frequent use of higher-level strategies; however, it appears as if prior knowledge by itself will not ensure the use of higher-level strategies.

Prior knowledge was not statistically correlated with interest (r = .20); learning goals (r = .17); and strategy use (r =.15). Prior knowledge as measured and conceptualized in this study did not appear to be a good predictor of students' interest, learning goals, and strategy use. However, other researchers have found prior knowledge, interest, learning goals, and strategy use to be strongly correlated with each other. For example, Benton, Corkill, Sharp, Downey, & Khramtsova, 1995) found a strong relationship between topic knowledge and individual interest (r = .53, $p < .001$). In the Benton et al's study, prior knowledge was measured as what an individual knows about a specific topic; and individual interest comprised of what knowledge and value the individual brought to the task from prior experience.

Cavallo and Shafer (1994) found a strong relationship between prior knowledge and learning goal orientation ($r = .49$, $p < .01$). Prior knowledge was operationalized as domain knowledge of meiosis. Learning goal orientation (a global personality construct) comprised of students' self-ratings and teachers' observation-based ratings of commitment to learning goals. Furthermore, the results of the review of literature conducted by (Alexander & Judy, 1988) on the interaction between domain specific and strategic learning also provides evidence for the strong relationship between prior or subject matter knowledge and use of learning strategies. In addition to the issue of conceptualization and measurement, the prior knowledge measure in this study was given to students 10 weeks before the measure of interest, learning goals and strategy use. Therefore, the separation in time also accounts for the low correlation between prior knowledge, interest, learning goals, and strategy use.

Although the results of this study indicated that the investigated cognitive and motivational variables were meaningfully related to each other and to the quality of student knowledge, certain limitations should be kept in mind when interpreting the findings. The predictors were self-reported measures of interest, learning goals, and strategy use. While the measure of strategy use was predictive and fairly reliable, it would have been preferable to use more items to assess this construct which may strengthen it. It may also be wise to include a performance measure of strategy use for young students in the elementary grades. In line with this recommendation, Guthrie et al. (in press) found that a performance measure of learning strategies accounted for a high proportion of the variance in fifth grade students' conceptual learning after their prior knowledge was controlled. Future studies should also include performance measures of students' prior knowledge of higher-level strategies, their conditional knowledge of strategies, and learning goals to better understand the relationships among these variables.

A correlational design was used to structure this investigation. Strengths and weaknesses of the correlational design were inherited. Since this study did not use an experimental or longitudinal design, it is inappropriate to make a clear statement concerning causality. Results of this study were also limited to fifth grade and to the selected ecological concepts. Consequently, it would be useful to replicate this study with other fifth grade students in different knowledge domains, and to examine the impact of the key study variables in a controlled setting or with a longitudinal design.

Despite these caveats, results of this study have contributed to our understanding of how prior knowledge, use of higher-level strategies, interest, and learning goals are related to each other and to conceptual understanding. The efficacy of each of the mentioned variables in predicting the variance in conceptual understanding was documented. In addition we found that: (a) strategy use did not predict a significant amount of the variance in conceptual understanding when prior knowledge, learning goals, and interest were controlled; (b) learning goals did not predict a significant amount of the variance in conceptual understanding when prior knowledge, interest, and strategy use were controlled; and (c) interest did not predict a significant amount of the variance in conceptual understanding when prior knowledge, learning goals, and strategy use were controlled. This pattern implies that motivation and cognition are meaningfully linked in their support for conceptual learning. Therefore, there is a need for a closer study of how motivation and cognition influence each other and different learning outcomes including conceptual understanding, reading achievement, and affective variables such as self-concept.

Results of this study provided support for the argument that learning has to be viewed as a multidimensional process involving the interplay of cognitive and motivational variables, such as, prior knowledge, interest, learning goals, and strategic processing (see Pintrich, Marx, & Boyle, 1993, for more information). Finally, results of this study suggest that science educators need to take fifth grade students' prior knowledge, interest, goals, and strategy use into account when designing instructional contexts for improving conceptual understanding.

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APPENDIX A
THE KNOWLEDGE TEST

ENVIRONMENTAL SCIENCE QUESTIONS

Name____

Grade________________________

Teacher____

School____

Boy_________ Girl___________________

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ENVIRONMENTAL SCIENCE CONCEPTS

1. What is it called when plants and animals live and work together?

a. population c. family

b. community d. habitat

2. In the process of photosynthesis

a. plants take in oxygen and release carbon dioxide

b. plants take in carbon dioxide and release oxygen

c. animals take in oxygen and release carbon dioxide

d. animals take in carbon dioxide and release oxygen

3. Which factor is not essential for photosynthesis?

a. nitrogen c. light

b. water d. carbon dioxide

4. The working together of living things with non-living things around them is called:

a. community c. population

b. ecosystem d. habitat

5. Which animal hunts, kills, and eat other animals.

a. herbivore c. predator

b. prey d. both b and c

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6. Which of the following terms defines a habitat?

a. It is a place where an animal grows or lives.

b. It is the kind of food that the animal eats.

c. It is the relationship between the animal, soil, air, and water.

d. It is the what the animal does in its environment.

7. What changes the sun's energy into energy for other living things:

a. the sea	c. the plants
b. the animals	d. the wind

8. The ocean ecosystem is important because:

a. It is important to whales.

b. it is an important food chain.

c. it is an important source of salt.

d. It has a pretty shoreline.

9. Next to each number write the biomes from column B that matches where the animals in column A can be found.

COLUMN A	COLUMN B
monkeys/tigers ______	Taiga
fish/frogs ______	Desert
lizard/camel ______	Tropical rain forest
wolves/mountain goats ______	Aquatic

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10. Which of the following statements about the ecosystem is correct?

a. dead trees can be reused

b. water can be reused but dead trees cannot be used.

c. both water and dead trees can be reused.

d. none of the above

11. Which of the following biomes would support the most number of animals?

a. tundra c. grassland

b. forest d. desert

12. Chlorophyll is necessary for photosynthesis because it:

a. takes in water c. takes in oxygen

b. captures sunlight d. captures carbon dioxide

13. What would happen to the hare's population if all of their predators were killed?

a. hares would be healthier because sick ones could rest and get well instead of spending their energy escaping from predators and get well instead of spending their time escaping from predators.

b. the hares would continue to reproduce until they had exceeded the land's carrying capacity, at which point many would starve.

c. the hares would grow taller and stronger.

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d. over several generations, rabbits would be the king of all of the animals.

14. Which of the following ecosystem receives the least amount of energy from the sun?

a. coastal forest

b. tundra

c. savannah

d. taiga

15. Which of the following terms is most important in producing the greatest amount of ocean life?

a. warm water

b. sunlight

c. cold water

d. plankton

Draw a food chain using all of the following organisms:

Snake Eagle Corn Rat

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16. Explain why you think your answer to your drawing is correct?

17. Draw a food chain using the following:

    Man, Grass, Sheep, Cow, Sun.

18. Explain why you think your answer to #17 is correct?

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APPENDIX B
THE LISQ

Name:____________________________

Teacher:__________________________

Please read each sentence carefully, and see how well you agree with them. There are no "right" or "wrong" answer to these items.

Circle the number that you agree with the most.

Circle only one number for each sentence.

Practice item:

A. Science teachers know a lot about science stuff.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree

If you have any questions about which one to circle, please ask a question now.

Read the statements to yourself and think about each one. Don't spend too much time on any one item. You will be given enough time to finish answering all of the items.

Now you are ready to start!

Part A

1. I don't mind reading more books and completing more homework to learn about plants and animals

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree

2. I don't mind working harder than usual to learn about animals that eat plants.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree

3. I will try my hardest to understand how plants make their own food.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

4. I think that students should try to learn the meaning of a science word like cells.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

5. If I try hard, I can finish all of my science homework on plants and animals.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

6. I will be very happy when I understand the meaning of a science word like food-web.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

7. How often do you read a book about plants and animals for fun.

Almost never.......... 1
About once a month.... 2
About once a week..... 3
Almost every day...... 4

Part B

8. I am willing to spend one hour on saturdays to learn about plants and animals.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

9. I will like to spend more time after school to learn about living things.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

10. I enjoy learning about plants and animals.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

11. I like to learn about animals and where they live.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

12. Science is my favorite subject.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

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13. When I grow up, I will like to study about plants and animals.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

14. Science is important to me and my friends.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

15. I wish our school had more stuff on plants and animals.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

16. My friends think I am really smart because I know about different plants and animals.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

Part C

17. I usually find a quiet place to do my science work.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

18. I use questions like why, what, and how to understand my science work on plants and animals.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

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19. When I do my science homework on the food-chain, I usually use the dictionary, my science class notes, and my science book.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

20. When I study for a science test, I try to see how my readings fit with what I had learned before in science.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

21. In science class, I try to see how what we are learning fits with what I know.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree.

22. I am always looking for ways to make science more fun for my self.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree

23. When I read about plants and animals, I make pictures in my head.

4	3	2	1
I strongly agree	I sort of agree	I disagree	I strongly disagree

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TABLE 1

Factor Loadings for the LISQ

Item Number	Factor One	Factor Two	Factor Three
ITEM10	.77836	.05851	.24705
ITEM12	.74321	.30447	.09289
ITEM11	.69694	.31006	.21300
ITEM13	.65008	.06529	.05549
ITEM8	.59333	.35899	.01238
ITEM7	.52566	.09476	.11855
ITEM14	.49643	.28216	.37117
ITEM4	.08725	.70303	.05736
ITEM6	.25150	.64839	.17713
ITEM9	.36838	.62924	.19390
ITEM15	.49206	.55663	.21144
ITEM2	.14075	.50744	.38221
ITEM3	.32550	.47215	.06563
ITEM16	.33256	.42162	.26835
ITEM17	.13498	.09529	.67326
ITEM21	.16808	.35936	.53611
ITEM23	.12143	.18992	.66289
ITEM22	.19331	.15176	.64870
ITEM5	.22098	.00771	.55650
ITEM20	.02563	.10012	.54555
ITEM18	.03401	.18089	.52363
ITEM19	.20421	.31227	.33168
Eigen value	6.766	2.219	1.454

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TABLE 2

Means and Standard Deviations for all Measured Variables

Variable	N	Mean	SD
Prior Knowledge	72	12.27	4.83
Interest	72	2.60	.65
Learning Goals	72	3.07	.58
Strategy Use	72	3.23	.54
Conceptual Understanding	72	14.76	4.91

TABLE 3

Intercorrelations Among The Measured Variables

Variable	1	2	3	4	5
1. Prior Knowledge	_	.20	.17	.15	.61**
2. Interest		_	.59**	.44**	.40**
3. Learning Goals			_	.60**	.34*
4. Strategy Use				_	.28*
5. Conceptual Understanding					_

Note: n = 72

*p < .01. **p <.001.

TABLE 4

Multiple Regression Analyses for Question 1

Dependent Variable	Independent Variable	R	R2	R2Cha	SigCha
Conceptual	Prior Knowledge	.60	.36	.36	.001
	Strategies	.64	.40	.04	.03
Conceptual	Prior Knowledge	.60	.36	.36	.001
	Interest	.66	.43	.07	.01
Conceptual	Prior Knowledge	.61	.38	.38	.001
	Learning Goals	.66	.42	.06	.01

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TABLE 5

Multiple Regression Analyses for Question 2

Dependent Variable	Independent Variable	R	R2	R2Cha	SigCha
Conceptual	Interest	.40	.16	.16	.001
	Learning goals	.42	.17	.02	.236
	Strategies	.42	.17	.01	.871
	Prior Knowledge	.68	.46	.29	.001
Conceptual	Prior Knowledge	.63	.38	.38	.001
	Learning Goals	.66	.44	.06	.01
	Interest	.68	.46	.03	.06
	Strategies	.68	.46	.00	.64
Conceptual	Prior Knowledge	.63	.38	.38	.001
	Learning Goals	.66	.43	.06	.01
	Strategies	.66	.44	.01	.50
	Interest	.68	.47	.03	.07
Conceptual	Prior Knowledge	.63	.38	.38	.001
	Interest	.67	.45	.08	.01
	Strategies	.67	.46	.01	.36
	Learning goals	.68	.47	.00	.47

TABLE 6

Multiple Regression Analyses for Question 3

Dependent Variable	Independent Variable	R	R2	R2Cha	SigCha
Strategies	Prior Knowledge	.15	.02	.02	.211
	Interest	.44	.20	.17	.003
Strategies	Prior Knowledge	.15	.02	.02	.211
	Learning Goals	.61	.37	.37	.001
Strategies	Learning Goals	.60	.37	.37	.001
	Interest	.61	.37	.01	.319
	Prior Knowledge	.61	.38	.00	.708

66

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