Relationships Among Learning Styles, Metacognition, Prior Knowledge, Attitude, and Science Achievement of Grade 6 and 7 Students in a Guided Inquiry Explicit Strategy Instruction Context.

by

Trudy Georgene Holden

B.A. (Ed.), Memorial University of Newfoundland, 1970
M.Sc., Memorial University of Newfoundland, 1975

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We accept this dissertation as conforming to the required standard.

____

Dr. Larry D. Yore, Co-Supervisor (Department of Social and Natural Sciences)

____

Dr. J. C. Anderson, Co-Supervisor (Department of Psychological Foundations in Education)

____

Dr. J. Walsh, Departmental Member (Department of Psychological Foundations in Education)

____

Dr. L. O. Ollila, Outside Member (Department of Communications and Social Foundations)

____

Dr. James A. Shymansky, External Examiner (Science Education Center, University of Iowa)

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University of Victoria

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Co-Supervisors: Dr. Larry D. Yore
Dr. John C. Anderson

ABSTRACT

The interactive-constructive model of learning with its emphasis on the relationships among learner, task and context served as the framework for the present study, which investigated the associations among science achievement and learner characteristics; learning style, metacognition, prior knowledge and affective attributes. Over the course of eleven weeks Grade 6 and 7 students were taught biological science topics by their regular classroom teachers using a guided inquiry approach with embedded explicit strategy instruction. Strategies included accessing prior knowledge using K-W-L charts, detecting main ideas, and recognizing and using the text-structure strategies of compare-contrast, cause-effect and description. Measures of cognitive-based and personality-based learning styles and attitude were used to pretest learning style and attitude toward school science. Objective tests of science knowledge, metacognitive awareness and metacognitive self-management served as pretest and posttest measures of conceptual science knowledge and metacognition. Pretest and posttest interviews of students also assessed metacognition. The interview data, attitude survey analysis and post-study teacher interviews served as qualitative sources of information that were used to clarify the results from the quantitative analyses. The results of analyses indicated that the subjects tended to demonstrate a field-dependent cognitive style. Style variations between males and females on the personality style measure were such that males were primarily intuition-feeling (NF) learners while females were primarily sensing-feeling (SF) learners. No clear pattern of relationship emerged between cognitive and personality learning styles. The relationship between cognitive learning styles and changes in conceptual knowledge was such that field-independent subjects made greater gains in conceptual knowledge than did field-dependent subjects. The few subjects who demonstrated dominant intuition-thinking (NT) learning style made greater conceptual knowledge gains than those that did not demonstrate an NT style. The demonstrated field-dependent and SF learning styles are likely not compatible with a guided inquiry approach to elementary school science. There were significant differences in conceptual growth between groups of subjects with low and

high scores on overall metacognition, metacognitive awareness and metacognitive self-management. Students with high levels of metacognition made greater gains in conceptual knowledge than did students with low levels of metacognition. Six of the 24 attitude items, loosely defined as self-perception and self-regulation, correlated significantly with metacognition and science achievement; two attitude items correlated with metacognitive awareness and metacognitive self-management, two attitude items correlated with the ISRA and two attitude items with all measures of conceptual knowledge. This disposition may be the link between metacognitive awareness and metacognitive self-management and related science success. It seems important to design teaching programs that address students in their preferred learning style yet expose them to those styles and strategies of learning associated with academic success in science. Motivational techniques where all aspects of an instructional program count toward course evaluation need to be considered. There seems to be a need for closer professional liaisons between those involved in research and teachers in the field. Future ecologically based research needs to be extended over longer parts of the school year, introducing fewer strategies over longer times and involving teachers and researchers working closely together.

Dr. Larry D. Yore, Co-Supervisor (Department of Social and Natural Sciences)

Dr. J. C. Anderson, Co-Supervisor (Department of Psychological Foundations in Education)

Dr. J. Walsh, Departmental Member (Department of Psychological Foundations in Education)

Dr. L. O. Ollila, Outside Member (Department of Communications and Social Foundations)

Dr. James A. Shymansky, External Examiner (Science Education Center, University of Iowa)

TABLE OF CONTENTS

Abstract ii

Table of Contents iv

List of Tables vi

List of Figures xii

Acknowledgments xiv

Dedication xvi

Chapter 1. Problem Focus and Significance 1

- Introduction 1
- Research Questions 4
- Limitations 6
- Significance 8

Chapter 2. Literature Review 10

- Introduction 10
- Historical Perspective 11
- Alternative Models 14
- Unified Model 18
- Learner Characteristics 22
- Contextual Environment 31
- Critical Tasks 38
- Summary 40

Chapter 3. Method 41

- Subjects 41
- Instructional Materials 42
- Assessment Instruments 43
- Procedure 51

TABLE OF CONTENTS (cont'd.)

Data Analysis 57

Chapter 4. Results 58

Cognitive-Based Learning Styles 58

Personality-Based Learning Styles 61

Relationship between Cognitive-Based and Personality-Based Learning Styles 77

Relationship between Conceptual and Metacognitive Knowledge 86

Relationship between Learning Styles and Conceptual and Metacognitive Knowledge 91

Relationship between Learning Styles and Changes in Conceptual and Metacognitive Knowledge 94

Qualitative Data 97

Chapter 5. Discussion and Implications 104

Implications for the Classroom 112

Implications for Future Research 114

References 117

Appendices 129

LIST OF TABLES

Table 1	Chronology of the Events of the Study.	53
Table 2	Chapter and Lesson Titles and Embedded Explicit Instructional Strategies.	54
Table 3	Mean, Standard Deviation and Range Values for the GEFT across Subjects and by Gender.	60
Table 4	T-tests for Independent Samples of Gender on the GEFT.	60
Table 5	Mean, Standard Deviation and Range Values for the LPI Category Styles across Subjects and by Gender.	70
Table 6	T-tests for Independent Samples of Gender on LPI Category Styles.	71
Table 7	Correlation Coefficients of the GEFT with the LPI Category and Dominant Styles, and Dominant Perception and Judgment Functions across Subjects and by Gender.	78
Table 8	T-tests of Field-Dependent Style with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions Across Subjects.	80
Table 9	T-tests of Field-Independent Style with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions across Subjects.	84

Table 10	Correlations between Prior Conceptual Knowledge (Pkcl) and Prior Metacognitive Knowledge (Pkml), Prior Metacognitive Awareness (Pkmla) and Prior Metacognitive Self-Management (Pkmlsm) across Subjects and by Gender.	87
Table 11	Correlations between Conceptual Knowledge (Pkc2) and Metacognitive Knowledge (Pkm2), Metacognitive Awareness (Pkm2a) and Metacognitive Self-Management (Pkm2sm) following Explicit Strategy Instruction across Subjects and by Gender.	87
Table 12	Correlations between Changes in Conceptual Knowledge (ΔPkc=Pkc2-Pkcl) and Changes in Metacognitive Knowledge (ΔPkm=Pkm2-Pkml), Metacognitive Awareness (ΔPkma=Pkm2a-Pkmla) and Metacognitive Self-Management (ΔPkmsm=Pkm2sm-Pkmlsm) across Subjects and by Gender.	88
Table 13	T-tests for Low and High Prior Metacognitive Knowledge (Low Pkml and High Pkml) with Changes in Conceptual Knowledge (ΔPkc).	89
Table 14	T-tests for Low and High Prior Metacognitive Awareness (Low Pkmla and High Pkmla) with Changes in Conceptual Knowledge (ΔPkc).	90
Table 15	T-tests for Low and High Prior Metacognitive Self-Management (Low Pkmlsm and High Pkmlsm) with Changes in Conceptual Knowledge (ΔPkc).	90

Table 16	Correlations between GEFT and Pretest and Posttest Conceptual Knowledge (Pkc), Metacognitive Knowledge (Pkm), Metacognitive Awareness (Pkma) and Metacognitive Self-Management (Pkmsm).	92
Table 17	Correlations between LPI Category and Dominant Styles with Pretest and Posttest Conceptual Knowledge (Pkc), Metacognitive Knowledge (Pkm), Metacognitive Awareness (Pkma) and Metacognitive Self-Management (Pkmsm) across Subjects.	93
Table 18	T-tests for Paired Samples of Conceptual Knowledge, Metacognitive Knowledge, Metacognitive Awareness and Metacognitive Self-Management across Subjects.	95
Table 19	T-tests for Samples of GEFT with Changes in Conceptual Knowledge (ΔPkc), Metacognitive Knowledge (ΔPkm), Metacognitive Awareness (ΔPkma) and Metacognitive Self-Management (ΔPkmsm).	96
Table 20	Number of Directional Changes in Percentages from Pretest to Posttest for Metacognitive Awareness and Metacognitive Self-Management.	100
Table G1	T-tests of Field-Dependent Styles for Males with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions.	202
Table G2	T-tests of Field-Dependent Style for Females with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions.	203

Table G3	T-tests of Field-Dependent Style with Paired Samples of the LPI Dominant Styles and Dominant Perception and Judgment Functions.	204
Table G4	T-tests of Field-Independent Style for Males with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions.	205
Table G5	T-tests for Field-Independent Style for Females with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions.	206
Table G6	T-tests for Samples of SF Category Style with Changes in Conceptual Knowledge (ΔPkc), Metacognitive Knowledge (ΔPkm), Metacognitive Awareness (ΔPkma) and Metacognitive Self-Management (ΔPkmsm).	207
Table G7	T-tests for Samples of ST Category Style with Changes in Conceptual Knowledge (ΔPkc), Metacognitive Knowledge (ΔPkm), Metacognitive Awareness (ΔPkma) and Metacognitive Self-Management (ΔPkmsm).	208
Table G8	T-tests for Samples of NT Category Style with Changes in Conceptual Knowledge (ΔPkc), Metacognitive Knowledge (ΔPkm), Metacognitive Awareness (ΔPkma) and Metacognitive Self-Management (ΔPkmsm).	209
Table G9	T-Tests for Samples of NF Category Style with Changes in Conceptual Knowledge (ΔPkc), Metacognitive Knowledge (ΔPkm), Metacognitive Awareness (ΔPkma) and Metacognitive Self-Management (ΔPkmsm).	210

Table G10	Percentage Distribution of Scores for Pretest Taped Interview Questions (TI1) and Posttest Taped Interview Questions (TI2) across the Seven Protocol Sets and for the Metacognitive Domains Investigated.	211

LIST OF FIGURES

Figure 1	Interactive-constructive model of reading--unified model.	21
Figure 2	Distribution of scores on the GEFT across subjects and by gender.	59
Figure 3	Category distribution for the sensing-feeling learning preference across subjects and by gender.	65
Figure 4	Category distribution for the sensing-thinking learning preference across subjects and by gender.	66
Figure 5	Category distribution for the intuition-thinking learning preference across subjects and by gender.	68
Figure 6	Category distribution for the intuition-feeling learning preference across subjects and by gender.	69
Figure 7	Dominant learning preference on the LPI across subjects and by gender.	73
Figure 8	Distribution for the dominant perception and judgment functions including the frequency of no perception or no judgment function.	76

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To my special friends who were interested in my work and encouraged me, I say thank you very much.

DEDICATION

To the memory of my mother Gertrude Squires Conway

1920-1994

CHAPTER 1

Problem Focus and Significance

Introduction

Educated citizens in the information age are seen as those able "to acquire, analyze, and apply complex information effectively; to locate, communicate, and produce information effectively; to solve problems quickly and efficiently and to be committed to lifelong learning" (Jones & Idol, 1990, p. 3). Since technology and science are integral parts of the information age, the modern school curriculum needs to provide attention to these disciplines. Programs of educational research must address these disciplines, delineate the factors involved in successful learning and, most importantly, ensure the transferability of research findings to real classroom settings.

In the field of reading, research from cognitive science and research on teaching have caused educators to rethink the teaching and learning process (Dole, Duffy, Roehler & Pearson, 1991). The result has been a cognitive-based view of reading where it is generally agreed "that reading is not a collection of independent skills but is a unified system by which specific texts trigger structural patterns to form coherent meaning" (Yore & Shymansky, 1991, p. 31). Reading, whether narrative or expository text, is seen to be an interaction between the reader, the text and the context that has as its goal the construction of meaning. This interactive-constructive model of reading provides a suitable foundation for science reading instruction.

In order to appreciate fully the significance of the interactive-constructive model of reading, it is necessary to consider specific learner characteristics involved. Prior knowledge has been identified as one of the

most important learner features in the reading process. It has been suggested that "prior knowledge is so pervasive and so important that we can only wonder why it traditionally has received so little curricular attention as an area worthy of specific training" (Pearson, Roehler, Dole & Duffy, 1992, p. 157). Under the general rubric of metacognition, it has been observed that learners' metacognitive knowledge (awareness) and executive control (self-management) of the task are critical to understanding. Metacognition is marked by effective strategy knowledge and use. Successful learners use their existing prior knowledge and metacognition through specific strategies to focus and monitor their comprehension during the reading process and fix or repair their comprehension once they realize it is in trouble. Many students do not learn strategies either automatically or incidentally, and there seems to be a lack of direct strategy instruction in classrooms. Students can be taught to access and to use their prior knowledge and to think about their thinking so as to monitor their comprehension through appropriate strategy use.

With emphasis on metacognition have come attempts to specify those strategies that "are necessary and sufficient for the improvement of comprehension ability" (Dole, Duffy, et al., 1991, p. 256). Much still needs to be done in delineating a full complement of research-validated strategies, but "some powerful strategies appropriate to particular academic goals and populations have been developed" (Pressley & Harris, 1990, p. 32). Some of the strategies found to be most effective are those of accessing prior knowledge, detecting main ideas, utilizing text structures, summarizing, self-questioning and responding to text.

Once a target strategy has been identified, it is useful for the teacher and the students to "establish the potential benefits of that strategy, the goals of strategy instruction and how and when to use the strategy" (Pressley & Harris,

1990, p. 32). The teacher must also model the strategy in context (Pearson & Dole, 1987). As the instructional process continues, the learner moves to control and to transfer ownership of the strategy and "assumes responsibility for regularly applying, monitoring and evaluating the strategy" (Pressley & Harris, 1990, p. 33). The ultimate goal is to have students become successful, self-regulated learners.

Garner (1992) suggested that an approach to strategic instruction as simply a "bag of tricks for strategic repertoires" is an incomplete picture (p. 248). It is necessary to consider individual differences and students' beliefs about their own abilities as learners to successfully utilize specific strategies. Pressley and Harris (1990) observed that before beginning specific strategy instruction it is necessary and appropriate to determine the affective and cognitive capabilities of the learner. That individual differences exist and that no one method is appropriate for all students has been widely acknowledged (e.g. Bruno, 1982; Dunn & Dunn, 1979; Vigna & Martin, 1982). Still, there is not compelling information regarding which student differences might reliably predict who would benefit from which strategies (Pressley, Goodchild, Fleet, Zajchowski & Evans, 1989).

Some of the early attempts to understand individual differences have grown out of psychological research concerned with personality variables, cognitive factors, and variations in perception. Cognitive style, as it later came to be known, had its roots in the early studies of perception by Witkin and his colleagues (e.g. Witkin, Moore, Goodenough & Cox, 1977; Witkin, 1978; Witkin & Goodenough, 1981). Defined as consistent and persistent modes of "organizing and processing information and experiences" (Messick, 1984, p. 61), cognitive style has the potential to impact strategy instruction.

Entwistle and Ramsden (1983) suggested that various cognitive styles as a facet of personality and personality in a very general sense may underlie styles of learning. Messick (1984) noted that styles are more deeply rooted in personality than is usually implied. Using Jung's theory of personality and the behavioral definitions of the Myers-Briggs Type Indicator, Hanson (1987) developed a new model of learning style, which may become the basis for a more comprehensive conception of learning style.

Schmeck (1983) suggested that, to date, attempts to relate cognitive and personality factors had fallen short of expectations but he maintained that ultimately such relationships may emerge. A close parallel between cognitive-based and personality-based perspectives would mean a significant move toward a comprehensive conception of learning styles. It would have major educational implications since beliefs that separate cognitive and affective dimensions of learning would become questionable and thus allow for more effective strategy instruction.

Pressley, Goodchild, et al., (1989) stated "there is not enough professional evaluation of techniques that are recommended in the literature" (p. 301). While much is known about strategy teaching and more is being learned each day, classroom research will provide "new information about which strategies are really useful to students, how students master particular strategies, and how misunderstandings can be corrected when they occur" (Pressley & Harris, 1990, p. 33).

Research Questions

The purpose of this study was to focus on four major factors influencing science achievement in Grade six and seven students. These factors included learning style, prior knowledge, metacognition and explicit strategy instruction.

Learning style was defined from a cognitive-based perspective and from a personality-based perspective. Prior knowledge focused on topic or conceptual knowledge, and metacognition included both metacognitive awareness and metacognitive self-management. The instructional strategies included accessing prior knowledge through self-questioning and responding to text, finding the main idea, and the text structure strategies of compare-contrast, cause-effect, and description.

Over the course of eleven weeks, five separate Grades six and seven classes from one school were taught one and one-half science units by their regular classroom teachers. The units, taken from Journeys in Science (Yore, Beugger, McDonald & Harrison, 1990), included Body Control Systems and Life Cycles. Using strategies specified by the researcher, the teachers taught four forty-minute science periods each week. Drawing from their own repertoire of strategies, the teachers made their own choices for three lessons during the eleven weeks of instruction. Pretest measures of prior conceptual knowledge, prior metacognitive awareness and self-management, learning styles and an informal attitude survey were taken. Posttesting included the conceptual and metacognitive knowledge measures. The following research questions focused the study:

1. What are the learning style profiles, from both a cognitive-based perspective and a personality-based perspective, for Grades six and seven science students?
2. What is the relationship between the cognitive-based view of learning style (presented by Witkin and his colleagues, and as measured by the Group Embedded Figures Test) and the personality-based view of learning style (presented by Hanson and his colleagues, and as measured by The Learning Preference

Inventory)?

3. What is the relationship between prior conceptual knowledge, metacognitive awareness and self-management prior to explicit strategy instruction?
4. What is the relationship between conceptual knowledge and metacognition following strategy instruction?
5. Are changes in metacognitive awareness and self-management associated with gains in science learning?
6. What are the relationships between learning styles of Grades six and seven science students and their prior conceptual knowledge, their metacognitive awareness, and their metacognitive self-management?
7. Does explicit strategy instruction improve conceptual knowledge, metacognitive awareness and metacognitive self-management for Grades six and seven students with different learning styles?
8. How does qualitative information from interviews and attitude surveys help clarify the patterns exhibited in questions 1-7?

Limitations

Several elementary schools were approached and asked to participate in the study. The schools initially contacted were selected because of their large number of students in the target Grades and because of their mixed populations. Five teachers and their students from one school decided to participate. It might be suggested that one school would not be truly representative of the larger population. This constituted a problem that was not possible to control and is expected of classroom-oriented research design.

The five elementary school teachers who participated in this study

were given three half-days of in-service and time for collaborative planning. The in-service was designed to explain the study, to present the science program's guided inquiry teaching method, to discuss topics to be studied, to describe an explicit comprehension instruction program, and to introduce and discuss the target reading strategies to be used during the course of the study. The teachers were given additional group and individual planning time during the study to finalize specific content, strategy and instruction details. It might be argued that the time given to the in-service and planning was too short to be effective. However, compared with other major in-service events and professional development opportunities, it was beyond the usual time allowance for implementation. Given the teacher commitment required for this study, it seemed unrealistic to expect any further time to be provided for implementing the new science units and the five reading strategies.

The time allowed for each of the classroom lessons corresponded to the time recommendations set out in the teacher guide books. An additional thirty minutes were allotted each time a strategy was introduced and a further fifteen minutes for the second time with a strategy. It might be suggested that more time was needed in order to bring the students to the point of independent use of the strategies. Time required for other subjects and activities did not allow for any extra time beyond the original commitment of eleven weeks--a very large amount of time as it was.

Journeys in Science (Yore, Beugger, et al., 1990) uses a guided inquiry approach and incorporates learning styles, learning cycles, content reading and teaching skills from the broader curriculum. It is a fairly new science program with texts, topics and materials presented in an interesting and attractive manner. The textbooks do not contain the voluminous amounts of

text characteristic of older science series. The teacher guides are very comprehensive with considerable background material available. Nevertheless, the program requires a depth of content knowledge that may not be part of most teacher training programs; and it might be difficult for elementary teachers to free the time to learn the content. This conceptual demand, in addition to the content reading strategies demands, may have placed unreasonable cognitive demands on teachers.

Significance

The value of this study is that it attempted to assess the ecological validity, that is, the classroom application with typical students and teachers, of research findings about effective science reading strategy instruction. Research findings have provided "direction and substance for making instructional decisions" (Otto, 1992, p. 1), but the real classroom settings for this study help to determine the ease or difficulty of translating such findings into the classroom environment.

This study should provide information regarding the delineation of those student characteristics responsive to specific strategy instruction. Thus teachers should be more able to determine not only what strategies work best with what tasks but also what strategies work best for which students. Once students are able to be successful using the strategies most suited to them, they may be able to achieve a comfort level with other strategies. As well, it would be expected that students would generalize learned strategies to other areas of learning.

The hybrid quantitative-qualitative research design involved multi-source and multi-method data collection, data analysis and interpretation. Quantitative measures and qualitative reports from the students, teachers,

and observer should provide a rich data base and help to determine what more needs to be done to improve the area of explicit strategy instruction. These insights should inform the theoretical perspective of science reading and serve the needs of students.

CHAPTER 2

Literature Review

Introduction

This chapter provides the theoretical and research framework for the present study. A discussion of contemporary models of learning is presented from an historical development perspective. The interactive-constructive model of reading with its roots in early constructivism is currently considered one of the most appropriate models of text-based learning. This model was used as the basis for the development of the present study. Specific learner characteristics including prior knowledge and metacognitive attributes, learner preferences, affective factors, and the desired image of a thoughtful reader; the contextual environment; and the critical tasks, that is, the "cognitive demands that occur under a set of conditions" (Walsh, 1992, p. 45) in making sense of science text are discussed within the framework of the interactive-constructive model of learning.

Successful learning means constructing meaningful understanding. This is no less true with learning from the printed page, which remains the primary method of conveying information, than for any other source of information (DiGisi & Willett, 1995; Shymansky, 1989; Shymansky, Yore & Good, 1991; Yore, 1991). School science textbooks continue to be the primary factor influencing science instruction (Yore, 1991). To a very large extent science textbooks are the determinants of what is taught and how it is taught (Gottfried & Kyle, 1992). With the goal of reading being understanding and with the prominence of textbooks in science classrooms, researchers have attempted to identify the processes involved in making meaning from text

(Carey, 1986). The overriding question to which answers continue to be sought is "How do we come to know what we know?" (Bodner, 1986, p. 873).

Historical Perspective

The interactive-constructive model of reading comprehension has had a long if not stormy history. Indeed the roots of constructivism can be traced back to Greek times (Novak, 1988). "Since the days of the Greeks constructing relations between experience and new information by generating interactive images between the old ideas and new events, has been a favorite and effective pedagogical technique" (Osborne & Wittrock, 1985, p, 68). However other research-based paradigms, events, beliefs, attitudes and political alliances often put constructivist ideas into the shadows and caused much of its potential to pass unnoticed.

Gray's (1941/1984) review of the literature from the late teens to the early twenties found that researchers spoke of the importance of purpose, textual difficulties, attitudes and interest in comprehension. He also observed that a reader's prior knowledge was considered crucial to understanding. He suggested that "the chief resource of the reader is his background of related experience. Only in so far as the reader's experiences relate in some form or other to the concepts or situations to which the author refers can the reader comprehend what is read " (Gray, 1941/1984, p. 27). He was careful to add that use of prior experiences seems to be related to the reader's attitudes, interests, motives and purposes.

Lipson and Wixson (1986) noted that much of this early research was largely ignored. This oversight may have been impacted in part by the heavy influence of the behaviorist tradition in psychology during the 1930-1970 period which opposed ideas involving the inner workings of the mind in

learning (Pearson & Stephens, 1994). The behaviorists' rigorous demand for observable evidence and search for connections among behavior, stimulus and reinforcers directed much reading research toward text-driven, bottom-up, skills-centered perspectives.

By midway through this century the dominant view of reading was essentially a perceptual process theory (Pearson & Stephens, 1994). At about the same time as the perceptual process theory was being proposed, interest in the reading process began to capture the attention of researchers from a variety disciplines including linguistics, sociology, and psychology. It is not surprising that with the arrival of psychologists on the scene the behaviorist impact became prominent (Driver & Bell, 1986). "Until [fairly] recently, the accepted model for instruction was based on the hidden assumption that knowledge can be transferred intact from the mind of the teacher to the mind of the learner" (Bodner, 1986, p. 873). Thus one of the most influential paradigms for reading research was that which viewed learning as a 'black box' process involving inputs and outputs (Millar, 1989).

A paradigm shift in research over the last 20 years revived interest in the interactive view of reading. Specifically, changes in two fields of endeavor have impacted reading research in general and science reading research in particular. Research in learning has moved from its heavy focus on the behaviorist tradition "toward a science of cognitive functioning" (Novak, 1988, p. 77). It became acceptable "even desirable, to study how humans think and learn about specific ideas in a discipline" (Shymansky, 1989, p. 1). As psychologists became more at ease with this shift in research, they began to address the influence of concepts and conceptual frameworks in learning with understanding. Some have described this as a cognitive revolution within the field of psychology, but it seems to be described more

accurately as a return to a concern about the constructs of the mind, which date back to Greek philosophers (Magoon, 1977). This shift allowed constructivist ideas to come to the fore.

The second area of change that impacted science reading research occurred in philosophy. Research interests in the nature and production of knowledge moved from experiments designed for proof or falsification to yield truth "toward constructivist views that centre attention on the complementation between the concepts, principles and theories we apply to observation of events or objects and the resultant construction of knowledge claims" (Novak, 1988, p. 77). The very nature of science as a discipline is seen to be a constructivist activity (Bodner, 1986) so that it is not surprising that science education research and school science should follow such a perspective. Nussbaum (1989) described the development of scientific knowledge as constructivist. He suggested that knowledge construction is temporary, developed to be the best fit to current knowledge, and is influenced by social and cultural as well as psychological and historical considerations. Conant (1947), Kuhn (1962) and Toulmin (1972) agree that scientists construct conceptual schemes that serve to focus what they perceive in the inquiry and the conclusions made. What Kuhn (1962) referred to as revolutionary, Toulmin (1972) called evolutionary. Yet, both seem to be saying the same thing, that is, old ideas are modified and a new explanatory paradigm evolves.

Novak (1988) suggested that scientists construct explanatory models in a continuous fashion with each new construction impacted by currently available ideas while undergoing gradual change. Consistent with this perception of science and scientist, Bodner (1986) noted "each individual, student, or a scientist, builds his or her own model of the universe on the

basis of pre-existing cognitive structures or schemes. Progress in science results from the fact that conflicts between theories are resolved by groups of scientists" (p. 877). Through a clearly articulated discussion of the principles of learning, Novak (1988) helped to strengthen the tenets of the interactive-constructive model of learning. He elaborated upon and clarified the relevance of prior knowledge as well as the role of concept and propositional learning in meaningful understanding.

A renewed and expanded interest in the cognitive variables involved in the reading process began to emerge in the 1970s (Lipson & Wixson, 1986). Schema theory (Bartlett, 1932), which strengthened the constructivist paradigm, was being emphasized (Pearson & Stephens, 1994). Schema theory, used as a means of explaining assimilation and accommodation of information in reading comprehension, focused upon the structure of knowledge as it is in the reader's memory (Stewart, 1985).

Interactive was used in explaining the source, perception and processing of information during the reading process. Rummelhart and Ortony (1977) described reading as an interactive process in which the reader relies upon any of general, semantic, syntactic, or environmental contexts as major clues to reading. Their position has been elaborated upon by others (e.g. Anderson, Reynolds, Schallert & Goetz, 1977; Samuels & Kamil, 1984). Together these researchers added clarity to Rummelhart's ideas and helped to crystalize the interactive nature of the reading process.

Alternative Models

Other competing models used to describe the reading process include the information processing model of reading (Samuels, 1994), the psycholinguistic model (Goodman, 1976), and the generative process of

reading (Wittrock, Marks & Doctorow, 1975; Linden & Wittrock, 1981). Prior knowledge or schema was seen by all of these as central to the reading process. Both bottom-up and top-down conceptions of reading have been influential in understanding more clearly the process of successful reading but neither extreme unidimensional perspective sufficiently explains reading. The essence of the bottom-up view of reading is that meaning resides in the text. The work for the reader is to decode words, structures, and relationships that are implicit in print. Once this is accomplished, meaning has been taken from the page and the resulting information is stored in memory (Shymansky, 1989; Strange, 1980). This view of reading is essentially a transmission perspective because meaning is thought to be transmitted to the reader through the decoding process. It also seems to follow logically from a behaviorist tradition and encouraged skill development as generic instruction.

By contrast, in the top-down or concept driven view, reading is a reader-generated process. It "assumes that what the reader brings to the printed page and what strategies the reader applies are the critical factors in comprehension" (Shymansky, 1989, p. 3). This position seems to represent a complete shift away from the bottom-up model but like the bottom-up model it presents a narrow and limited focus in trying to explain the reading process.

The evolving interactive-constructive model of reading provides a challenge to the traditional concepts of science education research and seems to provide a blend of features from both bottom-up and top-down models. Accordingly, the "learner actively and purposefully moves between currently held cognitive frameworks and newly encountered ideas and continually reconstructs meaning" (Shymansky, 1989, p. 7). This conception of science reading suggests that the situated context of the reading task will dictate the

specific decoding or memory demands at any instant as the reader constructs the best interpretation. The constructivist view is in stark contrast to that of the positivist perspective which maintains that there is a sort of true and universal knowledge that explains the way the world works (Shymansky, 1989). It may well be that the reality is indeed a blend of the interactive-constructive view and the positivist perspective. It is possible that comprehension involves constructing meaning within the bounds of what is believed to be true, that is, objective reality. This suggestion stands in stark contrast to the radical constructivist who holds that truth is simply the agreement with other knowledge and not the connection between knowledge and objective reality.

The interactive-constructive model of learning currently enjoys positive support as one of the more comprehensive models of reading available. Furthermore, the interactive-constructive perspective is compatible with the dominant constructivist perspective in science, mathematics and social studies learning. It has become the foundation for much educational research, has helped focus thinking and facilitate discussion, and provides predictive powers. It is a useful paradigm in which to interpret research findings on learning (Osborne & Wittrock, 1985) and has implications for teaching, learning, curriculum development and on-going research. This model puts content back in focus while maintaining due regard for processes. "It suggests that in a content area such as science for example, that we can help students learn about science by recognizing the importance of what they already know and helping them get in touch with that prior knowledge. It also stresses the importance of teachers understanding fully the science they are trying to teach and being able to recognize as many of the alternative frameworks that students might bring to

the classroom" (Shymansky, 1989, p. 6). The value of this model for science education research and education generally "lies in the philosophical compatibility between this model and the constructivist models of science learning" (Holliday, Yore & Alvermann, 1994, p. 879).

It is widely acknowledged that the brain is not a passive recipient of information as the bottom-up approach would suggest. "No longer do we think of reading as a one-way street from writer to reader with the reader's task being to render literal interpretation of text" (Samuels, 1983, p. 261). Neither is it an exclusively reader-driven system as the top-down enthusiasts would argue. Rather reading with understanding is recognized as a meaning construction process (Ruddell & Unrau, 1994) where the learner actively interacts with what is being read (Shymansky, 1989). This interaction is between the learner's knowledge, knowledge organization and the text to be read (Stewart, 1985). Understanding new information "involves organization and imaginative restructuring of the conceptions or frameworks which learners already have" (Driver & Bell, 1986, p. 444). The understanding that is gained from reading "varies as a function of the interaction among many factors including the reader's prior knowledge ... motivation and interest, ... sociocultural background, ... type of discourse, ... task demands, ... and contextual factors" (Lipson & Wixson, 1986, p. 115). Thus, "science reading and science learning can be described as an interaction between prior knowledge, concurrent experience, and information accessed from print and other sources in a specific social context that is focused on constructing meaning" (Holliday, Yore, et al., 1994, p. 879).

Consistent with other competing models of reading, the interactive-constructive model attempts to describe the nature and functions of learners' background or prior knowledge, their meaning making processes that have as

their aim true conceptual change, and the movement towards independent self-regulated learning. Learners' experiences with and responses to various textual materials, purposes for reading, and the broad category of affective factors including values, motivations and attitudes, and the environmental context in which learning occurs (Tierney, 1994) are also of prime concern in the interactive-constructive view of learning.

These factors have been presented in a different yet seemingly conceptually compatible format by Ruddell and Unrau (1994). Holding with basic tenets of the interactive-constructive model of reading, Ruddell and Unrau (1994) proposed a components model to explain the reading process. The reader, the text and classroom context, and the teacher form the components of this perspective. "These three components are in a state of dynamic change and interchange as meaning negotiation and meaning construction take place." Thus reading "is conceptualized as a sociocognitive interactive model that explains the reading process in the instructional context of the classroom" (Ruddell & Unrau, 1994, p. 988). The value of this view also lies in its ecological validity that situates learning in the classroom environment. It provides explanations of the reading process useful to both teachers and researchers.

Unified Model

In considering the interactive-constructive model of reading, it is necessary to include a discussion of the underlying assumptions and assertions central to the model. It is assumed that the learner's prior knowledge about task, domain and topic have important implications for how new learning experiences are interpreted. The locus of control is thought to reside within the learner so that the learner assumes responsibility

for learning and becomes an independent self-regulated learner. Through processes of activation of prior knowledge, interaction between learner and the variety of information sources, and self-regulation conceptual growth or conceptual change occurs. Understanding is considered to be constructed purposefully so that knowledge and understanding of the purposes for reading, that is, reading goals, set the focus and direction of the reading activity. Learning is assumed to be affected by variations in text material so that in those situations where text is considerate and where the learner knows how to use these materials learning is enhanced. Learning takes place in a sociocultural context, usually in the classroom where peer influences, the role of the teacher and classroom practices impact learning. Affective features including such factors as attitude, interest, motivation, and willingness to work hard and persist with difficult or extended tasks affect learning outcomes.

While it is acknowledged that the interactive-constructive model is fundamentally a cognitive process, the importance and the role of affective factors and of the sociocultural context of learning are also recognized (Paris, 1987). The interactive-constructive model in its evolutionary process is being perceived more as a sociocognitive model (Ruddell & Unrau, 1994). This model of learning is not restricted to learning from text. Whether information is presented orally as in the teacher talking or in the form of pictures, videos, demonstrations or activities, the learner must still construct meaning (Osborne & Wittrock, 1983). The reader processes new information by moving between new information and concurrent experiences and by comparing new information and experience with personal world view recollections (Kintsch & VanDijk, 1978; Osborne & Wittrock, 1983; Yore & Shymansky, 1991).

The single most important factor in the interactive-constructive model of reading with understanding is the concept of prior knowledge. Prior knowledge in a very broad sense encompasses domain and topic prior knowledge and metacognitive prior knowledge. Alexander and Kulikowich (1994) defined domain knowledge "as knowledge of a specific field of study (e.g., physics) and topic knowledge as the knowledge of scientific concepts directly referenced in the text". Garner (1987) suggested that metacognitive knowledge refers to knowledge about the self as learner, the task and the strategies used to complete the task. Holliday (1988) suggested that "in addition to learners' knowledge and experiences about studying, learners are similarly affected by an array of cognitive and affective goals ... and strategies ... These two latter traits are apparently just as important as productive metacognitive knowledge and experiences" (p. 3).

Building upon the work of previous researchers, Holliday (1988) proposed a tetrahedral interactive model to illustrate the cognitive and metacognitive aspects of learning. In his model he separated learner characteristics from cognitive and metacognitive activities. While his model admittedly focuses on "a particular viewpoint, [it] provides an heuristic for studying only selective notions and observations, and should be used as an analytical, dynamic tool ... that should be considered neither a permanent nor complete representation of reality" (Holliday, 1988, p. 8). Taking up this latter suggestion, it might be useful to present an alternative yet neither new nor revolutionary conception of the interactive-constructive nature of learning. Indeed consistent with Ruddell and Unrau (1994), it might be a little more unifying to consider cognitive abilities, prior knowledge including metacognitive activities, learner preferences and the host of affective factors all under the umbrella of learner characteristics. The two remaining factors

would then include the critical tasks Holliday (1988) suggested and the nature of the situation including materials, methods, and teachers in sociocultural context. This conception would allow for the interactive and interdependent nature of learning and would perhaps make the conceptualization a little simpler but no less comprehensive, which is also compatible with the format for discussion presented by Alexander and Kulikowich (1994). It is this conception (Figure 1) that forms the basis of the present study. Thus it is the intention in this study, within the framework of the interactive-constructive model of reading comprehension, to present a discussion of the learner characteristics, the contextual environment that includes teaching, teachers and the social context of learning, and the critical tasks.

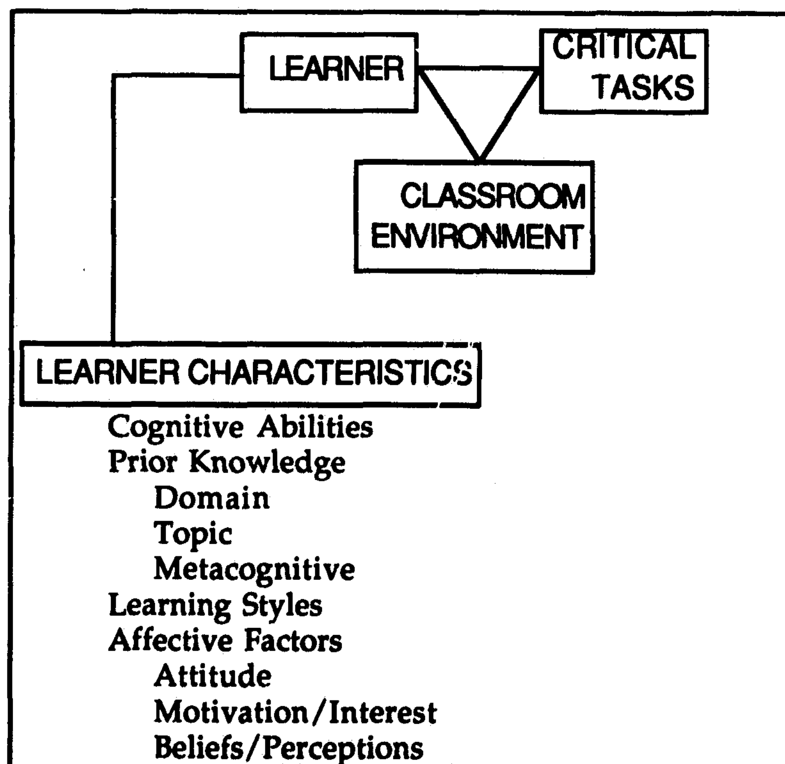


Figure 1: Interactive-constructive model of reading--unified model

Learner Characteristics

The learner characteristics central to learning with understanding include prior knowledge, learning preferences usually conceived of as learning styles and affective factors. Each of these factors operates to impact the learning process and is discussed separately.

Prior Knowledge

Prior topic knowledge is widely accepted as a key element among an array of learner characteristics found to significantly impact learning with understanding (Langer, 1984). Ausubel (1968) put this rather forcefully when he said, "If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly" (p. vi). Zeitoun (1989) found that prior knowledge accounted for more variance in science learning than did cognitive development. Others suggested that prior knowledge may be more important than both text structure and strategies training in impacting new learning (Lipson, 1982).

The role of prior topic knowledge has been the focus of many research endeavors (e.g. Holmes, 1983; Lipson, 1982; Pearson, Hansen & Gordon, 1979; Schmidt, De Volder, De Grave, Moust & Patel, 1989). Whether referred to as invented ideas, correct conceptions, misconceptions, naive theories, intuitive ideas, common sense knowledge, alternative frameworks, or preconceptions, children's science prior knowledge has been found to impact reading comprehension. The more correct knowledge one has about a discipline and a topic prior to being exposed to further information about the topic the easier it will be to understand what is read and the more successful will be new learning (Alexander & Kulikowich, 1994). New learning built on old learning is perhaps the simplest way to convey the basic constructivist idea.

Prior knowledge seems to be organized into hierarchical frameworks commonly conceived of as schema (Callahan & Drum, 1984). New information may be directly assimilated into existing frameworks resulting in conceptual growth. Otherwise, through a process of transformation and restructuring of the existing schema, new and old information are accommodated resulting in conceptual change (Holmes, 1983; Pearson, Hansen, et al., 1979). Prior knowledge allows the learner to disambiguate text, improve comprehension, increase recall and recognition, draw inferences, and direct attention to important information (Langer, 1984; Stahl, Hare, Sinatra & Gregory, 1991).

Accepting the notion that correct and properly stored prior topic knowledge positively impacts subsequent learning, the task for the teacher becomes one of accessing and engaging what the students already know about a topic and encouraging them to find links between what is already known and the new information so as to construct meaning. The students must be led to check or evaluate the derived meaning against some existing structure (Osborne & Wittrock, 1983). This verification process involves assessing whether the new conception is more powerful, matches more evidence, increases predictability and is understandable (Posner, Strike, Hewson & Gertzog, 1982). Thus, the students move toward becoming self-regulated learners, that is, learners who are cognitively, metacognitively, behaviorally and motivationally engaged (Zimmerman, 1990). Such self-regulated learners are competent at "the orchestrating of skill and will in order to meet the demands of academic work" (Walsh, 1992, p. 50).

Prior metacognitive knowledge is also important in constructing meaning from reading. Metacognition, a term borrowed from developmental psychology, includes theory and research that focuses upon

one's thinking about thinking (Flavell, 1979; Garner, 1992; Paris, Wasik & Van der Westhuizen, 1988). While some researchers argue that metacognition remains a fuzzy concept, others focus on one or the other components of metacognition and still others bemoan the lack of unanimous agreement on a definition. There is increasing agreement among researchers of metacognition as consisting of two components. Two papers (Brown, 1978; Flavell, 1979) serve to provide a conceptual foundation for the construct. Accordingly the two interdependent components of metacognition include metacognitive awareness (self-appraisal) and executive control (self-management) of cognition.

Self-appraisal (awareness) includes declarative knowledge, that is, what is known; procedural knowledge, that is, how to do the processes involved; and conditional knowledge, that is, why and when a process is used (Jacobs & Paris, 1987). Self-management (executive control), on the other hand, is dynamic and includes three of the processes involved in self-regulated thinking. These self-regulated activities include selection of a purpose, related knowledge, goal-oriented strategies and a heuristic assignment of time and effort to realize the goal (planning); checking or evaluating comprehension as a ongoing process (monitoring); and intentional redirection of activities or use of fix-up strategies when problems with comprehension arise (regulating) (Cross & Paris, 1988; Paris, Cross & Lipson, 1984). This perception of metacognition permits identification of the factors that affect thinking (Cross & Paris, 1988) and makes it possible to conceptualize learners' knowledge about and their use of personal cognitive resources. "What children know about the goals, tasks, and strategies of reading can influence how well they plan and monitor their own reading" (Jacobs & Paris, 1987, p. 255).

Learning Preferences

While the literature on metacognition speaks to variations among learners in terms of their metacognitive awareness and self-regulation, it does not appear to separate the role played by variations in learning preferences among students. Thus conceptions of metacognition do not mention differences in learning styles. "People differ in the habitual ways they react to tasks" (Pressley, Goodchild, et al., 1989, p. 305) so that there might be a link between learning preferences and effective learning processes. Any such link should serve to strengthen the tenets of the interactive-constructive model of learning by demonstrating that students are indeed unique in the way they learn and construct meaning from their environment.

Learning styles loosely defined as habitual ways of responding can also be considered to be consistent and persistent modes of "organizing and processing information and experiences" (Messick, 1984, p. 61). When described as 'usual modes of acting or habits', the suggestion is that cognitive styles develop slowly over the long term; described as 'preferences' implies some degree of modifiability; and described as 'persistent' suggests pervasiveness across broad domains.

Of the various dimensions of cognitive style that have been identified, field-dependence/field-independence has probably received the greatest research attention; and it is this dimension that has had the greatest application to education (Witkin, Moore, et al., 1977). Studies of field dependence-independence have been carried out "in areas as diverse as interpersonal behavior, learning and memory, perceptual constancies, defense mechanisms, automatic nervous system processes, cultural differences, dreaming, schizophrenia, child-rearing, laterality, and moral judgment" (Witkin, 1978, p. 5).

The Group Embedded Figures Test (GEFT) is a perceptual assessment procedure used to measure field-dependence and by inference field-independence. The subject is required to locate a previously seen figure within a larger figure. Results from this test provide information about how a learner "processes and stores information, and how it retrieves that information " (Martin, 1985, p. 25). The ability to overcome an embedding context allows the individual an analytical way of experiencing (Witkin, Oltman, Raskin & Karp, 1971). The dimension of field-dependence-independence represents, at the extremes, differing ways of approaching an experience and as such may be termed a global versus an analytical dimension of functioning. There is the further suggestion that this aspect of cognitive style is part of a broader dimension labelled psychological differentiation (Witkin, Oltman, et al., 1971).

It has been suggested that cognitive styles are a facet of personality, and indeed personality in a very general sense may underlie styles of learning (Entwistle & Ramsden, 1983). Messick (1984) noted that styles are more deeply rooted in personality than is usually implied when he said that styles are "characteristic self-consistencies in information processing that develop in congenial ways around the underlying personality traits" (p. 61). Reiterating and extending this point Messick (1994) pointed to the need to determine how styles are organized within personality. If a close parallel between cognitive style and personality type could be demonstrated, it would allow a move toward a more comprehensive theory of learning style. It would also have major educational implications. Learning styles could be more clearly identified using cognitive style information supplemented by personality information. This in turn would result in a better understanding of individual learning needs and allow more compatible learning-teaching

methods and strategies.

In 1994 Messick discussed briefly some of the attempts to relate styles to personality; however, he suggested that such attempts need to begin with existing theories of personality. Hanson (1987) attempted to demonstrate the connection between learning style and personality by embedding his view of learning style in existing personality theory. Using Jung's type theory and the behavioral definitions of the Myers-Briggs Type Indicator (MBTI), he provided a new conception of learning style. Accordingly, he suggested learning types or preferences based on two perceptual functions (sensing and intuition) and two functions for making judgments (thinking and feeling). Silver and Hanson (1982) proposed four learning types: sensing-thinking (ST), sensing-feeling (SF), intuition-thinking (NT), and intuition-feeling (NF). Each of these styles is characterized "by whatever interests, values, needs, habits of mind, surface traits and learning behavior naturally result from" the four style types (Silver & Hanson, 1980, p. 2). An attitudinal dimension of introversion and extroversion was considered to modify the functions of perception and judgment. Thus attitudinal processes are demonstrated in the preferred ways for dealing with ideas and tasks (Silver & Hanson, 1986).

Learners described as sensing-thinking (ST) are characterized as practical, efficient and results oriented. These learners prefer to perceive through their senses and make decisions based on thinking and logical consequences. Sensing-feeling (SF) learners tend to be sociable and interpersonally oriented, and their learning interests focus on people and not facts or theories. As with ST learners, they prefer to perceive through their senses but make their judgments based on personal feelings of likes or dislikes. The intuition-thinking (NT) learners are characterized as knowledge

oriented and theoretical and motivated by complex problems. These learners prefer to perceive through intuition rather than their senses and make decisions based on thinking rather than feelings. Learners described as intuition-feeling (NF) tend to be imaginative, creative and insightful. They perceive through intuition and make decisions by using their feelings. For these people their intuition is focused on people and values.

Silver and Hanson (1978) developed a 144-item questionnaire, the Learning Preference Inventory (LPI), to assess student learning preferences. Using the LPI, the respondent is asked to complete a given stem by ranking four choices from most to least preferred. The results identify preferences across the four personality-based learning styles and provide descriptions of how learners in each style group prefer to learn.

Hanson, Silver and Strong (1984) suggested that in regular school populations 35% of the students are SF learners, 26% are ST learners, 12% are NT learners, and 27% are NF learners. They further suggested that among gifted students 52% of learners are NF with the remaining three learning styles being relatively equal in distribution. They found that most teaching favors NT learners, but highlighted the need to accommodate the variety of learning styles in classrooms. To facilitate this need, they presented published information about both learning and teaching behaviors by style, detailed instructional suggestions for each learning type, materials and guidelines for planning, implementing, and evaluating instruction, as well as sample lessons for elementary and secondary school levels (Silver & Hanson, 1982; Silver & Hanson, 1986; Strong, Hanson & Silver, 1986).

It is likely that both cognitive processes and personality variables together define the parameters of learning style. Schmeck (1983) suggested that attempts to relate cognitive and personality factors had fallen short of

expectations. He said "no doubt the differences we observe will ultimately be explained by more basic theories of personality and cognitive styles" (Schmeck, 1983, p. 235). Adequate assessment of learning styles should result in "instruction tailored to the needs and capabilities of the individual child" (Harris & Pressley, 1991, p. 394). Attribute-treatment-interaction research (ATI) has generally not been compelling. However ATI research aimed at investigating the relationship between learning style and metacognition may provide useful information. These ATI results may help clarify how specific learners construct meaning and how teachers can modify their instructional process as they move students along the way to becoming independent self-regulated learners.

Affective Factors

There has been a tendency among some researchers (e.g. Cross & Paris, 1988; Flavell, 1979; Paris, Wasik, et al., 1991) to include affective factors under the rubric of metacognition. "Some argue that metacognition involves emotions and motivation, whereas others suggest that it is better conceptualized as knowledge without affect" (Jacobs & Paris, 1987, p. 258). The broader focus might only serve to contribute to the perceived fuzziness of the concept of metacognition. It might be more useful to separate out affective features from metacognition yet maintain it under the umbrella of learner characteristics. This approach is consistent with that suggested by Ruddell and Unrau (1994). Such a separation would allow a more focused view of metacognition on the one hand and appropriate emphasis on affective features on the other. Thus it might be possible to more clearly determine the relative impact of metacognition and affective factors as they impact reading comprehension.

Good teaching alone is not enough to ensure successful learning.

Learning "requires active intellectual effort by the learner" (Osborne & Wittrock, 1985, p. 66) and positive attitudes toward learning opportunities. The impact of affective factors on learning cannot be underestimated. Student motivation, attitude, and interest function to significantly impact learning outcomes. During the course of their school careers, students develop self-perceptions or beliefs about their abilities to do academic tasks, which affects their motivation to be successful, their interest, their tendency to persist or to give up, and their propensity to learn and use strategies (Pressley, Goodchild, et al., 1989).

Thoughtful Science Reader

The knowledge that good readers are more metacognitively aware and strategic than their less able counterparts has led some researchers to attempt to develop a profile of the active, thoughtful, expert reader (e.g. Pearson, Roehler, et al., 1992; Yore & Craig, 1990; Yore & Denning, 1989). The profile constructed by Yore and his colleagues "was a multifactor model" in which the successful science learner is seen as one who actively constructs knowledge to enhance learning (Yore & Craig, in press, p. 11). Conceptualization of expert learners is seen as a means to guide research and as a means to develop better ways to assist less able students in becoming strategic, effective, efficient, and self-regulated learners. "To develop truly thoughtful readers, we must ensure that they possess these characteristics" (Pearson, Roehler, et al., 1992, p. 154).

In order to ensure that readers possess the desired characteristics it is necessary to have an objective measure against which they might be evaluated in terms of their metacognitive awareness and executive control. Jacobs and Paris (1987) spoke to the need for "the creation of appropriate measures of metacognition" (p. 257). Using their image of an efficient science

learner and Jacobs and Paris' (1987) conception of metacognition, Yore and Craig (in press) developed an instrument to assess learners' metacognitive awareness. Their instrument, the Index of Science Reading Awareness consists of 63 forced-choice, multiple-choice items with the fourth choice allowing for open-ended responses. Interview protocols that parallel the inventory questions were developed. These instruments were used to assess in detail the metacognitive awareness of upper intermediate science students.

The Index of Science Reading Awareness (ISRA) has been used to demonstrate significant gains in metacognitive knowledge about reading, text and strategies following explicit instructional interventions and significant correlations between metacognition awareness and reading comprehension (Spence, 1994). Other uses of this tool could include whole class use for instructional and evaluation purposes much like what has already been done and individual student assessment. As an individual measure this tool could be used to help students better understand themselves as learners. They could learn about their strengths and weaknesses relative to successful learners, which could empower them as active learners and better equip them to become independent learners.

Contextual Environment

"Although individual cognitive activity has been the subject of most investigations of learning and education, its situated nature in a material and social world has garnered substantial recent attention" (Pea, 1993, p. 265). Knowledge is considered to be socially constructed within the community of the classroom, a community of discussion, reflection and action (Fosnot, 1993). The instructional process and explicit strategies instruction as they occur in the classroom will be the aspect of the contextual environment of

concern in this discussion.

Explicit Strategy Instruction

Metacognition that focuses on the processes as opposed to the products of reading has as its major outgrowth the development of specific strategies. Strategies in a very broad sense are "actions selected deliberately to achieve particular goals" (Paris, Wasik & Turner, 1991, p. 611). Strategies have also been defined as "processes (or sequences of processes) that, when matched to the requirements of tasks, facilitate performance" (Pressley, Goodchild, et al., 1989, p. 303). The interactive-constructive model of reading does not preclude explicit strategy instruction. This model "involves learner-directed comprehension strategies that are conscious, flexible, purposeful, and planned to establish intent, access information, invent meaning, verify ideas, apply understanding and store discoveries" (Yore & Shymansky, 1992, p. 12).

The aim of strategy use is to help students become independent, self-regulated learners, that is, learners who are "active, constructive, motivated ... in their own learning" (Garner, 1987, p. 1). Strategies serve to help students focus, organize, analyze, evaluate and review what they are reading (Yore, Shymansky, Beugger & Romance, 1986). Strategies allow students to become "cognitively active and engaged" (Smith, Blakeslee & Anderson, 1993, p. 114). Thus reading with understanding becomes the goal and result of direct strategy instruction (Taylor, 1992).

Apparently many students do not learn strategies implicitly and many teachers fail to teach strategies explicitly (Pressley & Harris, 1990). It may be that research-based strategies are not well understood by teachers or even in their repertoire of teaching methodologies. This may be because many studies are decontextualized from the classroom setting where most formal teaching and learning take place (Marx, Winne & Walsh, 1985; Rivard &

Yore, 1992). Criticisms related to ecological validity of nonclassroom studies highlight the need for classroom-based research. There is a need for contextualized studies where treatment interventions are delivered by the regular classroom teacher and incorporated into normal class activities, using texts that are normally part of the curriculum (Ridgeway, Dunston & Qian, 1993). As Pressley and El-Dinary (1993) suggested, "the very best strategies instruction emerges from collaboration between educational scientists and teachers, with each making critical contributions that cannot be made by the other ... the best work contributes to scholarly understanding of strategies instruction and practice" (p. 106).

Nevertheless, good readers have been found to be more strategic than their less able counterparts, they use a greater variety of strategies, are more likely to monitor their comprehension and more inclined to employ fix-up strategies when problems with comprehension arise (Paris, Wasik & Van der Westhuizen, 1988). Therefore, explicit instruction should help less able readers acquire and effectively use strategies. It has generally been found that the middle school years tend to be the time when explicit strategy instruction appears to be most effective in helping students become independent self-regulated learners (Haller, Child & Walberg, 1988).

Explicit strategy instruction means employing particular teaching strategies whose purpose it is to increase students' strategic awareness and usage. Effective strategy use means knowing what strategies are best to use under what conditions and knowing how to use these particular strategies. Once comprehension failures are detected, effective strategy use also means shifting to appropriate fix-up strategies (Pressley, Goodchild, et al., 1989).

It is important to teach strategies in content area context (Yore & Shymansky, 1992) and in the context of the regular classroom. It can be

argued that laboratory studies are easier to design and control for the multitude of confounding variables. However, it does not "matter how effective the treatment is in the laboratory; if the intervention cannot be implemented in customary classroom settings, it is of limited educational value" (Paris, Wasik & Van der Westhuizen, 1988, p. 161). Explicit strategy instruction by necessity needs to be conducted over a protracted period of time, and so carried out by classroom teachers, which may tend to cause confounding of teachers and treatment; and random assignment of students may be difficult because schools need to construct classes to meet system and pupil needs (Pressley, El-Dinary, Gaskins, Schuder, Bergman, Almasi & Brown, 1992).

While there are no definitive statements on how to teach strategies, several guidelines do exist (e.g. Fields, 1990; Pearson & Dole, 1987; Pressley & Harris, 1990). Effective strategy instruction should consider learners' prior knowledge and current needs and reflect cognitive and affective features. An accepted teaching paradigm for explicit strategy instruction would first establish need or set the purpose for what is to be read and select the strategy most appropriate to the desired learning outcome. Next, the teacher would model the particular strategy. Often teachers will 'think aloud', that is, discuss and explain what they are thinking and doing as they move through the strategy. Next, the teacher provides guided practice for the students. During this step the focus is on the student using the strategy while the teacher provides feedback and encouragement. During the consolidation phase, the teacher helps students come to a better understanding of the strategy, and how and when to use it. In the independent practice stage, the student begins to assume responsibility for use of the strategy in a specified context. Finally students become proficient at using the strategy in and across

content areas and so learn to effectively transfer strategies (Fields, 1990; Pearson & Dole, 1987). "Teacher modeling and self-regulated use of the procedure lie at the heart of good instruction" (Pressley & Harris, 1990, p. 32). As well students need to see the benefits of strategies if they are to make them an integral part of their learning process.

Strategy instruction in this paradigm should not focus on lock-step skills nor be construed as simply teaching strategies. "Good cognitive strategy instruction encourages students to construct powerful cognitive strategies" (Harris & Pressley, 1991, p. 394). It must provide comprehensive explanations regarding comprehension strategies (Pressley, El-Dinary, et al., 1992). Explicit strategy instruction is to be conceived of as "a model in which the what, why, and how of individual strategies are integrated into an overall plan about what it means to be strategic ... stated another way, effective strategy instruction simultaneously requires the pursuit of a genuine literacy coupled with explanations about how to be strategic while doing so" (Duffy, 1993, p. 244). Strategy instruction needs to go beyond direct explanation and include the transactions among teacher, students and text in the classroom as they "jointly construct understandings of the text ..." (Pressley, El-Dinary, et al., 1992, p. 516). This transactional instruction of strategies, "a blend of explicit instruction, direct explanation, reader response, and teacher-student interactions" is holistic and constructivist, and is embedded in meaningful academic tasks that actively engage and encourage students (Schuder, 1993, p. 183). In the context of meaningful interaction with teachers and peers, students learn how to transfer learned strategies to other situations.

Strategies

Explicit strategy instruction has been the focus of much attention over the years. Entire issues of research journals, book volumes, various

educationally oriented groups and associations and commercial enterprises have offered their expertise or materials to assist the area (Pressley, Goodchild, et al., 1989). It is not surprising that there have long been concerns about the research and theoretical basis for many of the reading skills and strategies used in classrooms (Olson, 1968; Pressley & Harris, 1990). "Strategy educators should be very selective about the procedures they teach, focusing their attention on ones that confer large gains in achievement arenas that are important to students" (Pressley, Goodchild, et al., 1989, p. 314). Several useful strategies have been identified through examination of how successful students carry out tasks (Harris & Pressley, 1991). However, considerably more research is needed before a full complement of tested strategies is available (Pressley & Harris, 1990).

Many of the research-based strategies may be grouped into three major categories to include those strategies aimed at activating prior knowledge, text structure strategies and text feature strategies. The latter two clusters seem not to be universally demarcated. For purposes of the present study, text structure strategies are meant to include those strategies that reflect the organizational plan of written text. While the terms may differ, some of the more commonly utilized science text structure strategies include cause-effect, collection, compare-contrast, description, and problem-solution (Armbruster, Anderson & Ostertag, 1989; Yore & Shymansky, 1992). Consistent with Paris, Wasik, and Turner (1991), main idea strategy is determined to be a text structure strategy for purposes of the present study. Text feature strategies, while not the direct focus of this study, need to be distinguished from text structure strategies so as to avoid confusion and allow for clarification. Text feature strategies include those strategies where learners readily see and use the visual displays, illustrations, various heading presentations and margin

notes to facilitate comprehension.

Accessing prior knowledge is crucial in attempting to improve science reading comprehension (Yore & Shymansky, 1992). A variety of methods exists for activating prior knowledge with one of the more useful being KWL charts (Ogle, 1986). These charts also help to set purpose and check progress. This three-step process requires the student to first determine what is already known about the topic (K), next to determine what it is that is to be learned (W), and finally to assess what has been learned (L). Ogle (1986) developed an easy-to-use, yet effective worksheet for this strategy. Used in the classroom, students might initially brainstorm to ascertain what they already know about a topic and generate questions regarding what they want to know. The teacher's role at this point would be to guide and direct student ideas. New understandings would be grouped under the heading of what was learned. Comparisons of entries in the three categories within and across students would allow for clear monitoring of learning.

Students tend to have difficulty with expository texts partially because they do not know the ways that text may be structured and so the meaning construction process suffers (Armbruster, et al., 1989). Strategies aimed at teaching text structure facilitate learners' awareness and use of text structure to locate information, evaluate evidence, assess the patterns of argument and construct meaning (e.g. Armbruster, Anderson, et al., 1989; Armbruster & Ostertag, 1993; Cook & Mayer, 1988; Holliday & McGuire, 1992). Armbruster, Anderson and Ostertag (1989) listed a variety of ways to provide explicit instruction about text structure. One such approach involves the student making a visual representation of the way the ideas are presented in the text. By creating their own representations following a carefully executed instructional process, the students could be expected to become independent

self-regulated users of the strategies (Spiegel & Barufaldi, 1994).

Being able to identify the main ideas in text is the essential step of meaning construction in reading (Paris, Wasik & Turner, 1991; Taylor, 1992). "Effective science readers must use a variety of relevant clues and self-questions to generate and verify hypotheses about the main idea" (Yore & Shymansky, 1992, p. 14). Finding the main idea means that the reader is able to make judgments about the relative importance of the information and is later able to integrate the information. Paris (1987) used the metaphor of a detective in which clues such as pictures, topic and context were used to find the main idea. Using this metaphor as a visual aid, students learn to identify main ideas.

Critical Tasks

Yore (1991) found that textbooks continue to be the most used resource in school instruction. Proponents of a teacher-driven curriculum have acknowledged that a textbook is important but more as a reference than as the curriculum. "The teacher-driven curriculum assumes that the teacher knows a great deal about science, about methods of instruction, and about the basic skills of reading and writing" (Glynn & Muth, 1994, p. 1062). A teacher-driven curriculum may be desirable but may not be realistic or practical. Teachers, especially those at the elementary level where they are expected to be generalists, may simply lack the time needed to provide an adequate teacher-driven curriculum in all content areas. Lack of time may not be defensible especially in terms of the goals and expectations placed on students by society. However, it is eminently more desirable for a teacher to use well-constructed, text-driven curriculum than a poorly conceived and ill-prepared teacher-driven curriculum. This seems especially important when the

subject matter is science, an area where teachers tend to feel ill-prepared especially in terms of content. Thus a good text-driven science curriculum in which "the textbook guides the teacher in the selection of topics, the organization of lessons, the assignment of activities, and the construction of tests" (Glynn & Muth, 1994, p. 1062) may be necessary. This would also allow the teacher needed time to learn about appropriate instructional methods, and other desirable aspects of effective teaching and learning.

A number of studies have demonstrated that many students lack both the skills and strategies to read effectively in the various content areas and especially in demanding expository material (e.g. Alvermann, Smith & Readence, 1985; Stahl & Jacobson, 1986). "Reader deficiencies perpetuate a situation of dependency on the teacher for interpreting content texts" (Rivard & Yore, 1992, p. 14). In addition to problems with readability, problems also exist with the way textbooks are written. Problems related to writing style, interest level of the material to be learned and inconsiderate text combine to make learning from texts difficult (Rivard & Yore, 1992). It is very important to carefully select text to be used. Journeys in Science (Yore, Beugger, et al., 1990) has attempted to provide considerate text that is engaging for students and has been written according to the beliefs of the interactive-constructive model of reading with understanding. The embedded, four-part, guided inquiry instructional approach attempts to introduce and focus learning, provide concrete experience and help students construct understanding from their collective experiences, and evaluate learning in a supportive sociocultural context.

Summary

"The interactive-constructive reading model supports a conception of comprehension instruction that is strategic, that provides declarative, procedural, and conditional knowledge, and that results in self-regulated meaning-makers or knowledge architects" (Rivard & Yore, 1992, p. 55). Thus students develop a holistic concept of what is meant by being strategic (Duffy, 1993). Teachers in this model possess and utilize knowledge about content, about pedagogical issues, about learners and about the sociocultural context in which learning takes place. In this context research must "examine acts of construction as they occur in schools" (Magoon, 1977, p. 655).

Ecologically based studies are "fundamental to bettering education" (Marx, Winne & Walsh, 1985, p. 200). Studies concerned with explicit strategy instruction may require ongoing reformulation so that traditional experimental methods may not be appropriate or useful (Edmonston & Novak, 1993). Indeed "educational research may have reached a crisis stage with regard to its major Fisherian experimental design tradition ... schooling, teaching, and learning go on without being explicable via traditional approaches, and serious doubts about methodology have been raised" (Magoon, 1977, p. 653). Research results from laboratory studies, that is studies involving small groups of students, specially trained teachers and very well equipped settings, must stand the test of ecological validity using research paradigms that reflect the realities of regular classroom situations. Indeed, Pressley and his colleagues (1992) put it well when they said "the ultimate goal of comprehension strategies instructional research as development of a practical theory of reading strategies instruction, one that can guide reading instruction as it actually occurs in school" (p. 215). Classroom-based research should be the ideal complement to such a goal.

CHAPTER 3

Method

Subjects

Several schools in the Greater Victoria School District were initially contacted and asked to take part in the study. The schools were selected primarily based on their large enrollment numbers and population mix. One school, five teachers and 126 students from five intact Grades 6 and 7 classrooms, the target grades for the study, decided to participate. Information from the school personnel suggested that the host school serves a mixed population but with a majority representation from lower and middle socio-economic groups.

The subjects for this study were 126 students, with 17 deleted from the analysis. The 17 deleted students included one English as a Second Language student, one who was moved to a psychiatric unit shortly after the study began, one who spent large portions of the day in a behavioral class, one who had excessive absenteeism, one who was out of the country during all of the teaching time, four who transferred out early on in the study, one who refused to do some of the assessment measures noting that she had verbal parental permission not to participate, and seven others who transferred in very close to the end of the study. Of the remaining 109 subjects, there were 56 males and 53 females. The students were members of naturally constituted classes of Grades six and seven. There were 52 Grade six students and 57 Grade seven students distributed across two Grade six classes, two Grade seven classes and one Grades six/seven split class.

Participation in the study required parental permission, and

participation in the interview part of the study required separate written parental permission. Of the 109 students participating in the study, 84 had permission for individual interviews. Eight of the 109 subjects had missing attitude data due to absenteeism and a lack of opportunity to do the survey at another time. The other assessment measures for these eight subjects were included in the analysis.

Instructional Materials

The small group in-service training was presented by the research supervisor. During the in-service the teachers were given journal articles dealing with explicit strategy instruction, use of textual materials in the classroom, and the interactive-constructive philosophy and the structured guided inquiry approach of the Journeys In Science elementary school science program. The teachers were also given the teacher guidebook for Journeys In Science, samples of the various strategies to be used in the study and information on the image of a thoughtful and successful reader of science text. Expandable folders to keep all of these materials for later reference or study were provided.

The researcher served as aid to the teachers, providing many of the materials needed to teach the science units. The publisher provided posters that were put on display in the science room to set the theme for each of the units to be studied. Part of the Journeys In Science program includes unit activity cards, which detail useful yet optional teacher-directed student activities for use at various points during the unit study. All of the teacher and student materials needed to do these of activities were prepared and placed in the school science room for use by the participating teachers and students.

Prior to the study the teachers were given the materials that they would need for instruction. These materials included publisher provided end-of-chapter and end-of-unit tests for optional use by the teachers, overhead transparencies for the strategies (KWL charts, detection of the main idea, and text structure forms for compare-contrast, cause-effect and description) to be used, and student work copies for these strategies. The teachers used the KWL charts and the main idea sheets during the study. However, as the lessons progressed the teachers took ever increasing responsibility for the preparation of a few of the strategy forms including cause-effect and description. Copies of the forms used for the various strategies are provided in Appendix A.

After the first chapter was completed, it was determined that the time required to prepare the individual lesson materials was more than the teachers had available. For all remaining lessons five sets of materials needed to teach the lessons were prepared in advance by the researcher and placed in the science room for use by the teachers and students. Individual teachers helped with materials as time permitted. Each teacher and student was provided with a copy of the Grade six text from Journeys In Science.

Assessment Instruments

The Group Embedded Figures Test (GEFT) was used as a pretest measure to determine cognitive-based learning style along the continuum of field-dependence to field-independence (Oltman, Raskin, & Witkin, 1971). The GEFT is a 25-item, timed, perceptual-analysis task. Seven items constitute a non-scored practice section; the two remaining sections each contain nine items. Subjects are given a time limit to complete each section but within a section they work at their own pace. For each item subjects are

presented with one of eight possible target designs that they are required to find and trace in a complex design. The target designs are presented on the back cover of the test booklet and are available to the subjects for repeat reference. The larger figures are presented most often two to a page in the test booklet. Items are scored as either completely correct, which receives a score of 1, or incorrect, which is scored 0. Total test score possibilities range from 0 to 18. The higher the score the more field-independent a subject is considered to be. The reliability for the GEFT was reported as 0.82 using the Spearman-Brown formula. Specific age-based norms are not available but subjects are described as moving from field-dependence to field-independence in the early teenage years and back toward field-dependence in the senior years.

The Hanson Silver Learning Preference Inventory (LPI) (Silver & Hanson, 1978) was used as a pretest measure to determine personality-based learning styles for the subjects. The LPI is a non-timed, 144-item task that measures preferences for perception and judgment and an attitude factor. Subjects are given 36 sentence stems with four completion choices. The task for the subject is to rate each completion choice from 1 to 4 with 1 meaning most preferred choice through to 4 meaning least preferred choice.

A weighted scoring scheme is used so that higher scores indicate a greater preference for a particular style of learning. Four separate score totals are obtained, one for each of the four learning styles. The scores are interpreted as a degree of preference including little or no preference, some preference, moderate preference, high preference or very high preference for each learning style. Although no age or grade norms have been developed for this inventory, subjects can be described according to their degree of preference for each of four styles of learning (sensing-feeling SF, sensing-thinking ST, intuition-thinking NT, and intuition-feeling NF). The four

separate score totals may also be used to describe subjects according to designations where the highest score is the dominant type, the next highest score is the auxiliary and the third score is the supportive preference. Finally, subjects may be described according to their perception function, that is, sensing or intuition, and according to their judgment function, that is, thinking or feeling, by determining any common perception or judgment features in the dominant and auxiliary types. Test-retest reliability for the LPI was reported as 0.89 (referenced in Gulkus & Barker, 1982).

A 24-item informal attitude survey (IAS) used as an ad hoc measure attempted to assess student attitude in the areas of school science, science books and school in general (Appendix B). The IAS was developed by the researcher in cooperation with the research supervisor as an ad hoc measure of attitude to complement the cognitive and personality views of learning style. A variety of attitude surveys, including those used as part of the British Columbia Assessment of Science (Bateson, Anderson, Dale, McConnell & Rutherford, 1986), by Halliday (1991), and the Ministry of Education Assessment of Reading and Written Expression (Jeroski, 1989), was used as the basis for the development of the IAS form. The 24 Likert-type items were randomly placed in the survey form with the task direction being simply to check the box that best reflected the subject's feelings toward a presented statement. Responses to each item varied along a five-choice continuum from strongly agree to strongly disagree. The score value for each item ranged from 1 to 5, according to the positive or negative presentation of the particular statement. The obtained score was the sum of scores across the 24 items. The higher the score, the more positive overall attitude was considered to be. Internal consistency for the IAS was 0.91.

A 75-item test of metacognitive awareness and metacognitive self-

management was administered as pretest (PKm1) and posttest (PKm2) measures. A copy of the test is included in Appendix C. It considered student's metacognitive awareness and self-management as they relate to being a self-regulated and independent learner. The test is based on 21 statements that describe a thoughtful, successful and independent reader of science text material (Rivard & Yore, 1992; Craig & Yore, 1995, Appendix C). Internal consistency for the pretest was 0.90 and for the posttest it was 0.89.

The first 63 test items form the Index of Science Reading Awareness (ISRA). It measures metacognitive awareness of the declarative, procedural and conditional domains as they relate to being a successful reader of science text. The ISRA employs a three-choice, multiple-choice format with a fourth, open-ended response option. Internal consistency for the ISRA was reported as 0.88 with subtest internal consistency of 0.51 to 0.82 (Yore, Craig & Maguire 1994). The Cronbach Alpha was 0.88 for both the pretest and the posttest. Concurrent, predictive and structural validity for the ISRA was examined and found to be reasonable for research purposes.

The remaining 12 test items were developed as an extension of the ISRA for the present study. The items represented the planning, monitoring or evaluating and regulating aspects of self-management (Jacobs & Paris, 1987). These items attempted to assess subjects' metacognitive self-management for those strategies that formed the focus of this study which included accessing prior knowledge, finding the main idea, and using text structure. Summarization strategy was also included among the self-management questions as this strategy had initially been included in the study. However, because of time constraints, it was omitted from the study when the number of chapters to be studied was reduced. As with some other metacognitive strategies that were not the direct focus of this study,

summarization remained in the assessment pool since it is naturally related to reporting detected main ideas. The items were multiple choice with a fourth option allowing for an open-ended response. The alpha coefficient for the pretest was 0.69, and for the posttest it was 0.59.

Item scores for the 75 questions ranged from 0 to 2 with a score of 0 representing incorrect or no knowledge, a score of 1 representing incomplete or surface knowledge, and a score of 2 representing comprehensive strategic awareness and management. Three scores were obtained for each subject for both pre and post administrations of the test. The first score out of a total of 126 points represented the strength of metacognitive awareness with a higher score indicating stronger pretest and posttest metacognitive awareness (PKm1a and PKm2a). The second score was out of a total of 24 points and represented the strength of metacognitive self-management with a higher score indicating stronger pretest and posttest metacognitive self-management (PKm1sm and PKm2sm). The final score was the total of the first two scores and represented the strength of metacognition overall. A high total score was considered to be indicative of the overall level of pretest and posttest metacognition (PKm1 and PKm2).

A tape recorder and tapes were used for pretest and posttest individual interviews (TI1 and TI2), which sought to get additional information about subjects' metacognitive awareness and self management in the context of open-ended questions (Appendix D). The pretest interviews consisted of open-ended questions. The same questions plus application-type questions were used in the posttest interviews. The interview questions assessing metacognitive awareness were those used by Craig and Yore (1995) and were based on the 21 characteristics of the thoughtful reader of science text. The interview questions assessing metacognitive self-management were

developed as an extension of the Craig and Yore (1995) questions. The application questions, which were asked in the posttest interviews only, were developed to assess subjects' application of learned strategies. As with the written PKm tests, the interviews retained the questions related to the summarization strategy. The questions used for the pretest and posttest taped interviews were randomized across seven protocols so that no question would bias later responses. Each subject was asked questions from one protocol only and received the same protocol for pretest and posttest interviews with the additional application questions included on the posttest interview. The interviews took about 10 to 15 minutes each. All taped responses were transcribed for scoring purposes.

The transcribed responses were scored using the same format as that used for the written metacognitive tests (Craig & Yore, 1995). Thus, each transcribed response was scored as 0, 1 or 2 points. A response was scored 0 if it indicated incorrect or no knowledge. A response received a score of 1 if it reflected surface or incomplete knowledge, and a response was scored as 2 points if it reflected comprehensive or strategic knowledge. Inter-rater reliability was established by having the research supervisor score a subsample of the items. Using a 10% subsample inter-rater reliability was assessed to be 85.5%. The following example illustrates the scoring rubric for a particular item and responses:

"Why do you use information in your head when you read your science textbook? What if your knowledge and the textbook knowledge do not match?" Q denotes that the response was queried or probed further.

(2) *"I use it so that I can understand it a lot better. (Q) Then I would first put it together and say to myself what I know about it, and what the book knows about it, and then I would put it all*

together to see if I could make a match with it to see if there's anything that I know more about what the book knows, and then I would probably ask the teacher if that was right".

(1) *"To help me understand it better. (Q) I probably won't use it. It just sits in my head because it's not going to be on the test and I don't think really. It's just that it's not going to be on the test we don't really have to think of that".*

(0) *"Yes. I usually don't concentrate. I don't feel like reading or doing any science it's just so boring like oh come on when is recess coming. I would just keep reading and be more interested like wow you know".*

A test of prior conceptual knowledge (PKc1) was administered and included six multiple-choice items, seven fill-in-the-blanks items for which a word list to choose from was provided, and seven short-answer questions (Appendix E). The items were selected from a pool of validated items provided by the publisher. The internal consistency for PKc1 was 0.53. A high proportion of no responses and guessing and a limited range of scores was considered to have contributed to this low level of reliability.

A test of conceptual knowledge (PKc2) administered as a post-measure differed from the first conceptual test in that it contained two additional short-answer, transfer-type questions (Appendix E). The short-answer questions were selected from the validated pool of items. The internal consistency for PKc2 was 0.79.

The teachers were asked to rate the reading levels of their students as below, at or above Grade (RR). Ratings were simply based on the teachers' professional judgments, and they were not given any criteria to use except to rate each student on one of the three designations. A rating of 1 meant the

student was below grade level in reading, a rating of 2 meant that the student was at grade level in reading, and a rating of 3 meant that the student was considered to be above grade level in reading.

Classroom interpretation of each strategy was at the professional discretion of the teachers. Part of the theory-into-practice or ecological approach assumes that teachers implement ideas within the context of their realities, which means that the effect of the idea must be viewed in terms of its power across various interpretations, contexts, and implementations. However, classroom observations, scheduled meetings with the teachers as a group, informal discussions with the teachers individually, post-study teacher questionnaires, and post-study, structured, teacher interviews were used to ensure, to the extent possible, that the teachers had used the specific instructional strategies and had used them in a manner consistent with in-service explanations. In the post-study questionnaire each teacher was asked to provide information about the strategies used during the study. These questionnaires outlined the chapter and lesson titles, and the strategies to be used with each lesson, and asked the teachers to indicate what they had actually done for each lesson. During the structured interviews, the teachers were asked how they had interpreted the strategies and implemented them into their teaching. General comments the teachers may have had about the study were elicited as well. Notes made by the researcher during these interviews were later transcribed and shown to the teachers to ensure their accuracy. Copies of the questionnaires and the interview questions are included in Appendix F. As a final source of information, samples of student notebooks were made available to the researcher.

Procedure

Prior to the start of the study the teachers attended three half-day in-service sessions given by the research supervisor, who is also one of the authors of Journeys In Science. During the first session the teachers were given an overview of the study and of Journeys In Science. The second session was taken up with housekeeping items from the previous session, discussion of the time involvement overall and for each unit and chapter, the time needed to introduce and strengthen the different strategies, and the decision to omit chapter parts seen as optional including the sections titled people in science, people who use science, and excursions. Each of the strategies to be used in the study was introduced and demonstrated in context. The final day of the in-service saw a review of Journeys In Science and the strategies, a discussion of concerns and final details of the time schedule to be followed. Follow-up conferences amongst the teachers and researcher reinforced and clarified the science program's philosophy, science content, reading strategies and instructional activities.

The study took place during the second half of the school year with the teachers beginning the study units the last full week of February. The initial plan was to complete two units, that is, five chapters, over a twelve-week period. The units to be covered were Body Control Systems (five) and Life Cycles and New Generations (six).

As the study progressed the teachers found that the time involved in preparing for their classes was beginning to interfere with other commitments, that the amount of class time needed for instruction was more than originally planned and that some of the students were finding the intensity of the study very difficult. In addition, it was not always possible to do the four classes a week because of other scheduled or unscheduled

activities. Instruction of the first chapter matched closely the original time plan but all of the teachers reported that the pace was rushed. By reducing the number of text chapters to be studied from five to three, the teachers were able to take the extra time then available to cover the material at a pace better suited to their students. Time allocations for the remaining two chapters changed such that the second chapter required one extra week of instructional time to complete, and the final chapter was completed with one and a half weeks of instruction beyond that originally planned. Thus the last two chapters took approximately two and a half weeks corresponding to about 400 minutes of instruction beyond that originally anticipated for these chapters. One of the teachers continued to find that class preparation time was significant and that the material was very difficult for the students. For the last weeks this teacher made the decision to cut the number of classes from four to three per week thus covering the same amount of material as the other teachers but a little later than the others.

Over the course of the study the teachers taught four forty-minute periods a week for eleven weeks using the instructional strategies specified. Photocopied outlines for each chapter indicated the time to be given to each lesson as recommended in the teacher's guide, and the particular instructional strategy to use. Each time a new strategy was introduced an additional thirty minutes of instruction time was scheduled, and the second time a strategy was used an additional fifteen minutes was scheduled to allow strengthening of the strategy. No further instructional time was given for subsequent uses of the strategy.

A chronology of events and the design of the study are presented in Table 1. The study began with the researcher doing the individual taped interviews (TI1). Students came from their classes to the interview in an order

convenient to the teachers. Each student was asked the questions from the protocol to which they had been randomly assigned. It took two weeks to complete the interviews.

Table 1

Chronology of the Events of the Study.

Pretests (February 1-19)	**Treatment (February 22-May 17)**	**Posttest (May 18 - June 22)**
Written Assessment of Learning Styles: -Group Embedded Figures Test (GEFT) -Learning Preference Inventory (LPI) (Mar. 22) Written Test of Conceptual Knowledge (Pkcl) Written Test of Metacognition (Pkml) Taped Student Interviews (TI1)	11 school weeks of science instruction given by each of the five teachers to their respective classes. They used the guided inquiry approach with embedded explicit strategy instruction.	Written Test of Conceptual Knowledge (Pkc2) Written Test of Metacognition (Pkm2) Taped Student Interviews (TI2) Informal Attitude Survey (IAS) as an ad hoc measure Teacher-Written Questionnaires Individual Teacher Interviews

Note: This process was repeated separately for each of the five classes. The science instruction took place in each class for 11 weeks from February 22 to May 17.

The next three tests administered in order included the GEFT, the PKm1 and the PKc1. The tests were administered by the researcher in the regular class groupings. The GEFT took approximately thirty minutes per class. The PKm1 required approximately 45 minutes for each class to

complete, and the PKc1 was completed usually in less than thirty minutes for each class. Testing was scheduled so that the PKc1 was administered on a Friday as the teachers were preparing to begin their teaching the next Monday.

For the next eleven weeks the teachers taught the lessons using the specified instructional strategies (Table 2). Interpretations of the strategies and other instructional decisions were at the professional discretion of each teacher. As well, the teachers were given the opportunity to chose their own individual instructional techniques for three separate lessons.

Table 2:

Chapter and Lesson Titles and Embedded Explicit Instructional Strategies

Conceptual Focus	Strategic Focus
February 22 - March 12 Chapter 12 The Endocrine System: Unit Opening and Chapter Opening	KWL Charts
Chemical Message	Main Idea
Location and Structure of Glands	Test Structure - Compare and Contrast
Function of Glands	Continuation of Compare and Contrast
When Glands Do Not Work Properly	Test Structure - Cause and Effect
Journey Highlights	KWL
Chapter Test	
March 22 - April 16 Chapter 13 The Nervous System: Chapter Opening	KWL Charts

Table 2 (cont'd.)

Conceptual Focus	Strategic Focus
The Brain	Text Structure - Compare and Contrast
The Spinal Cord and The Perysherial Nerves	Text Structure - Description
The Nerve Cell	Text Structure - Description
The Senses	Teacher Choice
Journey Highlights and Journey Review	KWL Charts
Chapter Test	
April 19 - May 14 Chapter 14 Life Cycles of Plants Unit: Unit Opening and Chapter Opening	KWL Charts
What is a Life Cycle?	Teacher Choice
Life Cycle of Seed Plants	Main Idea
Life Cycle of Mosses and Ferns	Text Structure - Cause and Effect
Plant Stems and Asexual Reproduction	Teacher Choice
Journey Highlights and Journey Review	KWL Charts

Classroom lessons were intended to follow the three-part teaching approach used with Journeys in Science. The first part was an introduction, which was designed to establish attending behaviors, identify what was to be learned and allow the new learning to be later integrated into a larger

framework. The goals of this phase were accomplished through use of motivational techniques and setting the problem focus. The second part was the experience phase, where the purpose was to design and discuss the particular investigation under consideration and review old or develop new skills necessary to carry out the investigation. This was accomplished in the context of ongoing teacher guidance, direction, and supervision. The final phase was post-experience, where the purpose was to bring things together and integrate new learning. This was achieved by organizing, analyzing, synthesizing and sharing newly learned ideas and by verifying, applying, and reinforcing what had been learned. This three-part, guided inquiry approach to science learning had embedded within it the various explicit instructional strategies that formed the focus of this study. Any time a new strategy was introduced, an additional thirty minutes were added to the instructional time. In the context of authentic science learning a strategy was introduced, explained, discussed and modelled. The process involved explanation and discussion of what the strategy was and when, where, how and under what conditions to use it. Through use of overhead transparencies, the teachers modelled the strategy and guided the students in its use. With subsequent use of the strategy, the teachers determined the level of need of the students in their understanding and use of this strategy.

Because the LPI had not arrived before the start of the study, it was not administered until the fourth week of the study. As with the other group tests it was administered according to class groupings and took about forty minutes to complete for each class. The attitude survey was administered as an ad hoc measure at the conclusion of the scheduled posttests. Administration time for the IAS was about twenty minutes per class.

Administration of the PKc2 followed immediately the end of the teaching

times. Four of the teachers finished at the same time; the fifth teacher finished later because part way through the study he had decided that it was better for his class if he reduced the number of classes from four to three per week. Because the students did not realize that they were all being given the same tests, the difference in test times was not a problem. The PKm2 was administered next followed by the individual TI2. The posttest interviews addressed the subjects in the same order as they had for the pretest interview and they were asked the questions that they had been asked during the pretest interview. In addition they were asked the application questions specific to the particular protocol. The teacher interviews marked the end of the study.

Regular meetings were held with the teachers as a group at the end of each chapter. At these meetings issues related to the finished chapter were discussed and times for the next chapter were finalized. Throughout the study there were informal meetings where comments were made, questions asked and issues clarified. The researcher kept notes of meeting agendas, and some of the teachers' comments, concerns and questions. A sampling of student notebooks was collected at the end of the study.

Data Analysis

The research questions guided the analyses with additional analyses been determined by current findings from this study. Both quantitative and qualitative assessment entered into this study. Descriptive statistics, correlations, and t-tests were the primary quantitative analyses used. The qualitative assessment was scored objectively according to predetermined rubrics yielding categorical values that could be entered into statistical analyses. The interview data were also analyzed according to qualitative features to clarify trends and patterns detected by statistical analysis of the quantitative data.

CHAPTER 4

Results

The results for the eight research questions are presented in four groups or question clusters. Questions 1 and 2 were concerned with learning style profiles from both cognitive and personality perspectives and with the relationships between these two perceptions of learning style. The results for these two questions are considered together. Questions 3-5 were concerned with the relationships between conceptual and metacognitive knowledges prior to and following inquiry-oriented science units with embedded explicit strategy instruction. These three questions are treated as a cluster. Questions 6 and 7 were concerned with the relationships between learning styles and conceptual and metacognitive knowledges prior to explicit strategy instruction and the differential effect of instruction on different learning styles. These questions focused on the impact of instruction on science learning, both conceptual and metacognitive, for Grades 6/7 students generally and for the differences in learning styles among students. These two questions also formed a useful cluster for examination of results. Question 8 dealt with the value of data from the interviews and the attitude assessment in terms of verifying, clarifying and elaborating results found for questions 1-7. The data collected from these sources were either focused on sub-samples of the original sample or reflected and responded to apparent concerns detected during the study.

Cognitive-Based Learning Style

Scores on the cognitive style Group Embedded Figures Test (GEFT) do not represent two distinct style types but rather a continuous distribution. Thus, definitions of field-dependence and field-independence tend to be

arbitrary decisions. For purposes of the present study, conservative estimates were used with scores from 0 to 4 being defined as field-dependence and scores from 14 to 18 being defined as field-independence.

The distribution of scores obtained on the GEFT are presented in Figure 2. Overall the distribution presents a positive skew with 28% of the subjects testing out as distinctly field-dependent (0-4) and 16% of the subjects testing out as distinctly field-independent (14-18). This is consistent with developmental expectations where generally it has been found that between the ages of 8 and 15 there is an increased percentage of students exhibiting field-independence (Witkin, Oltman, et al., 1971).

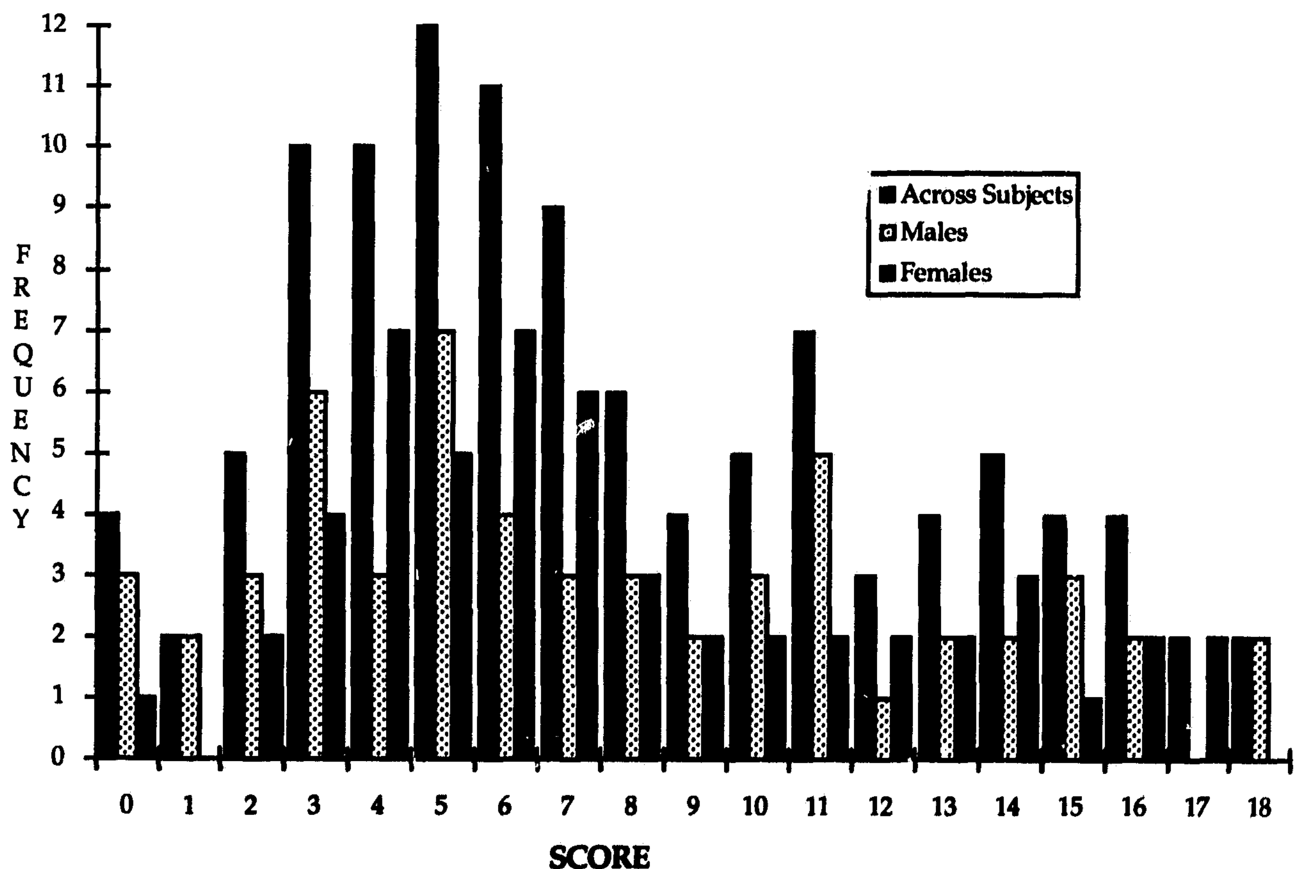


Figure 2: **Distribution of scores on the GEFT across subjects and by gender.**

Gender differences have been found repeatedly such that males tend to be more field-independent than females (Witkin, Oltman, et al., 1971). The present study did not support this expectation. The means, standard deviations and range values across subjects and for males and females are presented in Table 3. T-tests of differences in the average GEFT scores between males and females are presented in Table 4. The difference was not statistically significant. An inspection of the category data reveals that 30% of the males and 26% of the females tested out as field-dependent (0-4) and 16% of the males and 15% of the females tested out as field-independent (14-18).

Table 3

Mean, Standard Deviation and Range Values for the GEFT across Subjects and by Gender.

Variable	Gender	N	M	S.D.	Range	Minimum-Maximum
GEFT	across subjects	109	7.65	4.64	18	0-18
	M	56	7.57	4.94	18	0-18
	F	53	7.74	4.34	17	0-17

Table 4

T-tests for Independent Samples of Gender on the GEFT.

Variable	Gender	N	Mean	S.D.	t	df	2-tail probability
GEFT	M	56	7.57	4.94	-.18	107	.854
	F	53	7.74	4.34			

In summary, it was found that overall there was a tendency for the Grades six and seven students to be field-dependent. No significant gender differences were found for the GEFT data between males and females. Indeed, there were very close to equal numbers of males and females in the field-dependent (0-4) category and also very close to equal numbers in the field-independent (14-18) category.

Personality-Based Learning Style

The personality-based view of learning style assessed by the Learning Preference Inventory (LPI) provides information about learner preferences regarding four style types (sensing-feeling SF, sensing-thinking ST, intuition-thinking NT, and intuition-feeling NF) and two attitude preferences (introversion I, and extroversion E). The focus of the present study was limited to the four learning style types. The LPI does not address gender variations, nor were any references regarding gender found for this personality-based view of learning style. However, gender differences are usually reported in the cognitive-based view of learning style measured in the GEFT. Some of the analysis of the present data prompted investigations regarding gender. Important gender findings emerged and are included as part of the present analysis and discussion.

The LPI allows three major avenues for examining score results. The results may be analyzed according to the strength of preference for each of the four learning style types so that the focus is on category levels. The results may also be analyzed using dominant, auxiliary and supportive designations, which are determined by the intrasubject scores obtained for each of the four learning styles. These designations, however, do not in any way represent degree or strength of preference. Finally, the results may be examined by

determining the separate perception and judgment functions that speak to the preferred ways of receiving and processing information. These three perspectives organized the analyses and discussion of the LPI data that follow.

LPI Category Analyses

Examination of test scores from a category perspective allows description of the four learning styles. The scores obtained on each of the four learning styles are categorized based on the values provided by Silver and Hanson (1980). Subjects are described as having little or no preference (0-24), some preference (25-49), moderate preference (50-74), high preference (75-99), or very high preference (100-125) for each of sensing-feeling (SF), sensing-thinking (ST), intuition-thinking (NT), and intuition-feeling (NF) learning styles.

For purposes of the present study, category perception and judgment functions were developed and entered into the analyses. The category perception function describes ways in which information may be received, either by sensing (S) or by intuition (N). The category judgment function describes ways in which information may be acted upon, either by thinking (T) or by feeling (F). Each subject was described in terms of both of the category perception and judgment functions thus giving category perception and category judgment scores for each subject.

The LPI manual does not attempt to develop a quantitative indication of the perception preference or the judgment preference. Since the foundation of the LPI is based on a forced choice that is proported to reflect the subjects' preference, it is reasonable that extreme preferences can be identified quantitatively by calculating the average value for paired choice dealing with common perception modes or judgment modes. To obtain score values for the category perception and judgment functions, averages were calculated. The average of the SF and ST scores became the sensing category

perception function value. Likewise, the average of NT and NF scores became the score for the intuition category perception function; the average of ST and NT scores became the score for the thinking category judgment function; and the average of the SF and NF scores became the feeling category judgment value.

The graphic representation of the data according to category preferences is presented in Figures 3 through 6. Distribution of preferences for the sensing-feeling (SF) category learning type showed the greatest variation, as can be seen in Table 5. Almost 80% of the subjects showed moderate or stronger preference for this type of learning (Figure 3). High scores, that is, high preference for the SF category learning style has been found to be associated with academic difficulties. Using research support from the Myers Briggs Type Indicator (MBTI), it has been suggested that the SF learning style is most often associated with school drop-out. The 20% of the sample who showed little or some preference for this type of learning were represented mostly in the same category and were mostly males (Figure 3). Table 6 shows significant differences ($p = .001$) between males and females such that overall females showed significantly higher preference than males for the SF category learning type. The mean for the SF category style for females was 71.51 and for males was 55.16.

As a group, none of the subjects showed a very high preference for the sensing-thinking (ST) category learning type; and only 15% of the subjects showed a high preference for the ST type (Figure 4). ST is one of the learning types associated with academic success (Barker, Gulkus, Huber, Rose & Rowe, 1982). Most (85%) of the subjects showed moderate or less preference for this type of learning (Figure 4). Male and female preferences were fairly equal within this category preference so that there were no significant differences ($p = .442$) between

male and female preferences, as can be seen in Table 6. The mean for the ST category learning type for males was 58.79 and for females was 56.68.

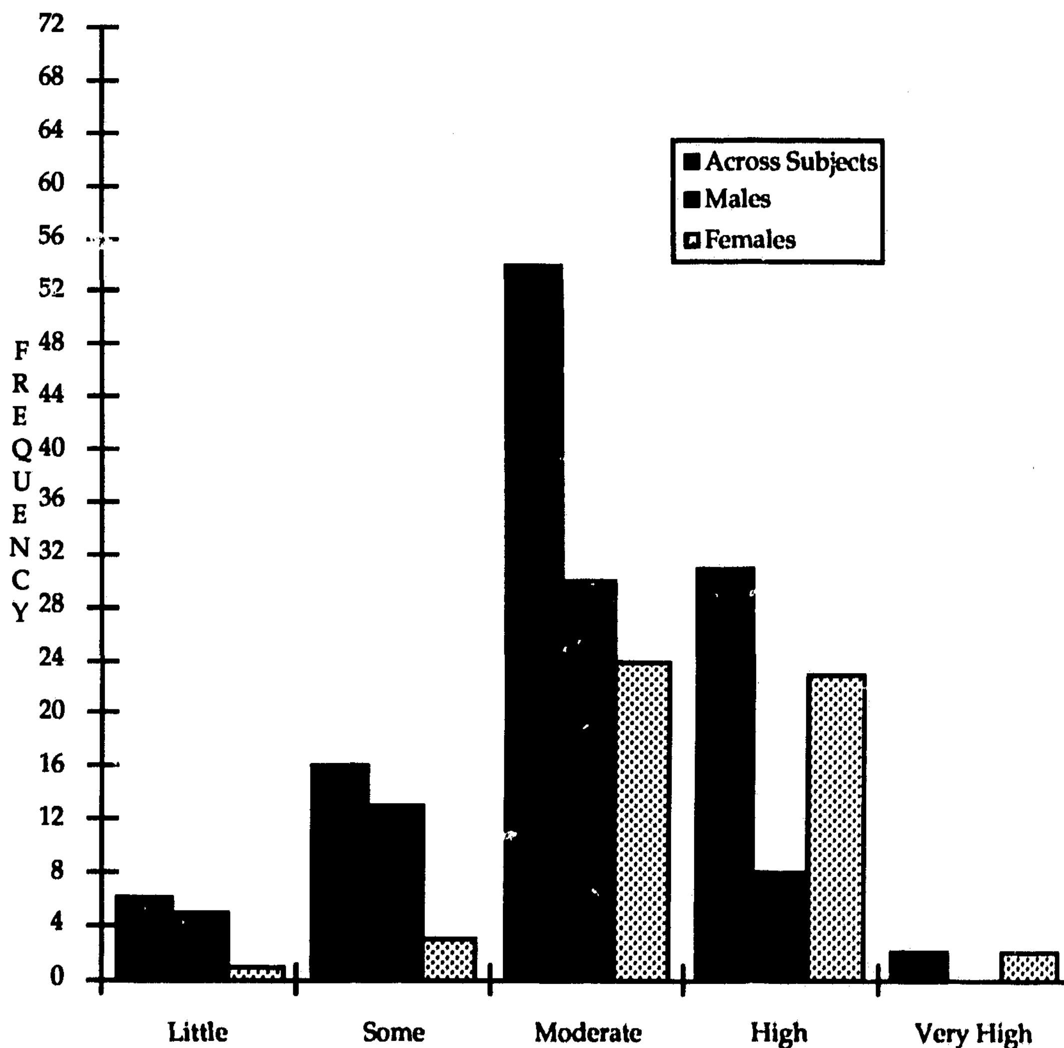
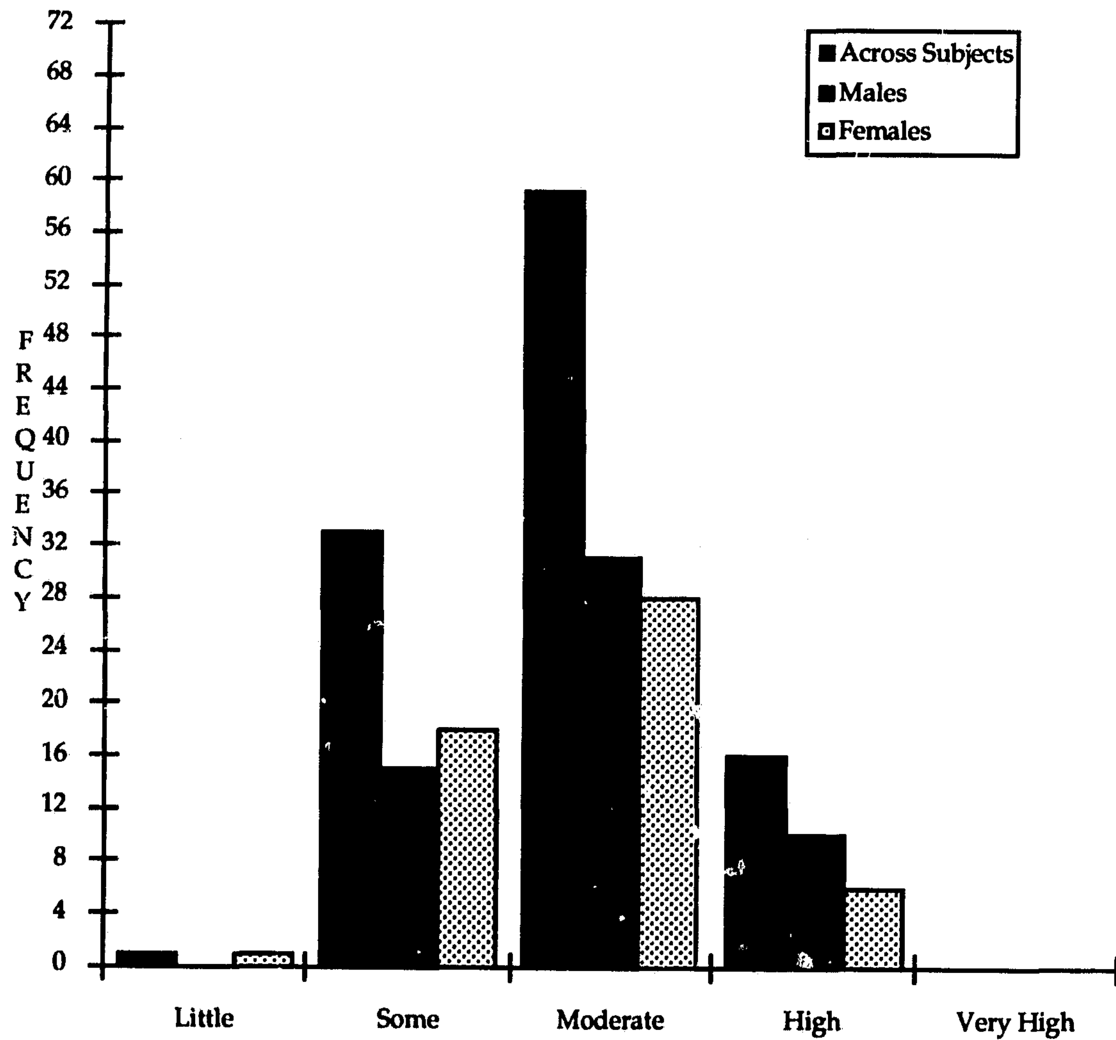


Figure 3: **Category distribution for the sensing-feeling learning preference across subjects and by gender.**

Little = 0-24
Some = 25-49
Moderate = 50-74
High = 75-99
Very High = 100-125

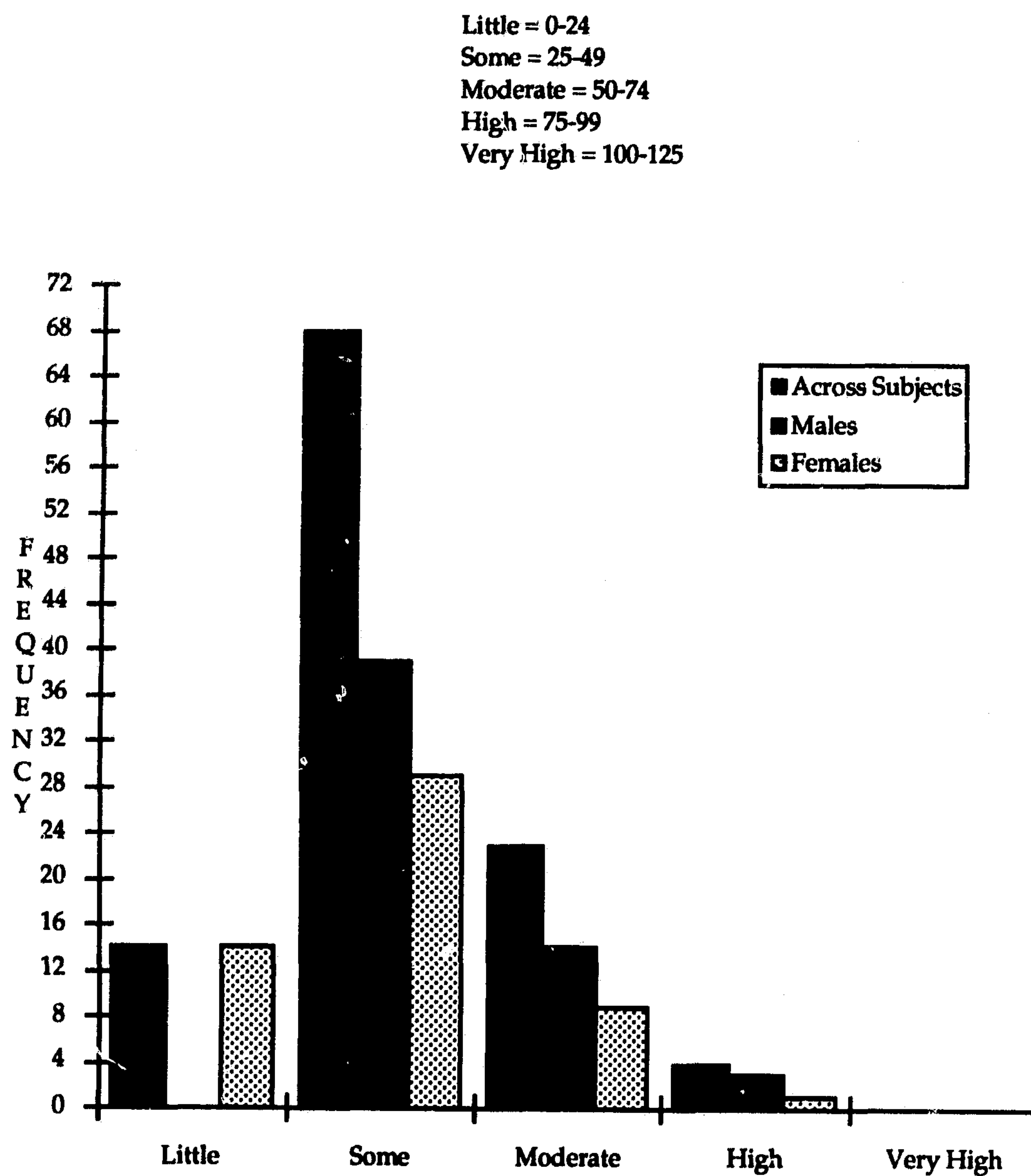


Sensing-Thinking Category Distribution

Figure 4: **Category distribution for the sensing-thinking learning preference across subjects and by gender.**

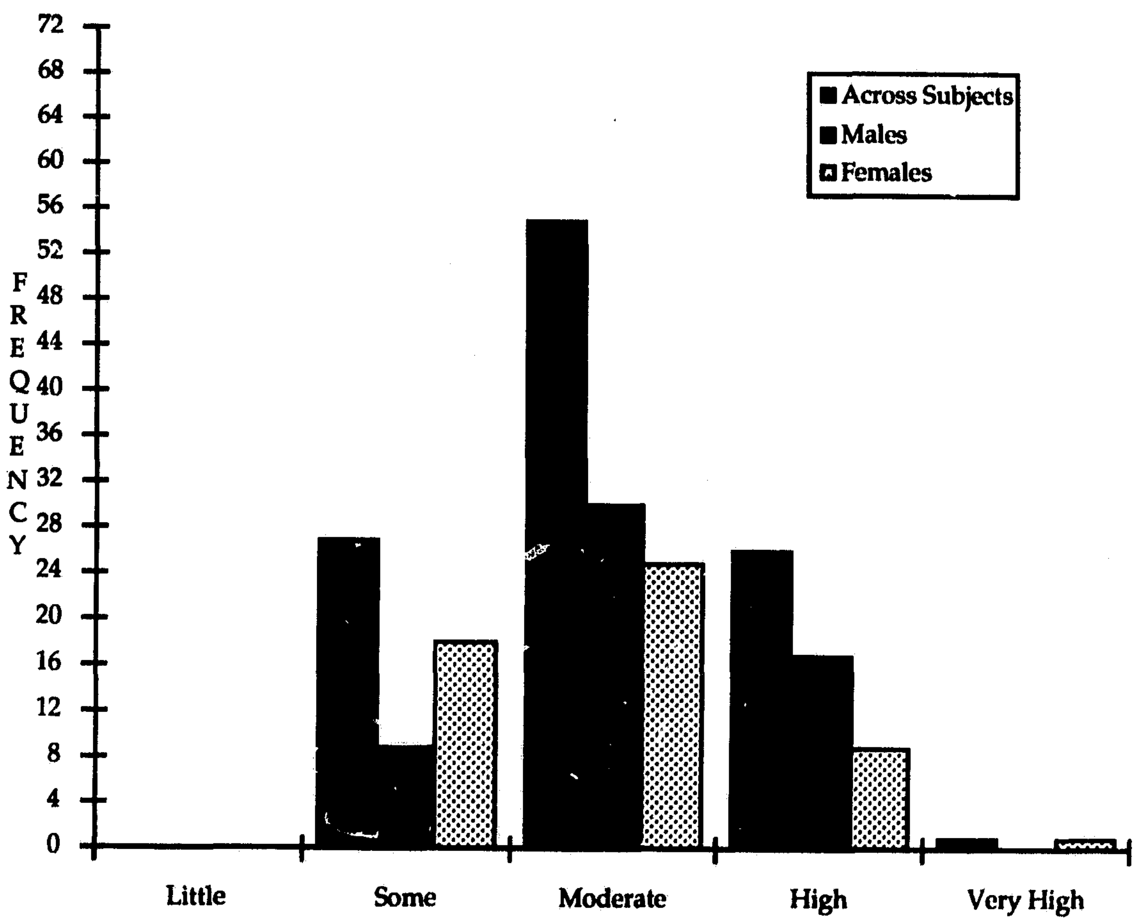
Only 4% of the subjects showed a high preference for the intuition-thinking (NT) category learning type (Figure 5), the learning type most often associated with the highest academic success (Barker, Gulkus, et al., 1982). Indeed, the vast majority (62%) of the subjects showed only some preference for this type of learning, and a further 13% showed little or no preference (Figure 5). The 13% in the little or no category were all females (Figure 5). Table 6 illustrates that males had a significantly (p= .003) stronger preference for the NT category learning style than females. The average for males on the NT learning type was 44.75, and the average for the females was 35.72.

There was a tight clustering around the moderate preference for the intuition-feeling (NF) category learning type, with 50% of the sample showing a moderate preference and a further 25% of the sample showing a high preference (Figure 6). One-quarter of the subjects showed less than moderate preference for the NF category learning type. The NF learning preference has been found to be associated with those students identified as gifted (Hanson, Silver & Strong, 1984). While there were no significant differences (p= .118) between male and female NF scores, the largest gender differences were evident at the some and high preference categories. It was found that 8% of the males and 17% of the females showed some preference and 14% of the males and 9% of the females showed high or very high preferences in this area (Figure 6).



Intuition-Thinking Category Distribution

Figure 5: **Category distribution for the intuition-thinking learning preference across subjects and by gender.**



Intuition-Feeling Category Distribution

Figure 6: Category distribution for the intuition-feeling learning preference across subjects and by gender.

Table 5

Mean, Standard Deviation and Range Values for the LPI Category Styles across Subjects and by Gender.

Variable LPI Category Styles	Gender	N	M	S.D.	Range	Minimum-Maximum
SF-Category	across subjects	109	63.11	19.04	102	5-107
	M	56	55.16	18.11	86	5-91
	F	53	71.51	16.30	84	23-107
ST-Category	across subjects	109	57.76	14.21	75	22-97
	M	56	58.79	13.75	62	28-90
	F	53	56.68	14.73	75	22-97
NT-Category	across subjects	109	40.36	15.83	85	8-93
	M	56	44.75	15.24	67	26-93
	F	53	35.72	15.23	79	8-87
NF-Category	across subjects	109	62.42	16.72	82	25-107
	M	56	64.86	16.51	68	25-93
	F	53	59.85	16.71	81	26-107

Note: SF-Category denotes Sensing-Feeling
ST-Category denotes Sensing-Thinking
NT-Category denotes Intuition-Thinking
NF-Category denotes Intuition-Feeling

Table 6

T-tests for Independent Samples of Gender on LPI Category Styles.

Variable LPI Category Styles	Gender	N	M	S.D.	t	df	2-tail probability
SF-Category	M	56	55.16	18.11			
	F	53	71.51	16.30	-4.94	107	.001
ST-Category	M	56	58.79	13.75			
	F	53	56.68	14.73	.77	107	.442
NT-Category	M	56	44.75	15.24			
	F	53	35.72	15.23	3.09	107	.003
NF-Category	M	56	64.86	16.51			
	F	53	59.85	16.71	1.57	107	.118

LPI Dominant Analyses

The Learning Preference Inventory (LPI) data may also be examined according to the pattern of intrascores for an individual. The highest of the four learning style scores represents the dominant type, the next highest score represents the auxiliary type, the third highest score represents the supportive type and the lowest score is considered to be the least used or inferior style preference (Silver & Hanson, 1980). Thus, the dominant learning style designation labels preferences without any regard for the actual differences in strength of the preference. When three of the four type scores are close together in value, the pattern is considered to be balanced. Given that much of the interpretation of the four type scores involves subjective determination of the proximity to or distance from other scores, it was decided to focus on the dominant or highest type score for analyses. Two

subjects were deleted from the dominant style analyses because tied scores prevented determination of a dominant learning style.

The results of this analysis are presented in Figure 7. It can be seen that the subjects were primarily sensing-feeling (SF) dominant type learners with 41% of the subjects, 14 males and 31 females, demonstrating this type as dominant. In a study comparing gifted school populations and regular school populations, Hanson, Silver, et al. (1984) found that in regular school populations 35% of the students demonstrated SF as their dominant learning type.

The sensing-thinking (ST) and intuition-thinking (NT) learning types were least preferred with 18% (13 males, 7 females) and 7% (5 males, 3 females) respectively choosing these types as dominant (Figure 7). Hanson, Silver, et al. (1984) found that 26% of the students demonstrated the ST type as their dominant type and 12% demonstrated NT as their dominant type.

The intuition-feeling NF type was dominant for 32% of the subjects compared with 27% in the Hanson, Silver, et al. study (1984). In the present study NF learning style was dominant for 23 males and 11 females.

Dominant Perception and Judgment Functions Analyses

The dominant perception function describes the way in which a person prefers to receive information. Two dominant perception functions are described such that a person will usually prefer either the sensing (S) or the intuition (N) function. The dominant judgment function describes the way in which a person prefers to make judgments about information. Two dominant judgment functions are also described such that a person will usually prefer either the thinking (T) or the feeling (F) function. Thus a person may evidence a dominant perception or a dominant judgment function but not both.

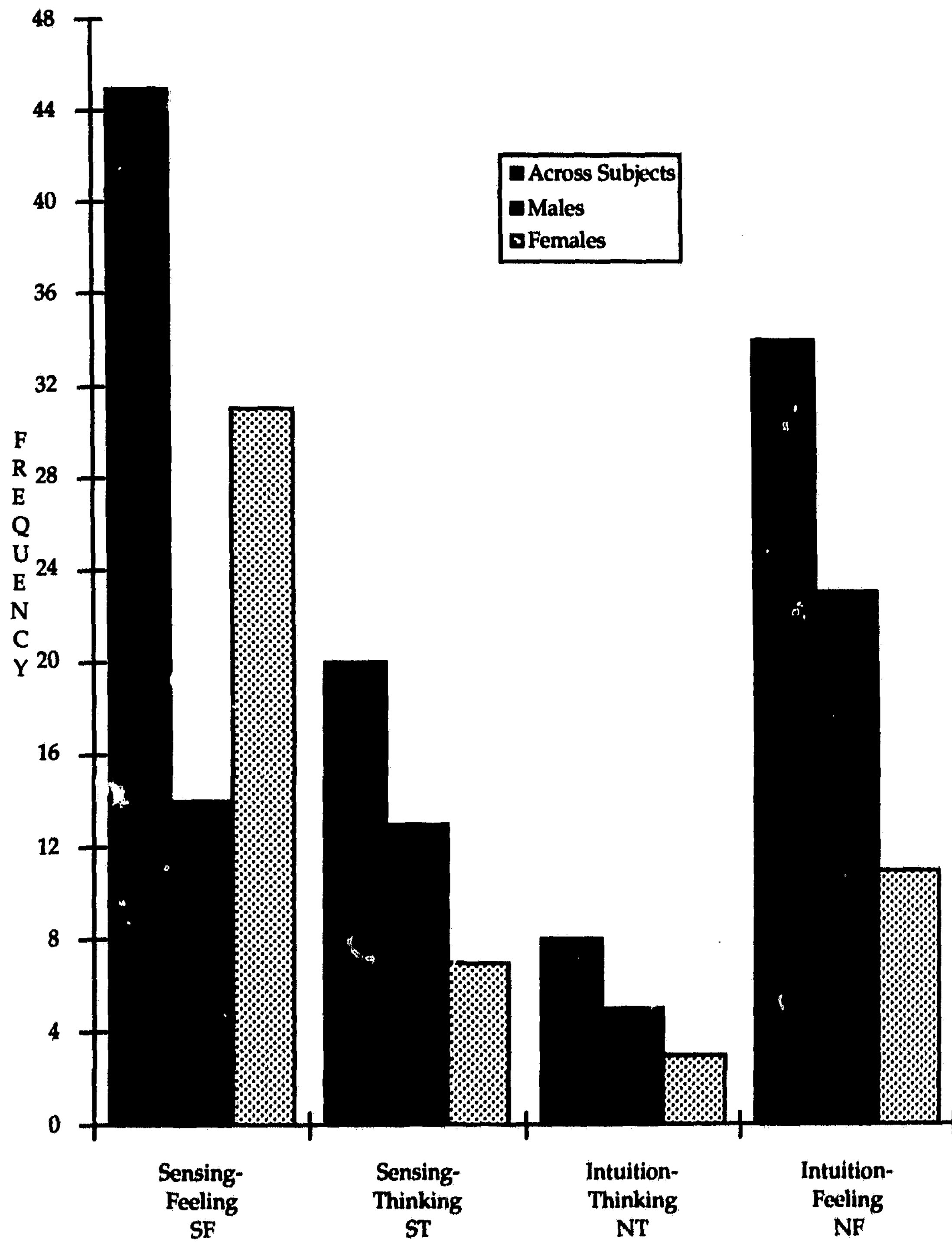


Figure 7: Dominant learning preference on the LPI across subjects and by gender.

The two highest scores are used to determine the dominant perception and dominant judgment functions. If the first letter describing the two highest learning style scores are the same (either S or N), the dominant perception function is described as sensing (S) or intuition (N) respectively. If the second letters describing the two highest learning style scores are the same (either T or F), the dominant judgment function is described as thinking (T) or feeling (F) respectively. There may be situations where there is no clear dominance for either the perception or judgment functions.

The LPI does not provide any guidance regarding the calculation of a score value for either the dominant perception or judgment functions. For purposes of the present study, the dominant perception function score was defined as the average of the two scores that had been used to determine the dominant perception function. Thus, by way of example, if a subject was determined to have a sensing dominant perception function (in which case SF and ST would have to be the two highest scores), the average of these two learning style scores was considered to be the dominant perception score. Likewise, the dominant judgment function score was defined as the average of the two scores that had been used to determine the dominant judgment function. Viewed this way, each subject may have only one dominant perception function (S or N) or one dominant judgment function (T or F) but not both. Some subjects may have neither a dominant perception function nor a dominant judgment function.

Silver and Hanson (1980) suggested that "the chances are that either the perception or the judgment function will be the same for both the first and second choices" (p. 29). As can be seen in Figure 8, the present results were not consistent with this expectation. Indeed, the majority of these subjects did not show either a dominant perception or a dominant judgment function as

defined by Silver and Hanson (1980). It was found that 60% of the students, 33 males and 33 females, did not evidence a dominant perception function and 64% of the subjects, 42 males and 28 females, did not evidence a dominant judgment function.

The percentages of dominant perception and judgment functions were very different from that reported by Hanson, Silver, et al. (1984). In the present study it was found that 31% of the subjects showed a dominant sensing perception, compared with the Hanson et al. (1984) study where 61% showed the sensing perception. Only 8% of the subjects showed a dominant intuition perception, compared with 39% in the Hanson, Silver, et al. (1984) study.

In terms of the dominant judgment function 4% of the subjects showed a preference for the thinking dominant judgment, compared with 38% in the Hanson, Silver, et al. (1984) study. Figure 8 shows that 32% showed a preference for the feeling dominant judgment compared with 62% in the Hanson, Silver, et al. (1984) study.

Taken together, the analyses of the LPI data using the category results, dominant preferences, and dominant perception and judgment functions present a picture of the personality-based learning styles of these Grades 6 and 7 students. The sensing-feeling (SF) learning style showed the strongest overall category and dominant preference. Most of the preference for the SF learning style was accounted for by the female subjects. The male subjects showed their strongest preference for the intuition-feeling (NF) learning style from both a category and dominant perspective. Male subjects also showed a significantly stronger preference than females for the intuition-thinking (NT) category learning style. The majority of the subjects did not show either a perception or judgment function. For those who did demonstrate a dominant function, sensing perception and feeling judgment were found to be the most common.

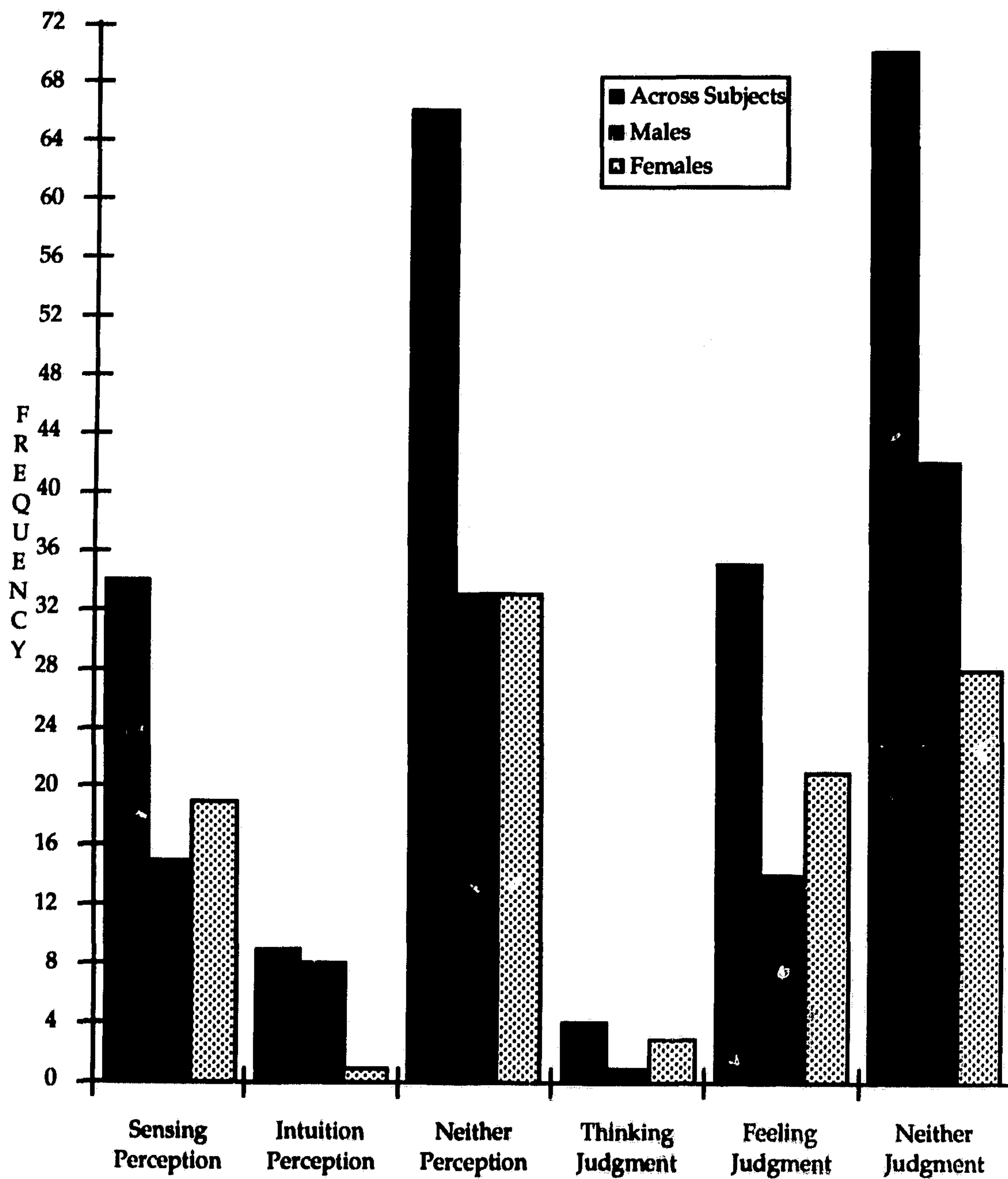


Figure 8: **Distribution for the dominant perception and judgment functions including the frequency of no perception or no judgment function.**

Relationship between Cognitive-Based and Personality-Based Learning Styles

The relationship between cognitive learning style, as measured by the GEFT, and personality-based learning style, as measured by LPI, was investigated through a series of correlations and t-tests. In some cases cell sizes were too small to allow useful comparisons. As well, no analyses were made between aspects of GEFT and LPI dominant designations by gender because of small cell sizes.

The first analysis examined the relationship between GEFT and LPI category levels, dominant designations, and dominant functions across subjects, and for males and females separately (Table 7). Separate correlations between GEFT and LPI data were done on the total sample and for subsamples specified as having dominant sensing and judgment functions as defined earlier. As can be seen in Table 7, there were no significant relationships across subjects between the GEFT and any of the LPI measures. Both SF and ST category styles were negatively correlated with GEFT, and NT and NF category styles were positively correlated with GEFT. A moderate positive relationship was found between GEFT and NT dominant learning style.

As can be seen in Table 7, there was a significant negative correlation between the GEFT and SF category style for males. No other associations using male subjects were significant. Table 7 also shows a significant correlation between GEFT and SF category style for females. No other associations involving female subjects were found to be significant. However, when the relationships between the GEFT and the various measures of the LPI for males and females were compared, it was found that males tended to show stronger associations than did females.

Table 7

Correlation Coefficients of the GEFT with the LPI Category and Dominant Styles, and Dominant Perception and Judgment Functions across Subjects and by Gender.

Variable	N	GEFT Across Subjects	N	GEFT Males	N	GEFT Females
SF-Category	109	-0.04	56	-0.30*	53	0.27*
ST-Category	109	-0.14	56	-0.08	53	-0.20
NT-Category	109	0.09	56	0.22	53	-0.05
NF-Category	109	0.10	56	0.25	53	-0.08
SF-Dominant	45	0.29	14	0.49	31	0.09
ST-Dominant	20	0.15	13	0.24	7	-0.04
NT-Dominant	8	0.38	5	0.71	3	-0.55
NF-Dominant	34	-0.27	23	-0.21	11	-0.26
S-Dominant Perception	34	-0.03	15	-0.03	19	-0.24
N-Dominant Perception	9	0.23	8	0.36	1	N.A.
T-Dominant Judgment	4	-0.58	1	N.A.	3	-0.79
F-Dominant Judgment	35	0.14	14	0.29	21	0.05

*$p < .05$

Note: Two subjects were deleted from the dominant designations because of tied scores.

SF denotes Sensing-Feeling
ST denotes Sensing-Thinking
NT denotes Intuition-Thinking
NF denotes Intuition-Feeling

S denotes Sensing
N denotes Intuition
T denotes Thinking
F denotes Feeling

Field-Dependent Style and LPI

The relationship between cognitive style and personality style was also investigated by comparing field-dependent (GEFT scores 0-4) and field-

independent (GEFT scores 14-18) cognitive styles with the various measures of personality style. Comparisons were made between field-dependent cognitive style and personality-based category styles, category perception and judgment functions, dominant styles and dominant perception and judgment functions. Comparisons were also made between field-independent cognitive style and personality-based category styles and between category perception and judgment functions.

The results of t-tests of the field-dependent style with LPI category styles and category functions are presented in Table 8. As can be seen, several comparisons reached significance ($p < .05$). There was a significant difference between sensing-feeling (SF) and sensing-thinking (ST) category styles for field-dependent subjects ($p = .009$). Thus field-dependent subjects were more likely to have a SF than a ST category style score. A significant difference was also found between SF and intuition-thinking (NT) category styles for field-dependent subjects ($p = .001$), such that they tended to have a higher SF than NT category style score. However, there was not a significant difference between SF and intuition-feeling (NF) category style scores; nor was there a significant difference between the ST and NF category style scores for the field-dependent subjects. There was a significant difference between ST and NT category style scores for field-dependent subjects ($p = .001$), such that field-dependent subjects had a higher ST than NT category style score. There was also a significant difference between NT and NF category style scores for field-dependent subjects ($p = .001$), such that they had a higher NF than NT category style score.

Both tests involving the category perception and judgment functions for field-dependent subjects were significant ($p = .002$ and $p = .001$). Thus, as can be seen in Table 8, field-dependent subjects had higher sensing category

perception scores than intuition category perception scores and higher feeling category judgment scores than thinking category judgment.

Table 8

T-tests of Field-Dependent Style with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions across Subjects.

Variable LPI Category Styles and Functions	N	M	S.D.	t	df	2-tail probability
SF-Category	31	66.48	14.14	2.80	30	.009
ST-Category		58.26	13.51			
SF-Category	31	66.48	14.14	6.84	30	.001
NT-Category		37.39	11.87			
SF-Category	31	66.48	14.14	1.20	30	.240
NF-Category		60.32	18.36			
ST-Category	31	58.26	13.51	5.48	30	.001
NT-Category		37.39	11.87			
ST-Category	31	58.26	13.15	-.39	30	.696
NF-Category		60.32	18.36			
NT-Category	31	37.39	11.87	6.27	30	.001
NF-Category		60.32	18.36			
S-Category Perception	31	62.37	11.14	3.37	30	.002
N-Category Perception		48.85	11.63			
T-Category Judgment	31	47.82	7.01	6.04	30	.001
F-Category Judgment		63.40	7.97			

Field-dependent style was also compared with category styles and

category functions for males and females separately. The results of the t-tests are presented in Appendix G, Table G1 for males and in Table G2 for females. Similar patterns of differences were found for males and females as found for the total sample, but some of these differences were not significant due to the small number of subjects in the comparisons.

As can be seen in Table G1, four comparisons reached significance. There was a significant difference (p= .001) between SF and NT category styles for field-dependent males, such that they tended to have higher SF than NT category type scores. There was also a significant difference (p= .001) between ST and NT category types, such that field-dependent males tended to have higher ST than NT category style scores. A significant difference (p= .002) was also found between NT and NF category types for field-dependent males, such that they tended to have higher NF than NT category type scores. There was also a significant difference (p= .001) on the category judgment function such that field-dependent males tended to have higher feeling than thinking category judgment scores.

The t-tests comparisons for female subjects between field-dependent style and LPI category styles and category functions are presented in Table G2. Six of the t-test comparisons reached significance. There was a significant difference (p= .015) between SF and ST category style for field-dependent females, such that they tended to have higher SF than ST category style scores. A significant difference (p= .001) was also found between SF and NT category styles for field-dependent females, such that they tended to have higher SF than ST category type scores. Table G2 also shows a significant difference between ST and NT category styles for field-dependent females (p= .001), such that they tend to have higher ST than NT learning style scores. There was also a significant difference (p= .001) between NT and NF category styles for

field-dependent females, such that they tended to have higher NF than NT category type scores. Both the category perception and judgment functions reached significance. Field-dependent females tended to have higher sensing than intuition category perception and higher feeling than thinking category judgment scores.

Field-dependent subjects were also compared on LPI dominant styles and dominant functions. As can be seen in Table G3, cell sizes tended to be small with the majority of cell sizes being less than 10. A significant difference (p= .030) was found for field-dependent subjects on the ST and NF dominant style comparisons, such that they tended to have higher NF than ST dominant type scores. It must be noted that the cell size for the ST group was 6. No other comparisons reached significance.

Overall, field-dependent subjects in this study had the highest SF category style scores and the lowest NT category style scores, with NF category scores slightly higher than ST category style scores positioned between the extremes (SF>NF, ST>NT). Furthermore, field-dependent subjects had higher sensing category perception scores and feeling category judgment scores. When considered along gender lines, the pattern of significant and nonsignificant results for the category style comparisons were the same except for one comparison. Field-dependent males were not significantly different for the SF and ST category styles but field-dependent females tended to be SF rather than ST category style. Differences between field-dependent males and females were found on the category perception function. Field-dependent males tended to show no significant differences between sensing and intuition category perception but females tended to be sensing category perception. Both males and females tended to be feeling category judgment. These results generally matched the expected perception and processing/

judgment characteristics of field-dependent people.

Field-Independent Style and LPI

The results of t-tests of the field-independent subjects for differences between category styles and category functions are presented in Table 9. Only two comparisons reached significance. There was a significant difference ($p= .007$) between the intuition-thinking (NT) category style scores and the intuition-feeling (NF) category style scores for field-independent subjects. Field-independent subjects tended to have higher NF than NT category style scores. There was also a significant difference ($p= .049$) for field-independent subjects on the category judgment function, who tended to have higher feeling than thinking category judgment scores.

Field-independent subjects' category styles and category functions were analyzed for males and females separately. The results of the t-tests are presented in Table G4 for males and Table G5 for females.

The pattern of results for field-independent males was similar to the pattern of results across subjects on the field-independent dimension (Tables 9 and G4). There was a significant difference ($p= .051$) between NT and NF category styles among field-independent males, such that field-independent males tended to have higher NF than NT category style. As can be seen in Table G4, no other comparisons for field-independent males reached significance.

Table 9

T-tests of Field-Independent Style with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions across Subjects.

Variable LPI Category Styles and Functions	N	M	S.D.	t	df	2-tail probability
SF-Category	17	59.59	24.98	.45	16	.661
ST-Category		56.47	13.63			
SF-Category	17	59.59	24.98	1.29	16	.215
NT-Category		45.71	22.65			
SF-Category	17	59.59	24.98	-.25	16	.808
NF-Category		61.71	12.80			
ST-Category	17	56.47	13.63	1.39	16	.184
NT-Category		45.71	22.65			
ST-Category	17	56.47	13.63	-1.08	16	.294
NF-Category		61.71	12.80			
NT-Category	17	45.71	22.65	3.07	16	.007
NF-Category		61.71	12.80			
S-Category Perception	17	58.03	14.08	.62	16	.546
N-Category Perception		53.71	14.94			
T-Category Judgment	17	51.09	9.68	2.13	16	.049
F-Category Judgment		60.65	9.04			

As can be seen in Table G5, three of the six category style comparisons and both of the category function comparisons for field-independent females were significant. In all comparisons involving the sensing-feeling (SF)

category style, the results were statistically significant and each time favored the SF category style. Thus, field-independent females tended to have higher SF than any of ST ($p= .021$), NT ($p= .003$), or NF ($p= .003$) category style scores. Field-independent females tended to have higher sensing than intuition category perception scores, and higher feeling than thinking category judgment scores. Field-independent females demonstrated similar perception and judgment characteristics and patterns as did field-dependent females and males.

In summary, field-independent subjects tended to have the highest NF category style scores, closely followed by SF and ST with NT category style scores being the lowest (NF>SF, ST>NT). Furthermore, field-independent subjects tended to have higher scores on sensing category perception and feeling category judgment. Field-independent males also tended to be NF category style, while field-independent females tended to be SF category style. These results did not entirely match the expectations for field-independent students who were expected to demonstrate higher intuiting and thinking attributes.

As a final summary of the relationship between cognitive-based learning style (GEFT) and personality-based learning style (LPI), it was found that there was a significant negative correlation between GEFT and SF category style for males and a significant positive correlation between GEFT and SF category style for females. Depending on the pairs of category styles used for comparison, field-dependent subjects tended to be SF>ST, NF>NT. The SF>ST, NF>NT pattern was expected for field-dependent subjects. This finding was fairly consistent between males and females. Field-independent subjects tended to be NF>SF, ST>NT. This pattern did not entirely match expectations for field-independent subjects. In fact, female field-independent

subjects demonstrated the same learning styles, perception and judgment patterns as field-dependent females. Field-independent males more closely approximated expectations and demonstrated a different pattern than field-in dependent females.

Relationship between Conceptual and Metacognitive Knowledge

The next set of research questions focused on prior conceptual and metacognitive knowledge. The first question sought to determine the relationship between prior conceptual knowledge (PKcl) and metacognitive knowledge (PKml), including the metacognitive components of awareness (PKmla) and self-management (PKmlsm). The correlation coefficients of the relationships are presented in Table 10. The correlation between prior conceptual knowledge and prior metacognitive self-management was found to be significant ($p < .05$) across subjects. There were no significant correlations between prior conceptual knowledge and prior metacognitive knowledge and prior metacognitive awareness for males or for females.

The correlations between post-instructional conceptual knowledge (PKc2) and metacognitive knowledge (PKm2) including awareness (PKm2a) and self-management (PKm2sm) were stronger than the associations prior to instruction. As can be seen in Table 11, all three associations were significant at the .05 level for these subjects. However, for males only posttest metacognitive self-management was significantly ($p < 0.01$) correlated with posttest conceptual knowledge. For females, both posttest metacognitive knowledge and metacognitive awareness were significantly ($p < 0.05$) correlated with posttest conceptual knowledge.

Table 10

Correlations between Prior Conceptual Knowledge (PKcl) and Prior Metacognitive Knowledge (PKml), Prior Metacognitive Awareness (PKmla) and Prior Metacognitive Self-Management (PKmlsm) across Subjects and by Gender.

Variable	Gender	N	PKm1	PKm1a	PKm1sm
PKc1	across subjects	109	0.17	0.14	0.20*
	M	56	0.25	0.23	0.23
	F	53	0.08	0.05	0.16

*$p < .05$

Table 11

Correlations between Conceptual Knowledge (PKc2) and Metacognitive Knowledge (PKm2), Metacognitive Awareness (PKm2a) and Metacognitive Self-Management (PKm2sm) following Explicit Strategy Instruction across Subjects and by Gender.

Variable	Gender	N	PKm2	PKm2a	PKm2sm
PKc2	across subjects	109	0.30**	0.29**	0.26**
	M	56	0.25	0.21	0.35**
	F	53	0.33*	0.34*	0.16

*$p < .05$
** $p < .01$

Comparing the information in Tables 10 and 11 illustrates that, for males, the associations between conceptual knowledge and metacognition

and conceptual knowledge and metacognitive awareness remained almost unchanged from pretest to posttest. For females, the association between conceptual knowledge and overall metacognition and conceptual knowledge and metacognitive awareness changed from nonsignificant on the pretest to significant on the posttest.

It had been expected that in the context of a guided inquiry science program with embedded explicit strategy instruction subjects would make significant growth in conceptual knowledge (Yore, 1984, 1986) and the various measures of metacognition (Spence, 1994). Contrary to these expectations, none of the correlations between changes in conceptual knowledge and changes in written measures of metacognition including awareness and self-management were significant. Indeed, as can be seen in Table 12, all correlations were nonsignificant.

Table 12

Correlations between Changes in Conceptual Knowledge (ΔPKc=PKc2-PKcl) and Changes in Metacognitive Knowledge (ΔPKm=PKm2-PKml), Metacognitive Awareness (ΔPKma=PKm2a-PKmla) and Metacognitive Self-Management (ΔPKmsm=PKm2sm-PKmlsm) across Subjects and by Gender.

Variable	Gender	N	ΔPKm	ΔPKma	ΔPKmsm
ΔPKc	across subjects	109	-0.12	-0.11	-0.08
	M	56	-0.20	-0.21	-0.04
	F	53	-0.06	-0.03	-0.13

Researcher observations during the study suggested that the subjects were more interested, cooperative and willing to work hard on the pretest measures of metacognition than on the posttest measures. These

observations, combined with the unexpected results in Tables 10, 11 and 12 necessitated further investigation of the results.

Two subgroups based on pretest metacognitive scores were selected for further analysis. A low metacognitive group, defined as subjects with scores one or more standard deviations below the sample mean on the metacognitive tests, and a high metacognitive group, defined as subjects with scores one or more standard deviations above the sample mean on the metacognitive tests, were selected for further analysis. These groups were defined by their metacognition, metacognitive awareness and metacognitive self-management and were compared in terms of changes in conceptual knowledge.

Table 13 shows a significant difference between changes in conceptual knowledge for subjects with high and low initial metacognitive knowledge. As expected, low prior metacognitive knowledge resulted in significantly lower changes in conceptual knowledge than did high prior metacognitive knowledge.

Table 13

T-tests for Low and High Prior Metacognitive Knowledge (Low PKml and High PKml) with Changes in Conceptual Knowledge (ΔPKc).

Group	N	ΔPKc	S.D.	t	df	2-tail probability
Low PKml	14	9.79	4.14	-2.09	29	.045
High PKml	17	13.35	5.16			

The results of t-test comparisons between low and high prior metacognitive awareness and changes in conceptual knowledge showed

significant differences. The low prior metacognitive awareness group showed significantly less change in conceptual knowledge than did the high metacognitive awareness group (Table 14).

Table 14

T-tests for Low and High Prior Metacognitive Awareness (Low PKmla and High PKmla) with Changes in Conceptual Knowledge (ΔPKc).

Group	N	ΔPKc	S.D.	t	df	2-tail probability
Low PKmla	13	9.15	4.06	-2.74	26	.011
High PKmla	15	13.93	5.04			

Finally, as can be seen in Table 15, significant differences were found between low and high prior metacognitive self-management groups. Low prior metacognitive self-management showed significantly less change in conceptual knowledge than did high prior metacognitive self-management.

Table 15

T-tests for Low and High Prior Metacognitive Self-Management (Low PKmlsm and High PKmlsm) with Changes in Conceptual Knowledge (ΔPKc).

Group	N	ΔPKc	S.D.	t	df	2-tail probability
Low PKmlsm	22	10.32	4.62	-2.56	40	.014
High PKmlsm	20	14.20	5.22			

In summary, the relationships between conceptual knowledge and the various measures of metacognition are tenuous due to the questionable value of the metacognitive posttest results. The subgroup comparisons revealed expected results. Subjects with low pretest overall metacognition, low metacognitive awareness and low metacognitive self-management demonstrated significantly less growth in conceptual knowledge than did subjects with high pretest overall metacognition, high metacognitive awareness and high metacognitive self-management.

Relationship between Learning Styles and Conceptual and Metacognitive Knowledge

The next two research questions focused on the relationships between learning style and conceptual knowledge and the various forms of metacognitive knowledge. The questions considered the relationship both before and following guided inquiry with embedded strategy instruction.

Table 16 shows that cognitive learning style as measured by the GEFT correlated significantly ($p < 0.01$), with all pretest measures of conceptual knowledge, metacognitive knowledge, metacognitive awareness, and metacognitive self-management. On the posttest measures, only conceptual knowledge was significantly correlated ($p < 0.01$) with the GEFT. The remaining posttest metacognitive measures were positively but not significantly correlated with conceptual knowledge. These post-instruction correlations must be viewed in light of the questionable results on the written metacognitive measure.

The relationship between personality-based learning style as measured by the LPI and conceptual and metacognitive knowledge was considered for each of the three major methods of viewing LPI data, that is, category levels,

dominant designations and dominant functions. Table 17 shows that the LPI category styles did not correlate significantly with any of the pretest conceptual or metacognitive measures; indeed, all of the correlations were weak.

Table 16

Correlations between GEFT and Pretest and Posttest Conceptual Knowledge (PKc), Metacognitive Knowledge (PKm), Metacognitive Awareness (PKma) and Metacognitive Self-Management (PKmsm).

Variable	N		PKc	PKm	PKma	PKmsm
GEFT	109	Pre	0.25**	0.31**	0.31**	0.22*
	109	Post	0.43**	0.10	0.10	0.07

*p< .05
**p< .01

Significant correlations were found between LPI dominant styles and some of the pretest cognitive and metacognitive measures. There were significant correlations between the ST dominant style and prior metacognitive self-management (0.47), the NT dominant style and overall metacognition (0.88), and the NT dominant style and prior metacognitive awareness (0.85). Overall, the correlations between the NT dominant style and all prior conceptual and prior metacognitive measures were strong. There were significant correlations between intuition dominant perception and overall prior metacognition (0.79) and between intuition dominant perception and prior metacognitive awareness (0.77). Strong, but nonsignificant correlations were found between the thinking dominant judgment function and the measures of prior metacognitive knowledge. These results appear to suggest that subjects with dominant NT style, intuition perception and thinking judgment have well articulated style, perception and judgment attributes that

parallel metacognition.

Table 17

Correlations between LPI Category and Dominant Styles with Pretest and Posttest Conceptual Knowledge (PKc), Metacognitive Knowledge (PKm), Metacognitive Awareness (PKma) and Metacognitive Self-Management (PKmsm) across Subjects.

		Pretests				Posttests			
Variable	N	PKcl	PKml	PKmla	PKmlsm	PKc2	PKm2	PKm2a	PKm2sm
SF-Category	[illegible]	-0.08	-0.07	-0.07	-0.04	-0.14	-0.08	-0.10	0.01
ST-Category	109	0.10	-0.09	-0.10	-0.01	-0.02	-0.01	-0.00	-0.04
NT-Category	109	0.11	0.17	0.16	0.16	0.23*	0.03	0.04	0.01
NF Category	109	-0.12	0.01	0.03	-0.09	-0.04	0.10	0.10	0.04
SF-Dominant	45	-0.02	0.05	0.01	0.20	-0.09	0.13	0.11	0.18
ST-Dominant	20	-0.27	0.39	0.36	0.47*	-0.07	0.45*	0.45*	0.35
NT-Dominant	8	0.53	0.88**	0.85**	0.68	0.78*	0.70	0.75*	0.29
NF Dominant	34	-0.11	0.28	0.32	0.05	[illegible]	0.29	0.25	0.37*
S-Dominant Perception	34	0.03	0.11	0.09	0.19	0.10	0.18	0.18	0.16
N-Dominant Perception	9	0.07	0.79*	0.77*	0.56	0.45	0.16	0.18	0.02
T-Dominant Judgment	4	0.10	0.85	0.74	0.93	0.13	0.83	0.79	0.98*
F-Dominant Judgment	35	0.10	-0.01	-0.01	-0.01	-0.05	0.37*	0.34*	0.33

*p< .05
**p< .01

The correlations between LPI category styles, dominant styles and dominant functions with posttest cognitive and metacognitive measures are also presented in Table 17. There was a significant correlation between NT category style and posttest conceptual knowledge (0.23). As can be seen in Table 17, all other correlations between category styles and posttest metacognitive measures were weak. There were five significant correlations

between dominant styles and the posttest cognitive and metacognitive measures. The ST dominant style was significantly correlated with both posttest metacognition (0.45) and with posttest metacognitive awareness (0.45), while the NT dominant style was significantly correlated with posttest conceptual knowledge (0.78) and with posttest metacognitive awareness (0.75), and the NF dominant style was significantly correlated with posttest metacognitive self-management (0.37). Both of the dominant judgment functions were significantly correlated with some of the posttest cognitive measures. It was found that the thinking dominant judgment was significantly correlated with posttest metacognitive self-management (0.98), and the feeling dominant judgment correlated significantly with posttest metacognition (0.37) and with posttest metacognitive awareness (0.34). Correlations involving posttest metacognition, metacognitive awareness and metacognitive self-management must be viewed with skepticism.

Relationship between Learning Styles and Changes in Conceptual and Metacognitive Knowledge

The next research question investigated the potential differential effects of guided inquiry with embedded explicit strategy instruction on conceptual and metacognitive knowledge for subjects with different learning styles. Prior to the analysis of these data, the effect of explicit strategy instruction on conceptual knowledge and on the measures of metacognitive knowledge across all subjects was investigated.

Table 18 shows the results of t-tests designed to assess the effect of strategy instruction. There were significant gains across subjects in the area of conceptual knowledge following explicit strategy instruction ($p = .001$). The changes in both metacognitive knowledge and metacognitive awareness were

significant but, as can be seen from the means in Table 18, there was a significant decrease in scores on both measures. The scores on metacognitive self-management also decreased from pretest to posttest but the decrease was not significant. These metacognitive changes must be viewed in light of the questionable student effort afforded the posttest. Further analyses attempted to explore the results of the various metacognitive measures. These analyses focused on the individual taped interviews and were qualitative in nature.

Table 18

T-tests for Paired Samples of Conceptual Knowledge, Metacognitive Knowledge, Metacognitive Awareness and Metacognitive Self-Management across Subjects.

Variable	N	M	S.D.	t	df	2-tail probability
PKc1	109	4.06	2.40	-28.49	108	.001
PKc2		16.25	4.97			
PKm1	109	97.30	19.80	2.53	108	.013
PKm2		92.68	19.76			
PKm1a	109	82.95	16.65	2.58	108	.011
PKm2a		78.83	17.09			
PKm1sm	109	14.35	4.54	-1.05	108	.295
PKm2sm		13.85	4.14			

There were significant differences between field-dependent and field-independent cognitive styles and changes in conceptual knowledge ($p = .002$). Thus subjects identified as field-independent tended to make significantly greater gains on the post conceptual test than subjects identified as field-dependent. As can be seen in Table 19, there were also significant differences between those subjects identified as field-dependent and those described as

field-independent on changes in both overall metacognition and in metacognitive awareness (p= .010, and p= .009). In each case subjects identified as field-dependent lost significantly less than subjects described as field-independent on both metacognition and metacognitive awareness. Changes in metacognitive self-management did not vary as a function of field-dependence/field-independence although the direction of the change was the same as that found on metacognition and metacognitive awareness. As has been previously noted, the results of the analyses involving changes in all measures of metacognition must be viewed cautiously.

Table 19

T-tests for Samples of GEFT with Changes in Conceptual Knowledge (ΔPKc), Metacognitive Knowledge (ΔPKm), Metacognitive Awareness (ΔPKma) and Metacognitive Self-Management (ΔPKmsm).

Variable	Group	N	M	t	d	2-tail probability
ΔPKc	Low GEFT	31	10.65	-3.35	46	.002
	High GEFT	17	14.35			
ΔPKm	Low GEFT	31	-2.48	2.69	46	.010
	High GEFT	17	-18.53			
ΔPKma	Low GEFT	31	-2.23	2.71	46	.009
	High GEFT	17	-16.35			
ΔPKmsm	Low GEFT	31	-0.26	1.29	46	.203
	High GEFT	17	-2.18			

Changes in conceptual knowledge and the various measures of metacognition were also compared for high and low category learning styles as measured by the LPI. As can be seen in Tables G6, G7, G8, and G9, no pattern of significant differences emerged from these analyses. Thus there seemed to be little or no relationship between changes in conceptual knowledge and changes in metacognition as a result of variations in the personality-based category styles. The only comparison to approach significance was that between high and low NT category style and changes in conceptual knowledge. Thus there was a fairly strong tendency for those subjects described as high NT category style to make greater gains on the test of conceptual knowledge than those subjects described as low NT category style. This finding, although not significant, is consistent with expectations.

Qualitative Data

The final research question was an attempt to understand better the present results through use of qualitative data. The major sources of qualitative data were the taped interviews (TI1 and TI2), the informal attitude survey (IAS), and post-study individual teacher interviews. The pretest and posttest interview data and the IAS data were analyzed quantitatively as well as qualitatively. The quantitative analysis helped to direct and support the qualitative analysis.

The interview questions seemed to require the subjects to think and reflect on aspects of their learning that most seemed unfamiliar with. The responses suggested that the subjects had difficulty organizing and expressing their thoughts, so that often it was necessary to probe answers. As a group they seemed not to be independent learners but rather depended primarily on

teacher direction for guidance and as the source of solution when difficulties arose. A common response was "I'd go ask the teacher". Asking a classmate for the correct answer was also frequently cited. The classmate of choice was most often the student sitting closest as opposed to a student known to be academically successful. The most used strategy seemed to be that of re-reading and most of the time it seemed to be without any changes from the way the material had initially been read.

The transcribed interview responses were scored as 0, 1, or 2 according to a predetermined rubric. These scores were translated into percentages. Table G10 presents the percentage of subjects who achieved scores of 0, 1, or 2 on both the pretest and posttest interview questions. For purposes of clarity and cross comparisons with other data sources, the percentages are presented in the order in which the questions appeared in the interviews for each of the seven protocols.

As an overall measure of metacognition, Table G10 shows that the majority of subjects achieved a score of 1 on both the pretest and posttest interview questions. A score value of 1 was taken to mean incomplete or surface metacognitive knowledge. While approximately 30% of the subjects received a score of 0 on the pretest, this percentage dropped to approximately 23% on the posttest interview questions. A score of 0 was taken to mean incorrect or no metacognitive knowledge. As well, the percentage of subjects achieving a score of 2 almost doubled on the posttest, from 11% on the pretest to 19% on the posttest. A score of 2 was taken to mean in-depth metacognitive knowledge. Thus there was a shift away from incorrect or incomplete metacognitive knowledge toward in-depth metacognitive knowledge for the subjects. This shift indicates an apparent growth in metacognition detected by the interview protocols that was not detected by the

written measure of metacognition.

The information in Table G10 was also examined according to the metacognitive domains assessed. Pretest percentages were compared with posttest percentages for the metacognitive awareness domains of declarative, procedural, and conditional knowledge and the metacognitive self-management domains of planning, evaluation and regulation. By way of example, the first percentages reported in Table G10 are for question 9d. Comparing the pretest percentages with the posttest percentages suggests that there was a decrease in the percentage of subjects who achieved a score of 0 and an increase in the percentage of subjects who achieved a score of 1. This change was interpreted to mean a positive change. This type of comparison was made for each of the metacognitive domains investigated. In instances where the direction of change from pretest to posttest could be determined to be from 0 and/or 1 to 1 and/or 2, the change was considered to be positive. When the direction of change was from 2 and/or 1 to 1 and/or 0, the change was considered to be negative. In those instances where there was no change or where the change could be to either 0 or 2 from 1, the change was considered to be neutral. The changes so determined were tallied and are presented in Table 20.

As can be seen in Table 20, the metacognitive awareness domains of declarative and conditional knowledge showed considerably more positive changes than either negative or neutral changes for the interview data. Likewise for the self-management aspect of metacognition, there were more positive changes than either negative or neutral changes in the areas of planning and regulation. Thus it seems reasonable to conclude that these subjects tended to demonstrate growth in the metacognitive awareness domains of declarative and conditional knowledge and growth in the

metacognitive self-management domains of planning and regulation. The changes in both procedural and evaluation knowledges were fairly close together with positive, negative and neutral changes cancelling each other. When, for purposes of comparison, negative and neutral changes are combined, it would seem reasonable to suggest that these two areas of metacognitive knowledge were likely most difficult for these Grades 6 and 7 students or the strategy instruction provided did not concentrate on these metacognitive dimensions.

Table 20

Number of Directional Changes in Percentages from Pretest to Posttest for Metacognitive Awareness and Metacognitive Self-Management.

Metacognitive	Number of Directional Changes		
Domain	Positive	Negative	Neutral
Awareness			
d-declarative	13	4	4
p-procedural	6	6	9
c-conditional	16	2	3
Self-management			
pl-planning	6	1	1
e-evaluation	2	4	2
r-regulation	5	1	2

The data in Table G10 were examined from the perspective of the strategies focused upon in the present study (accessing prior knowledge through use of KWL charts strategy 17, detecting main ideas strategies 11 and 15, and text structure strategies 3 and 10). Accessing prior knowledge and main idea strategies showed more positive changes than either negative or neutral changes. Text structure strategies showed more negative and neutral

changes than positive changes.

The application questions, which sought to have subjects apply and use learned strategies, were included as posttest questions only. The vast majority of the subjects showed some facility in the application and use of strategies aimed at accessing prior knowledge and detecting main ideas. By contrast the majority of the subjects demonstrated difficulty, that is obtaining a score of 0, in the application of text structure strategies. Thus the results from the application questions were found to be consistent with the findings relative to metacognitive awareness and self-management of the targeted strategies.

In summary the subjects in this study demonstrated positive changes in declarative, procedural, planning and regulation knowledge measured by the interview protocols that were not detected by the written measures. Their performance on application questions, which focused upon the targeted strategies, was consistent with their performance on the questions regarding their metacognitive knowledge of these same strategies. Thus, they demonstrated facility with questions relating to accessing prior knowledge and detecting main ideas; and they demonstrated difficulty with questions relating to text structure strategies.

Six of the 24 attitude statements used in the informal attitude survey (IAS) seemed to be most useful in terms of understanding test results. Attitude numbers 7 and 16, which involve self perceptions regarding school success generally and school science success in particular, correlated significantly with all measures of conceptual knowledge including pretest conceptual knowledge, posttest conceptual knowledge, and changes in conceptual knowledge. Thus those subjects who viewed themselves as academically successful tended to achieve higher conceptual test scores than did those who did not hold positive self perceptions.

Attitude numbers 17 and 22, which assessed the value attached to school and the value attached to reading science books, correlated significantly with all pretest and posttest metacognitive measures including overall metacognitive knowledge, metacognitive awareness, and metacognitive self-management. Thus those subjects who valued school and science books tended to do better on measures of metacognition than did those who did not value school or science books. The connection between the value attached to school and reading science books and metacognition is not readily obvious. However, it may relate to the intentionality aspect of academic success.

The remaining two attitude items numbered 23 and 24, which involve personal responsibility toward checking school work and completing homework and seem to reflect academic independence and self regulation correlated significantly with the ISRA items. Thus those subjects who were independent self-regulated learners tended also to be more metacognitively aware. This finding is consistent with the general literature relating to independent self-regulated learners and their metacognitive knowledge.

In summary, those aspects of attitude concerned with self perception, self regulation and the value attached to school seemed to most impact conceptual knowledge and metacognition. While this is not a new finding, it underscores the importance of these factors in academic success.

Discussions and post-study interviews with the teachers helped to clarify some of the findings in the present study and particularly the results of written posttest metacognitive measures. Researcher observations were consistent with many of the teacher comments and served to highlight the importance of student attitudes and habits.

The teachers suggested that most in-class assessment techniques tend to

be multiple-choice format. Students generally seem to have limited experience with short-or long-answer type questions, which require them to integrate and perhaps apply their understanding of new learning. Indeed it seems that as students move through their schooling assessment techniques tend toward computer-scored, multiple-choice questions. Several of the conceptual knowledge questions used in the present study were of the integration and application type and as such would be difficult for the students.

The most frequently made comment by the teachers related to the pressure and commitments. Generally the science topic content was unfamiliar to the teachers and they needed what they considered extreme amounts of time simply to prepare the content. One teacher for example spoke about spending almost entire weekends simply reading, learning and preparing the material. Another of the teachers had a science background but still found preparation time onerous. One of the results of this seems to be that most effort went into content study so that the process of explicit strategy instruction, metacognition, and the interactive nature of science learning likely became a secondary focus all for the teachers and thereby for the students. As the teachers found content demands significant, it seems they responded in much the same way the students did. It seems that the teachers focused on content mastery for purposes of evaluation. Thus the expectations of statistically significant growth on student metacognitive awareness and self-management as reflected in change scores would not likely be realized and indeed they were not.

CHAPTER 5

Discussion and Implications

The interactive-constructive model of learning, which is consistent with the view that successful science learning involves constructing meaning from diverse information sources, served as the model for the present study. This model considers perception and processing of information and how prior knowledge, metacognition, task and context influence the meaning construction process (Yore & Shymansky, 1991). The guided-inquiry with embedded strategy instruction was developed from the interactive-constructive model. This instructional approach is consistent with explicit strategies instruction (Pearson & Dole, 1987) and transactional strategies instruction (Pressley, El-Dinary, Gaskins, et al., 1992).

This pretest-posttest case study explored the learner dimension in learning biological science topics in the context of regular elementary classrooms. It assessed changes in conceptual knowledge and in metacognitive awareness and executive control as a result of a guided inquiry science program with embedded strategies instruction, and determined the differential impact of this instructional approach for various learning styles on both conceptual knowledge and metacognition. The focus of the present study was not the extension of theory, rather, the application of previous research findings in regular learning environments with regular teachers and students so as to determine the ecological validity of these research-based strategies. Thus, the design of the study was directed, enriched and limited by the realities of regular classrooms. To accomplish the purposes of the study, one school serving a mixed population participated in an eleven-week pretest and posttest study. A total of 109 students, 56 males and 53 females, and 5

teachers took part in the study. The students, 52 from Grade six and 57 from Grade seven, were members of naturally constituted classes. Using the Journeys in Science series, the teachers taught four-forty minute periods a week using prescribed science lessons and predetermined comprehension strategies. Interpretation of the material and the strategies were at the professional discretion and judgment of the teachers; however, the research supervisor and the researcher where available for discussion throughout the study.

Conceptual knowledge, metacognitive awareness, and metacognitive self-management were assessed as pretest and posttest measures. Cognitive and personality-based learning styles were assessed using established procedures. An informal attitude survey served to assess student attitudes towards school science, science books and school in general. Individual pretest and posttest student interviews probed metacognitive awareness and metacognitive self-management. Information from post-study teacher interviews focused generally on the study and on specific aspects of the study. The attitude survey and the student and teacher interviews provided data designed to help clarify research results detected in learning styles, conceptual and metacognition tests.

The results of the present study must be interpreted with caution, not only because of the usual problems associated with classroom-based research but because of specific observations made during the present study. During the administration of the various assessment measures, it was noted that student attitude toward the items and willingness to put forth best effort seemed at times to be affected by the presence or absence of the teacher in the classroom. Students tended to work fairly well when the teacher was present but had a tendency to treat the situation lightly if their own teacher stepped

out of the class momentarily. As the study progressed, the students seemed to have difficulty maintaining interest, experienced problems with persistence, tended to become uncooperative, and generally seemed not to put their best effort forward. During posttests they seemed primarily motivated by an attitude reflected in the question --- does this count? Thus they appeared to be interested and willing to work only if the particular task counted toward grading. These observations warrant cautious interpretation involving posttest metacognitive results and they also point to some very important realities and implications, which will be discussed later in this chapter.

The results of the cognitive learning style assessment suggested that these Grades 6 and 7 students were primarily field-dependent. Both males and females demonstrated this tendency equally. In terms of personality-based learning style, these students may be described primarily as either sensing-feeling (SF) or intuition-feeling (NF) learners. The SF preference that perceives concretely and judges through personal belief systems is seen to be consistent with the field-dependent tendency that processes globally. There were differences between males and females on the personality-based learning styles. Some males in this sample appeared to demonstrate processing and judging attributes more closely aligned with the analytical demands of science and science teaching. Most females and some males in this sample appeared to prefer and demonstrated field-dependence, sensing perception and feeling judgment, which does not appear to closely match the demands of science. Very few of the students demonstrated the intuition thinking (NT) learning style, which is most closely associated with academic success.

There was no general pattern of relationships between cognitive-based learning style and personality-based learning style as measured in this study.

While most of these students could be described as field-dependent and SF learners, both of which seem to be consistent with each other, gender differences appeared to confound the correlations when field-independence and field-dependence were correlated with pairwise comparisons of personality-based learning style. Specifically, field-independent males demonstrated an intuition-feeling (NF) >sensing-thinking (ST), intuition-thinking (NT) >sensing-feeling (SF) profile and field-dependent males demonstrated a sensing-feeling (SF) >intuition-feeling (NF), sensing-thinking (ST) >intuition-thinking (NT) profile which was somewhat aligned with expectations based on the characteristics established by Witkin, Oltman, et al. (1971). Field-independence is associated with analytical, sequential, rational thinking, and field-dependence is associated with global thinking. Both field-independent and field-dependent females demonstrated the same SF>NF, ST>NT profile that was somewhat consistent with a field-dependent person but not consistent with a field-independent person. It seems reasonable to conclude that field-independent cognitive style represents something in common with the LPI style types, yet this is inconsistent with the tenets of the LPI model of learning styles which suggests that each of the four styles of learning is different from the other.

Due to the questionable posttest results from the written metacognition tests, little can be said about expected and desired metacognitive growth or about possible relationships between conceptual and metacognitive growth. However, associations between metacognition and conceptual knowledge and the impact of metacognition on science learning were demonstrated by comparing changes in conceptual knowledge with low and high levels of pretest metacognitive awareness and metacognitive self-management. In all comparisons those students with high pretest scores on metacognitive

awareness and metacognitive self-management made greater gains in conceptual knowledge than did those students with low pretest scores on metacognitive awareness and metacognitive self-management.

Pretest assessment results demonstrated that male students showed stronger associations between conceptual knowledge and metacognition than did their female classmates. For female students all pretest associations between conceptual knowledge and metacognition were weak. However, the results of posttest analyses revealed interesting differences. Among the male students the correlations between conceptual knowledge and metacognition were reasonably unchanged from pretest to posttest. For female students the correlations between conceptual knowledge and metacognitive self-management remained unchanged from pretest to posttest. However, associations between conceptual knowledge and metacognition and metacognitive awareness demonstrated significant growth.

The results of the qualitative analysis of the individual taped student interviews demonstrated positive changes in the metacognitive domains of declarative, procedural, planning, and regulation knowledges. As well positive changes in posttest interview scores for questions that assessed the targeted strategies of accessing prior knowledge and detecting main ideas paralleled satisfactory achievement levels in application questions that focused upon these same strategies.

The failure of comparisons between pretest and posttest written metacognitive measures to reach statistical significance and the positive changes in metacognition found from qualitative analysis of the interview data may be due to dominant influences of specific types of personality-based learning styles (SF and NF) as measured and reported upon in this study, negative and uncooperative student behaviors especially evident on posttest

measures, length of the written metacognitive tests and the reading level required to complete the written metacognitive tests. Problems associated with completing the written metacognitive tests seem less plausible since the students seemed to experience no difficulties with this same test as a pretest measure. The negative student behaviours toward some of the assessment measures may be an expression of the mismatch between preferred ways of learning and science teaching styles and curriculum demands and students' lack of understanding of their own personal learning preferences and needs. Thus while schools may adopt desirable science curriculum, textbooks, and instructional processes and be committed to encouraging all students to pursue science studies, other issues related to learning preferences need to be considered. As well, differences in learning styles among male and female students may have implications not only for the instructional techniques but also for class compositions, which may need to take into consideration gender-based learning style preferences.

Cognitive learning style correlated significantly with pretest and posttest conceptual knowledge and with pretest metacognitive measures. The field-dependent tendencies of many students in this study might serve to negatively impact growth in conceptual knowledge, metacognitive awareness and metacognitive self-management in the context of teaching environments, which seem to favor field-independent and intuitive thinking learners.

The NF style, which best described the male students in this study showed moderate correlations between pretest and posttest metacognition and metacognitive awareness and significant correlation with posttest metacognitive self-management. Thus it might be that the commonality between NF learning style and metacognition helped the male students. A

similar explanation does not seem to hold for the female students. The SF learning style showed only the weakest of associations with any of the pretest or posttest conceptual knowledge and metacognitive comparisons. However, the significant correlations between the feeling judgment function and posttest metacognition overall and metacognitive awareness might mean that the female students were able to use their feeling judgment in some way to facilitate learning.

Another avenue of explanation may lie with the findings on the informal attitude survey. Six of the 24 items loosely labelled self-perception-regulation correlated significantly with both metacognitive awareness and metacognitive self-management. Thus, it might be that metacognition and conceptual knowledge are associated through this intermediary affective factor of self-perception-regulation. This disposition or habit of mind may be the link between metacognitive awareness (knowledge about strategies) and metacognitive self-management (use of strategies) and achievement in science (conceptual growth).

Generally it seems that the attempt to introduce the philosophy and guided inquiry approach of Journeys in Science and the explicit strategies instruction process was too ambitious for three half-days of in-service. It seems that some of the teachers did not fully understand the purpose or the method of explicit strategies instruction. As well the strategies seemed to have been introduced by most of the teachers more as a lock-step process than as the transactive process intended. In one instance a teacher had not used the time allotted for introduction of the new strategies but did do so when given more explanation. This lack of awareness that explicit strategy instruction is a transactive process between teacher and student was evidenced in some of the teacher comments. One teacher described the main

idea strategy as fairly useless, and another suggested that the strategies served mainly as a method to organize knowledge and factual information mostly for rote purposes. Other comments pointed to the lack of comfort with the instructional process and a tendency to prefer the methods that the teachers had used over the years. The difficulties that grew out of the length of the in-service may account for the lack of positive changes in procedural knowledge observed on the qualitative analysis of the interview data and reduced the chances that the students would become thoughtful and metacognitive about the target strategies.

The students seemed to be motivated primarily by evaluation and the role any required task might have in the grading process. When they asked and were told that the posttest metacognitive measures did not count toward the final result on their yearly science program, they simply did not put in the effort necessary to be successful. These attitudes and the tendency to be teacher- or peer-dependent as opposed to self-regulated learners may help to explain the lack of positive changes in some aspects of metacognitive awareness and self-management observed on the qualitative analysis of the interview data. Thus these students tend not to monitor or check their understanding or progress in school activities.

In summary, the guided inquiry approach with embedded strategy instruction utilizing a reasonable science program produced significant conceptual growth across all types of students. Students with a field-independent style and well-developed metacognition of science reading showed greater gains than did the students with a field-dependent style and poorly developed metacognition. No perception-judgment learning style was differentially affected by this instructional approach.

Implications for the Classroom

The implications of the findings from this study for the classroom break down into two major areas, those directed toward students and the instructional process and those directed toward teachers.

Field-dependent cognitive-based learning style and SF and NF personality-based learning styles seem to be most common among the upper elementary students. Yet most teaching seems to favor field-independent cognitive-based learning style and NT and ST personality-based learning styles as evidenced by the higher academic success rates of these styles. It seems important to modify the instructional process in an attempt to meet the needs of these field-dependent SF and NF learners. For those students who would be described as SF learners, instructional strategies that promote positive self-concept, are interpersonally oriented, emphasize collaborative approaches and allow for small group work seem most suitable. At almost the other end of the continuum is the NF learner. Students who prefer this style of learning work well in environments that are nondirective, flexible and innovative and where there is an emphasis is placed on problem solving.

While the need to instruct students using their preferred learning style is acknowledged, it seems equally important to help students develop facility in using other learning styles. It might be useful to employ the 4-MAT system of instruction as proposed by McCarthy and her colleagues (e.g. McCarthy, 1980; McCarthy, 1985; McCarthy & Leflar, 1983; Samples, Hammond & McCarthy, 1985). According to the 4-MAT system, the instructional process can be divided into four parts so that students spend one-quarter of their time learning in their preferred learning style and the remainder of the time gaining competency learning through the other styles of learning.

Students would also do well to have opportunities to use the writing-to-learn approach as suggested by Holliday, Yore and Alverman (1994). The writing-to-learn process applied to science would allow students the opportunity to use elaborated writing not only to demonstrate their learning but also to enhance and promote their meaningful learning. "Writing should glue thinking to paper, provide a public record of thinking, promote critical thinking, allow the transformation of vague ideas to clear conceptions, and stimulate the construction of understandings" (Holliday, Yore, et al., 1994, p. 885). This approach would give students the chance to talk, negotiate, write and rewrite so that their learning might become clear and crystallized.

It is recognized that it is desirable to motivate students to value learning and to accept the long-range goals of learning. However in reality students seem to be motivated mostly by meeting the requirements necessary for successful course completion. Whatever the process of evaluation it might be useful to cast it in a model of "it all counts"; thus students would get credit for all aspects of the program considered to be involved in the particular subject.

One of the valuable outcomes of the study was increased use of the library by the students. The librarian noted that during the course of the study the students were in the library more frequently and they were more actively involved in research projects for their science classes than was usually the case. This might point to the need for increased opportunity for independent library work and search/select strategies.

From the teachers' perspective, a valuable outcome of this study was the opportunity to work closely with colleagues. The teachers supported each other, shared ideas and materials and the more experienced teachers helped those less experienced. If teachers were encouraged and able to do more study

units in common, it might divide the workload, allow for sharing expertise and thereby improve the program and as well allow for more frequent in-school colleague interaction and support than is currently the practice. Such a system might have built into it access to external expertise and resources as needed. This is being done to some extent and on an informal basis but it might be useful to consider a more planned approach.

Implications for Future Research

There certainly seems to be a need for more studies that are centered in the context of regular classrooms. It seems equally important that these studies locate among student populations most in need of the type of support that develops out of research-based studies. Traditional experimental studies continue to be needed. It is the results of such studies that advance theoretical knowledge and provide direction for classroom studies.

The fact that the present study did not demonstrate significant growth on posttest metacognitive measures following explicit strategy instruction needs to be investigated further. Since the purpose of this study was not to develop teachers' science content knowledge and since teacher deficits in conceptual knowledge was a confounding factor in the present study, future research should avoid the frustration caused by conceptual knowledge demands. This might be accomplished by using science topics familiar to and known by the teachers or those topics that teachers currently use as part of the curriculum.

There seems to be a need to investigate further the role played by attitude, especially that termed self-perception-regulation, in the development of metacognitive processes. In the present study it correlated significantly with some of the conceptual and metacognitive measures. It

seems that attitude is part of the broader metacognitive process as some researchers have suggested. The affective disposition and habits of mind associated with science literacy appear to be closely aligned with metacognitive awareness and executive control.

This study found that the NT personality-based learning style was significantly associated with pretest and posttest conceptual knowledge, pretest and posttest metacognitive measures and the self-perception-regulation attitude factor. It may be that the NT learning style student, the self-regulated learner, the thoughtful expert reader of science textual material who is strategic, metacognitively aware and able to exercise metacognitive self-management are all the same. Future research needs to investigate more closely larger numbers of students who demonstrate preference for the NT learning style type to determine how well they reflect the self-regulated metacognitive learner. A close parallel would help to bring clarity and some degree of unity to a group of characteristics as yet fairly separate.

The entire issue of gender variations in the personality-based view of learning style needs further investigation. That there is no information available on gender differences yet that gender differences did emerge in the present study points to the need for further research. Any further confirmation of gender differences in personality-based learning styles could be expected to significantly impact science teaching styles and science curriculum.

Another problem in the present study was the length and intensity of the study, given the amount of material to be covered and the number of strategies introduced. Future research needs to be extended over a longer part of the school year perhaps even employing a multi-year approach, using fewer numbers of classes per week and focusing on fewer strategies. Thus it

would be possible to determine the impact of explicit strategy instruction on the variables under consideration and design better measures of transfer.

In a very interesting and compelling article based on a staff development, Duffy (1993) demonstrated teachers progress in becoming good strategy teachers. He suggested that the continuum "does not suggest a developmental stage model of teacher development. To the contrary, teachers' progress was recursive, not linear, with progress affected by a complex array .... The points of progress do suggest, however, questions about what is really involved in strategy teaching ..." (p. 113). In the course of the article he suggested nine points (confusion and rejection, teacher controls the strategies, trying out, modeling process into content, the wall, over the hump, I don't quite get it yet, creative-inventive, and unnamed) that teachers move through in becoming strategy teachers. It seems that any one teacher was involved in the staff development program for at least one year and worked not with their entire class but rather with their five lowest achieving students. This article makes it very clear that among many other important factors that time and researcher involvement are crucial.

It seemed that the teachers in the present study were moving in the recursive manner discussed by Duffy (1993) between points one to four, and this may not be unreasonable given the many issues arising out of the study. However, if the ultimate purpose of classroom-based research is to help those students who are neither strategic nor metacognitive, it may be necessary to consider the model reported upon by Duffy (1993). Thus further research would need to be designed for regular classrooms with a teacher commitment for a year and with the researcher becoming an active participant in the ongoing process.

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APPENDIX A

STRATEGY GUIDES FOR TEACHER AND STUDENT USE

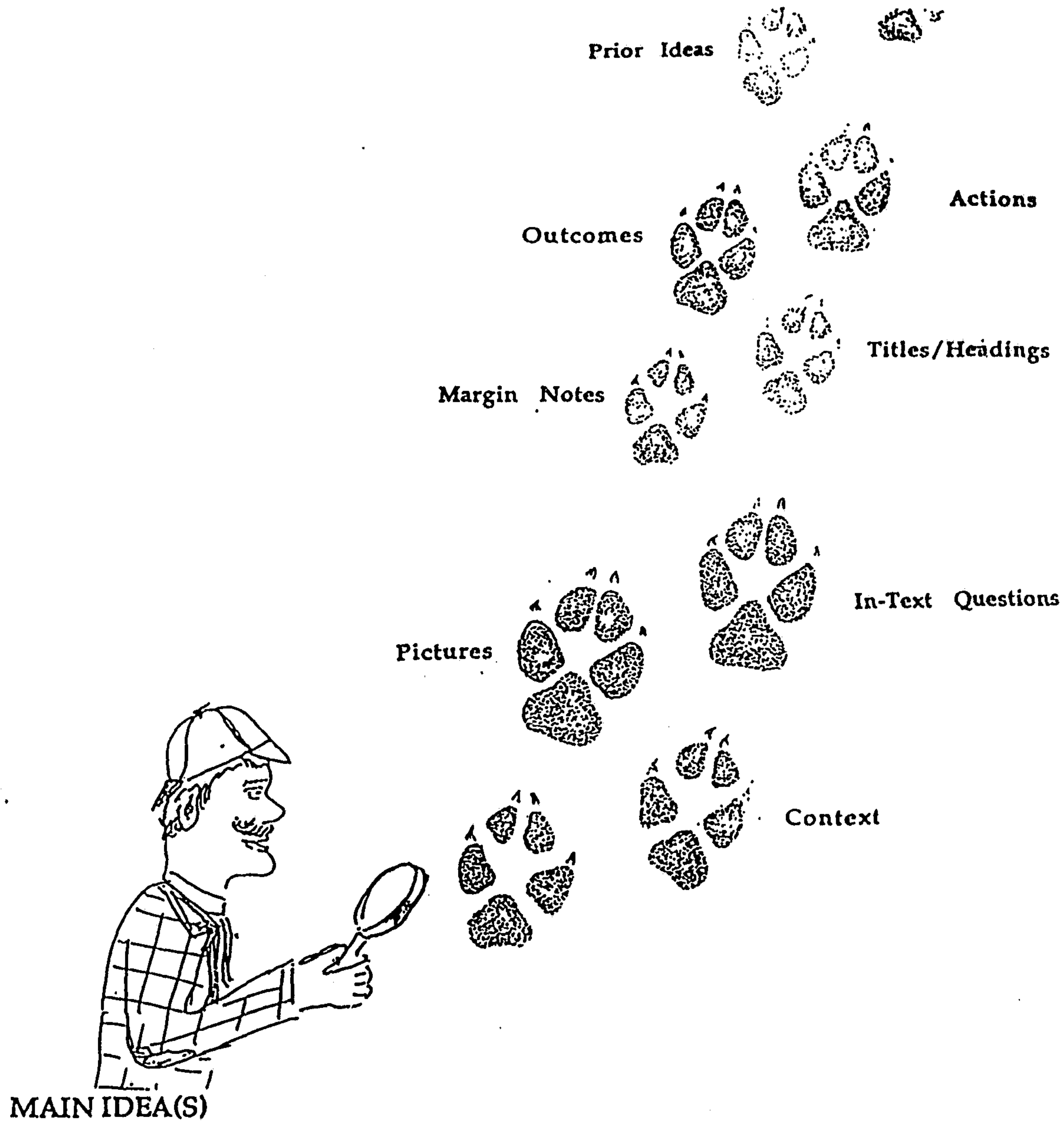
The following pages contain copies of the strategy guides for teacher use in transparency form and for student use in hard copy form. Notes at the bottom of each page indicate the chapter and lesson numbers where the strategy was used.

KWL CHART

KNOW, WANT TO KNOW, AND WHAT WAS LEARNED

What You Know K	What You Want to Know W	What You Learned L

KWL Charts were used at the beginning and ending of each chapter.



MAIN IDEA(S)

____

____

Main idea was used for Chapter 12, lesson one, Chemical Messages and chapter 14, lesson two, Life Cycles of Seed Plants.

TEXT STRUCTURE

COMPARE-CONTRAST

Location and Structure of Glands - Lessons 2 & 3, Chapter 12

GLAND	SIZE	STRUCTURE	
Pituitary			
Thyroid			
Parathyroid			
Adrenal			
Pancreas			
Ovaries & Testes			

The text structure compare-contrast strategy was used for Chapter 12, lesson 2 Location and Structure of Glands and finished in lesson 3 Functions of Glands. It was used the second time with Chapter 13, lesson 1 The Brain.

TEXT STRUCTURE

COMPARE-CONTRAST

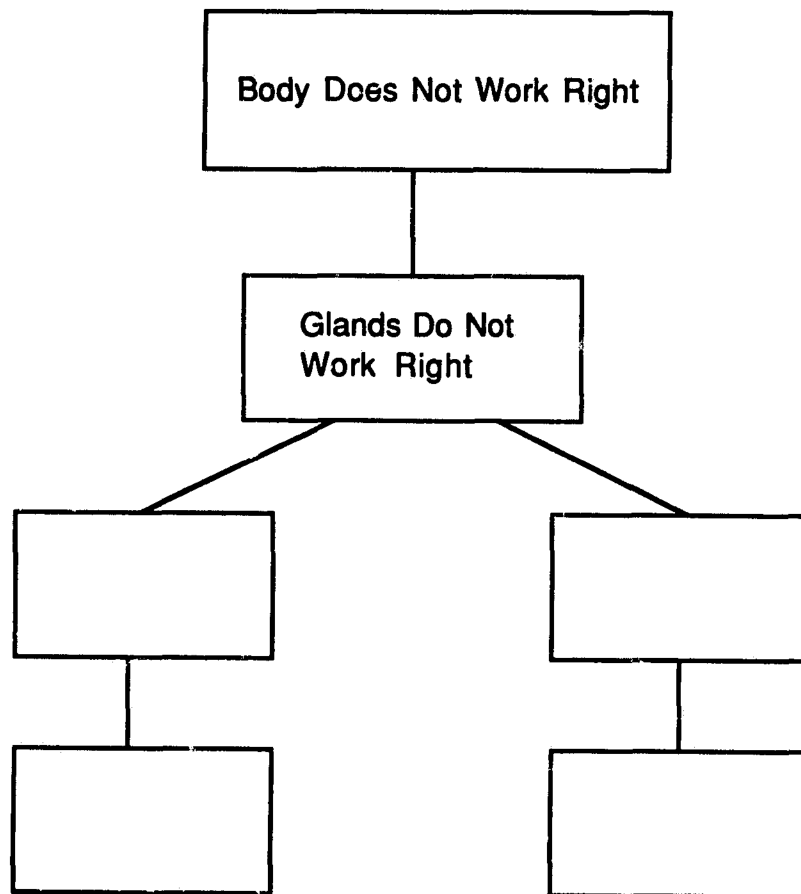
The Brain - Lesson 1 Chapter 13.

Major Parts			
1.			
2.			
3. (i) (ii) (iii)			

TEXT STRUCTURE

CAUSE-EFFECT

When Glands Do Not Work Properly
Lesson 4 Chapter 12

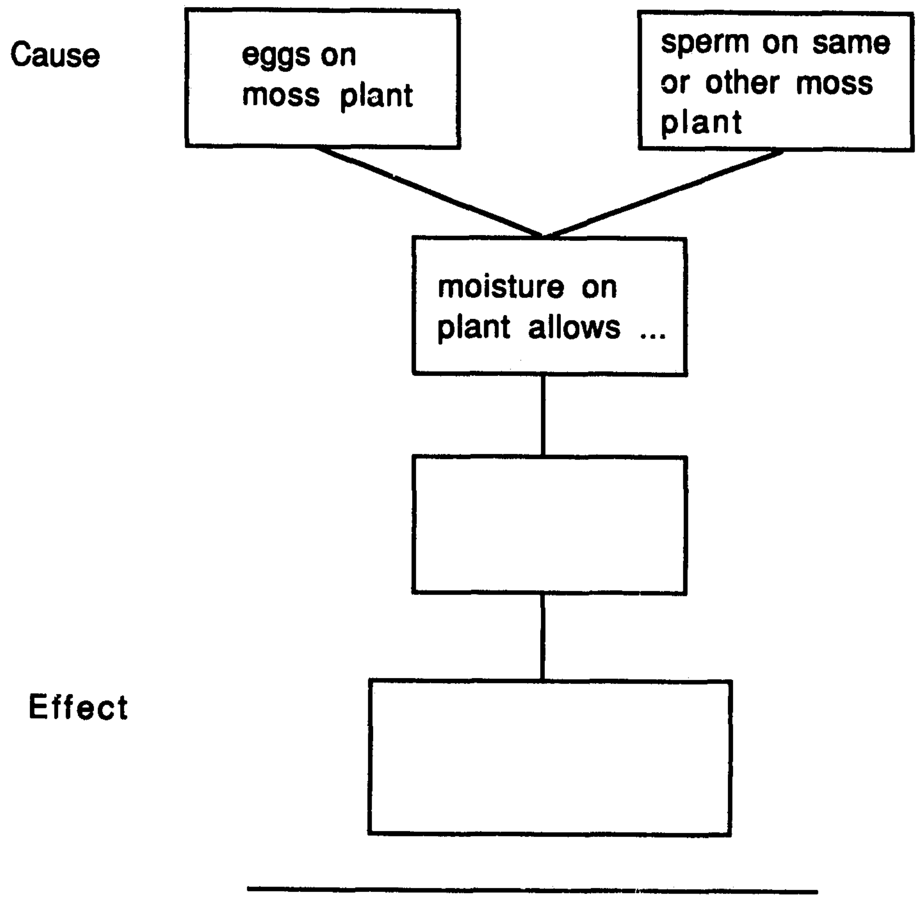


The text structure strategy cause-effect was used for Chapter 12, lesson 4, When Glands Do Not Work Properly. The second use of the strategy was for Chapter 14 lesson 3 Life Cycles of Mosses and Ferns. The teachers developed most of the forms for this use of the strategy.

TEXT STRUCTURE

CAUSE-EFFECT

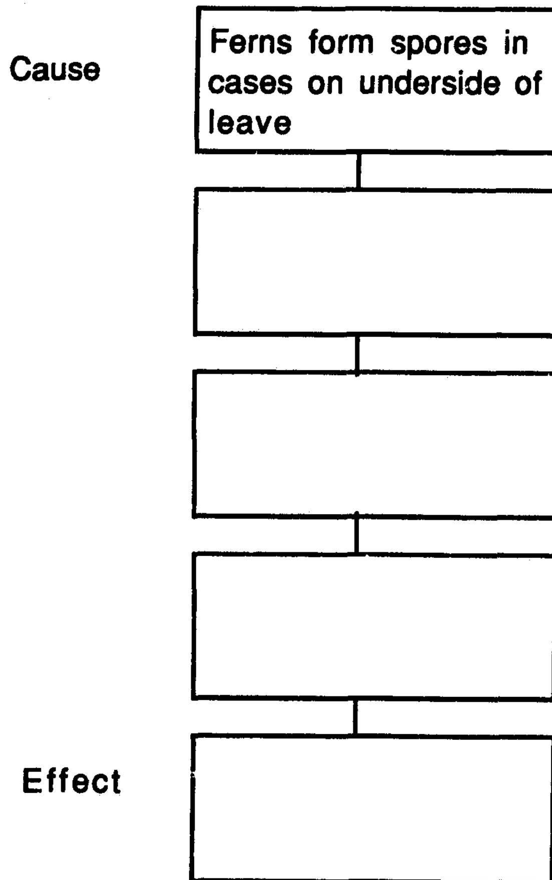
Life Cycles of Mosses and Ferns Lesson 3, Chapter 14



TEXT STRUCTURE

CAUSE-EFFECT

Life Cycles of Mosses and Ferns Lesson 3, Chapter 14



TEXT STRUCTURE

DESCRIPTION

Lessons 2 and 3, Chapter 13.

Step 1. Item to be described

Step 2. Primary features of this item:

(i) ______________________________
____

(ii) ______________________________
____

Step 3. Supporting features for each of the primary features listed above.

(1)	(2)
______________	______________
______________	______________
______________	______________
______________	______________
______________	______________

Step 4. Auxillary features for the supporting features.

____
____
____
____

Step 5. Secondary features of this item.

The text structure strategy description was used for Chapter 13 lesson 2 The Spinal Cord and The Peripheral Nervous System and lesson 3 The Nerve Cell.

APPENDIX B

THE INFORMAL ATTITUDE SURVEY (IAS)

INTRODUCTION

This is a survey to see how you feel about science, science books and school. There are no right or wrong answers. Please follow the directions and put a check mark in the box that best describes how you feel about the sentence.

Please read the following sentences. For each sentence mark the choice which best tells how YOU feel about the sentence.

Name					
	Strongly Disagree	Disagree	Can't decide	Agree	Strongly Agree
1. There are many books about science that I hope to read.					
2. Reading science books is for learning not for enjoyment.					
3. Science textbooks are too long and dull.					
4. I feel that studying science in school is important.					
5. I do not enjoy science.					
6. Books about science make good presents.					
7. I do well in science classes.					
8. I like to study science in school.					
9. Science is a valuable subject.					
10. My school classes are boring and dull.					
11. I would rather do other things than go to school.					
12. Science classes are boring.					
13. Watching TV is better than reading books on science.					
14. I enjoy learning new things.					
15. Science is dull.					
16. I do well in school.					
17. School is a waste of time.					
18. I would like to study more science.					
19. Books about science are boring.					
20. I like school.					
21. Reading books on science is a good way to spend spare time.					
22. Reading books on science is dull.					
	Never	Sometimes	Can't decide	Most times	Always
23. I check my work before I hand it in.					
24. I do my homework.					

APPENDIX C

The following pages contain the profile of a desired image of an efficient, successful reader of science text materials and the 75-item pre- and post-metacognitive test.

A DESIRED IMAGE OF AN EFFICIENT, SUCCESSFUL READER OF SCIENCE TEXT MATERIALS

A desired image of an efficient, successful reader of science text material includes 21 descriptive statements. The corresponding taped interview (TI) protocol numbers and metacognitive test item numbers are also noted. The metacognitive components corresponding to each statement are indicated with the appropriate letter, d=declarative, p=procedural, c=conditional, pl=planning, e=evaluating or monitoring, and r=regulation.

A DESIRED IMAGE OF AN EFFICIENT, SUCCESSFUL READER OF SCIENCE TEXT MATERIALS

Pkm Item Numbers	TI Protocol Number	Strategy Number	The desired image of an efficient, successful reader of science text materials should be a person who is able to:
			Science Reading
28d, 6p, 10c	3	1	Realize that science reading is an interactive/ constructive process by which you construct meaning from personal experience, recorded experiences of other people and the context of the reading.
23d, 61p, 27c	7	2	Develop a sense of the motivation and value for the reading and feel confident that the reading will help them to understand, reinforce, and enrich personal experience, interests, and needs, and to solve problems.
30d, 53p, 40c	6	3	Have the self-confidence in their reading abilities and realize that a comprehension problem may result from poorly written text or abstract ideas, and not just a personal comprehension block.
24d, 55p, 15c	3	4	Enjoy science reading and are likely to read science materials outside the prescribed text, and pursue personal interests in science topics through science reading materials.
12d, 60p, 7c	5	5	Monitor their own successes at understanding the reading information as the reading progresses and detecting discrepancies in light of the established purpose, and consciously adopt or determine strategies to review the text information, which help create a better fit between their schema and the perceived meaning of the text, carry out these strategies, and re-assess the goodness-of-fit for the reviewed textual information and their understandings.

Pkm Item Numbers	TI Protocol Number	Strategy Number	The desired image of an efficient, successful reader of science text materials should be a person who is able to:
19d, 46p, 34c	2	6	Adjust their comprehension monitoring to more conscious levels when demands of the reading increase when difficulties are perceived, and when comprehension is blocked.
			<u>Science Text</u>
11d, 2p, 59c	6	7	realize that words are labels for ideas, ideas are based on experiences, and text is stored descriptions of ideas (experience); that readers must evaluate the textual material; and that readers determine their own purposes for carrying out their reading.
4d, 9p, 44c	1	8	Realize that the text is not an absolute truth and that all science writing is a form of interpretation and, at least to some extent, all science writing may be a distortion or simplification of information and ideas that have been developed or recorded through the processes of science.
43d, 63p, 45c	1	9	Evaluate text passages for plausibility, completeness, and interconnectedness by using their available knowledge to correct mistakes in science text writing or to fill in missing information necessary to make the text plausible.
5d, 54p, 41c, 71pl, 68e, 73r	5	10	Identify a variety of text structures including description, simple listing, chronological ordering, compare-contrast, cause-effect, and problem-solution and select reading strategies appropriate to the text structures they encounter.
			<u>Science Reading Strategy</u>
33d, 16p, 47c	2	11	Select reading strategies appropriate to the needs of the reading process, for example, when the purpose of the reading is to obtain an overview of the text, the student uses skimming, key words, titles and headings, and first sentences in paragraphs to retrieve the main ideas.

Pkm Item Numbers	TI Protocol Number	Strategy Number	The desired image of an efficient, successful reader of science text materials should be a person who is able to:
35d, 32p, 42c	2	12	Assess their own personal skills as learners and choose strategies for reading the text that fit their self-assessment and avoid reading difficult information without access to prior declarative knowledge (critical vocabulary and key background concepts) or prior procedural knowledge (plans to review and re-process difficult ideas or concepts).
25d, 8p, 50c	2	13	Use visual adjuncts in texts, such as graphs, charts, and photographic reproductions to help clarify, organize, reinforce, enrich, or verify the meanings they derive from the text.
29d, 1p, 36c	6	14	Use efficient vocabulary development skills to determine the meaning of words from context; to dissect words into prefixes, suffixes and root-words; to utilize classification, concept maps, metaphors, and analogies to show relationships of key words; and to use mnemonic aids to help remember key words.
57d, 26p, 51c, 69pl, 74e, 67r	4	15	Identify main ideas in a text, delineate supporting ideas, and rephrase ideas to show logical connections and hierarchical relationships explicit or implicit in the text.
56d, 21p, 52c, 72pl, 66e, 75r	1	16	Summarize text passages using the following macrorules: delete redundancies, delete trivia, provide superordinates, or select topic sentences, or invent topic sentences when missing.
49d, 38p, 20c, 70pl, 64e, 65r	3	17	Ask themselves questions about the readings that require comprehension and reflect the purpose(s) for reading the textual material.

Pkm Item Numbers	TI Protocol Number	Strategy Number	The desired image of an efficient, successful reader of science text materials should be a person who is able to:
62d, 3p, 39c	7	18	Use inferential and applied comprehension skills to critically synthesize, analyze, evaluate, and apply information regarding fact and opinion, bias, generalizations, causal relationships, and distinctions.
13d, 18p, 58c	5	19	Utilize efficient search-ahead procedures that allow them to construct meaning from related or linked information in other parts of the sentence or paragraph.
48d, 17p, 22c	7	20	Choose appropriate study skills when there is a need to remember detailed information from text, such as summarizing, outlining, peer testing, and reciprocal teaching.
37d, 31p, 14c	4	21	Create organized mental images of information in order to help fit the information into existing schema and to help encode the information into long term memory.

WRITTEN TEST OF METACOGNITION

The 75-item pre- and post- metacognitive test included 63 items for metacognitive awareness and 12 items for metacognitive self-management. The scores assigned (0,1,2) to each multiple choice item are included. The corresponding taped interview (TI) protocol number and the strategy number corresponding to each item are also noted. The metacognitive component probed by each item is indicated with the appropriate letter, d = declarative, p = procedural, c = conditional, pl = planning, e = evaluating or monitoring, and r = regulation.

WRITTEN TEST OF METACOGNITION

INTRODUCTION

This test is to help me to understand what you know about science textbooks and science reading. You will not be graded on this test, but you are taking part in a scientific study so do your best! Read the directions before you start the questions.

Science Textbooks and Science Reading

Read each question carefully and select the answer (circle letter) that best answers the question or write your own answer to the question in the space provided.

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
6	14	p		1. When you come to a word and you don't know what it means you should:
			0	a) ignore the word and read on
			2	b) use the words around it to figure it out
			1	c) ask someone else
				d) ____________________________
6	7	p		2. When you read the words in your science text you should:
			2	a) try to link the words in the text to experience you have had with that idea
			0	b) read slowly and repeat long and difficult words to yourself
			1	c) think about what you are reading
				d) ____________________________
7	18	p		3. When you read critically you should:
			2	a) judge if information is fact or opinion
			1	b) think about what you are reading
			0	c) read slowly to improve understanding
				d) ________________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
1	8	d		**4.** Text in science books is:
			1	a) sometimes hard to believe
			2	b) someone's view of what is true
			0	c) always true because it is about science
				d) ______________________________
5	10	d		**5.** Sentences in paragraphs are:
			0	a) all arranged the same way
			1	b) arranged from most to least important
			2	c) show description, compare/contrast, problem/solution and cause/effect
				d) ______________________________
3	1	p		**6.** To learn from science text you should:
			0	a) mentally say every word to yourself
			2	b) discuss topic with others and do experiments
			1	c) write down definition of new vocabulary
				d) ______________________________
5	5	c		**7.** Good readers stop and ask themselves questions as they read because:
			1	a) they want to have good questions to ask the teacher
			2	b) they want to see if they are on track and understand what they are reading
			0	c) they have the time to do it
				d) ______________________________
2	13	p		**8.** To use the pictures, graphs and diagrams on a page you should:
			1	a) look at them after you read
			0	b) look at them when your teacher tells you
			2	c) look at them before you read and as you read
				d) ______________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
1	8	p		**9.** When you read science text you should:
			0	a) accept as true everything you read
			1	b) accept the text as true if it matches your beliefs
			2	c) remember that the text is someone's view of what is true
				d) ________________________________
3	1	c		**10.** If your science text is difficult to understand you should prepare for reading assignments by:
			0	a) resting your eyes to avoid strain
			2	b) refreshing your memory, doing experiments and discussing the topic with others
			1	c) looking up the definition of all new vocabulary in the assigned pages
				d) ________________________________
6	7	d		**11.** The words in your science text are:
			0	a) for you to pay attention to
			2	b) ideas and experiences about a topic
			1	c) what the author believes to be true
				d) ________________________________
5	5	d		**12.** Good readers check their understanding while reading in order to:
			2	a) detect reading problems, improve understanding and get a better overview
			0	b) be a better test taker and get better grades
			1	c) make sure they can read the new vocabulary
				d) ________________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
5	19	d		**13.** Looking back and looking forward in science text while you are reading is:
			2	a) helpful in making sense of text
			1	b) something good readers do
			0	c) cheating
				d) ______________________________
4	21	c		**14.** You make organized mental pictures of what you have read because:
			0	a) you won't need to write it down
			1	b) it makes it more interesting
			2	c) it helps you to remember it and combine new information and old information
				d) ______________________________
3	4	c		**15.** Students who are interested in a science topic read additional information material because:
			2	a) they want to find out more information
			1	b) they like reading about science
			0	c) they have nothing better to do
				d) ______________________________
2	11	p		**16.** In order to decide which approach to use while you are reading, you should:
			0	a) keep reading until your teacher gives you another approach
			1	b) think about what you are reading
			2	c) think about why you are reading
				d) ______________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
7	20	p		**17.** When you read to remember you should:
			0	a) say all the words over and over
			2	b) outline what you are reading
			1	c) concentrate and try hard to remember
				d) ______________________________
5	19	p		**18.** If you don't know what a whole sentence means you should:
			0	a) sound out the words
			2	b) think about the other sentences in the paragraph
			1	c) read it again
				d) ______________________________
2	6	d		**19.** When reading becomes more difficult it is:
			2	a) harder to understand
			0	b) time to stop reading
			1	c) less interesting
				d) ______________________________
3	17	c		**20.** If you are reading science text you ask yourself questions because:
			2	a) you can remind yourself of the purpose for reading and check how well you understand
			1	b) you can see if you know the new vocabulary
			0	c) it is a good thing to practice for class discussions
				d) ______________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
1	16	p		**21.** To identify the important information that you need in order to write a summary you should:
			2	a) ask yourself who, what, why, when, where, how
			0	b) read all the information over and over
			1	c) copy the first sentence of each paragraph
				d) ______________________________
7	20	c		**22.** You outline what you are reading because:
			1	a) it will be quicker to read than the whole thing
			0	b) it is a good thing to do
			2	c) it helps you to remember
				d) ______________________________
7	2	d		**23.** The main goal of reading science text is:
			2	a) to understand what it's about
			1	b) to answer the questions at the end of the chapter
			0	c) to sound out all the words
				d) ______________________________
3	4	d		**24.** Students who are interested in science topics:
			0	a) read their science text over and over
			1	b) read their science text carefully
			2	c) read additional materials about the topics they are interested in
				d) ______________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
2	13	d		**25.** Things on a page of your science text that are there to help you understand are:
			2	a) pictures and diagrams
			0	b) long words and numbers
			1	c) titles and headings
				d) ______________________________
4	15	p		**26.** If you want to figure out what the main idea is you should:
			0	a) read carefully
			1	b) read the first and last sentence in the paragraph
			2	c) combine clues such as titles, headings, and pictures
				d) ______________________________
7	2	c		**27.** You should stop and think about why you are reading:
			1	a) at the end of your reading
			0	b) when your teacher tells you to
			2	c) before, during, and after the reading
				d) ______________________________
3	1	d		**28.** Understanding a science concept like "vector" is:
			0	a) based on whether you know how to say the word
			1	b) based on reading your science text
			2	c) based on your experience and the ideas of other people
				d) ______________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
6	14	d		**29.** Sounding out, using context, and looking for root words are:
			0	a) what you do if you have time
			2	b) what you do to figure out words
			1	c) what you do as you read
				d) ________________________________
6	3	d		**30.** If you don't understand what you have read, it may be because:
			0	a) the teacher didn't tell you the right pages
			2	b) sometimes science text is not well written
			1	c) the illustrations, diagrams, and charts are not very clear
				d) ________________________________
4	21	p		**31.** To help you remember information you should:
			0	a) say it over and over
			2	b) make an organized mental picture of it
			1	c) copy down all the information
				d) ________________________________
2	12	p		**32.** When you identify a reading difficulty you should:
			0	a) avoid the difficulty and keep on reading
			2	b) try to identify the cause of the difficulty and plan a way of overcoming the difficulty
			1	c) ask the teacher for help in overcoming the difficulty
				d) ________________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
2	11	d		**33.** Knowing why you are reading helps you to:
			0	a) decide if you have enough time to read
			2	b) select the most appropriate reading approach to use as you read
			1	c) make the reading more enjoyable, useful and valuable
				d) ________________________________
2	6	c		**34.** You should check more often to make sure you understand when:
			1	a) you are tired
			0	b) the teacher tells you to
			2	c) the reading becomes more difficult or when you are reading new information
				d) ________________________________
2	12	d		**35.** Topics in science are easier to understand if:
			2	a) you know something about the topic
			0	b) you have a comfortable place to sit
			1	c) you can read all the words
				d) ________________________________
6	14	c		**36.** You use the meaning of other words and the general meaning of the text when:
			1	a) you want to sound out a word
			2	b) you come to a word and don't know what it means
			0	c) you want to skip the word
				d) ________________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
4	21	d		**37.** Making organized mental pictures of information is:
			0	a) a way to make reading interesting
			2	b) a way to remember information and fit new ideas into what you already know
			1	c) a good thing to do to remember new words
				d) ______________________________
3	17	p		**38.** To see if you know why you are reading and if you understand what you are reading you should:
			1	a) see if you know the new vocabulary
			2	b) ask yourself questions about what you have read
			0	c) keep reading to see how long it takes to read the assignment
				d) ______________________________
7	18	c		**39.** It is important to judge if the information is fact or opinion because:
			2	a) it will help you decide the amount of scientific trust you can give the text
			1	b) you should know the difference
			0	c) you will read more slowly
				d) ______________________________
6	3	c		**40.** When you don't understand you decide if the reason is you or the text because:
			2	a) if it is the text you should ask for help
			1	b) if it is the text you should put it away
			0	c) if it is the text you should read it again
				d) ______________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
5	10	c		**41.** Good readers make notes for paragraphs differently because:
			1	a) not all paragraphs are the same length
			0	b) some paragraphs are more interesting
			2	c) the sentences in paragraphs are arranged in different ways
				d) ________________________________
2	12	c		**42.** You use your knowledge about a topic and knowledge about reading strategies because:
			2	a) it will help you overcome reading difficulties
			1	b) it makes the reading more interesting
			0	c) you have the time to do it
				d) ________________________________
1	9	d		**43.** The information that you need to make sense of science text is:
			0	a) in the teacher's head
			1	b) in the science text
			2	c) in the text and in your head
				d) ________________________________
1	8	c		**44.** You should realize text in science books is someone's view of what is true because:
			0	a) it makes reading easier
			1	b) otherwise you may think the text represents absolute truth
			2	c) it may not be what you think is true
				d) ________________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
1	9	c		45. You use the information in your head when you read science text because:
			0	a) it is such an easy thing to do
			1	b) it helps you figure out new words
			2	c) it helps to make sense of science text
				d) ______________________________
2	6	p		46. When the reading becomes more difficult you should:
			1	a) read more slowly
			2	b) check more often to make sure you understand
			0	c) put the reading away
				d) ______________________________
2	11	c		47. You choose an approach to use for your reading because:
			0	a) it makes the reading more interesting
			1	b) it is the approach that you find easiest
			2	c) it will help you accomplish your purpose for reading
				d) ______________________________
7	20	d		48. Is there a difference between reading and reading to remember?
			0	a) reading and reading to remember are both the same
			2	b) reading to remember is harder because you have to make connections to other things
			1	c) just reading is harder because you have to sound out all the words
				d) ______________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
3	17	d		**49.** Asking yourself questions about your reading is:
			2	a) a way to check on why you are reading
			0	b) like being a teacher
			1	c) a good thing to do to see if you know the words
				d) ________________________________
2	13	c		**50.** You refer to the pictures, diagrams and definitions on a page in your science text because:
			0	a) you have enough time
			2	b) they help you to set purpose, remember and understand
			1	c) they are interesting and they are easier than the words
				d) ________________________________
4	15	c		**51.** You combine clues such as titles, headings and pictures to:
			1	a) help you figure out new words
			2	b) help you figure out the main ideas
			0	c) make the reading more interesting
				d) ________________________________
1	16	c		**52.** You should tell the important information in your own words because:
			1	a) it helps you tell others about the reading
			2	b) it shows if you understand
			0	c) it makes the paragraph shorter
				d) ________________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
6	3	p		53. If you don't understand your text you should:
			2	a) decide if the reason is you or the text
			0	b) put the text away
			1	c) assume that you need to try a different approach
				d) ________________________________
5	10	p		54. Sentences in a paragraph are put together in different ways. Some are used to describe, some are in chronological order, and some compare and contrast ideas. When you read you should:
			2	a) make notes differently for each type of arrangement
			1	b) identify how the paragraph is put together
			0	c) treat each arrangement the same way
				d) ________________________________
3	4	p		55. To find out more about science topics you should:
			2	a) read your science text and other science books
			1	b) read your science text very carefully
			0	c) read your science text over and over
				d) ________________________________
1	16	d		56. Summarizing is:
			0	a) telling the first sentence in each paragraph
			1	b) telling all the information in your own words
			2	c) telling the important information in your own words
				d) ________________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
4	15	d		57. Figuring out the main ideas is:
			1	a) a way to concentrate
			0	b) difficult
			2	c) a way to see if you understand
				d) ______________________________
5	19	c		58. Looking ahead and back in your science text is a good idea because:
			0	a) you can get finished your reading faster
			1	b) you can see if you know the new words that are important
			2	c) you can get an overview of the text, recall earlier ideas and link ideas together
				d) ______________________________
6	7	c		59. You should think about the words you are reading because:
			2	a) they are ideas about a science topic
			1	b) they may be new vocabulary words
			0	c) they are for you to pay attention to
				d) ______________________________
5	5	p		60. While reading you should check to see if you understand and are on track by:
			0	a) seeing if the text is interesting
			2	b) stopping and asking yourself questions
			1	c) checking with other readers
				d) ______________________________
7	2	p		61. Before you start to read you should:
			0	a) choose a comfortable place to read
			2	b) stop and think about why you are reading
			1	c) look at the title of the book
				d) ______________________________

TI Protocol Number	Strategy Number	Metacognitive Component	Score	
7	18	d		62. Reading critically is:
			2	a) recognizing when the text is fact and when it is opinion
			1	b) knowing the difference between fact and opinion
			0	c) knowing the difference between text and illustrations
				d) ______________________________
1	9	p		63. When you try to make sense of science text you should:
			0	a) listen to what the teacher says
			1	b) use the information in your text
			2	c) use information in your text and in your head
				d) ______________________________
3	17	e		64. Your science group was given some questions to answer by reading your science textbooks. You selected one question to answer for your group, how would you check to see that you are doing a good job at answering your question?
			0	a) check with other members of my group to see who was done first
			2	b) make a deal with people from other groups doing the same question to check on one another's answers
			1	c) do my best and use all the time provided to answer the question
				d) ______________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
3	17	r		65. After checking your K-W-L chart, you find the L-column does not relate to any of the ideas in the W-column - What do you do next?
			1	a) re-read the science textbook focusing on the questions from the W-column
			0	b) forget it, the L-column and the W-column are not related
			2	c) find another information source to use to answer the W-column questions
				d) ______________________________
1	16	e		66. How can you check to see if you have written a good summary of a science passage?
			1	a) have a good science student read the summary to see if he/she agrees
			0	b) check to see if all words are spelled correctly and the punctuation is correct
			2	c) check to see that the most important ideas are included, that a small amount of detail is given for different ideas and that I did not repeat myself
				d) ______________________________
4	15	r		67. You have re-read the same science passage three times and still cannot find the main ideas; what do you do next?
			0	a) re-read the science passage one more time slowly
			2	b) find another book about the same topic and read it or do an experiment about the idea to collect more information
			1	c) check the pictures, margin notes, index and glossary to get more clues
				d) ______________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
5	10	e		68. You are reading a cause-effect science passage and you read "if this happens", what do you do?
			0	a) do nothing or look back to see if something is missed
			2	b) look ahead to find "then this happens" and try to understand the relationship between the two ideas
			1	c) read slower to see what happens next
				d) ________________________________
4	15	pl		69. If you were asked to give a 2 minute speech about a new chapter in your science textbook, what would your plan be for reading the chapter?
			0	a) read all of the chapter quickly to be able to tell everything
			1	b) read the chapter to find out the interesting things
			2	c) read the chapter to find important ideas and useful details
				d) ________________________________
3	17	pl		70. How would you plan to use a K-W-L chart of a science topic when you read your science textbook?
			2	a) use the ideas in the first two columns to help set up reasons for reading and to help make sense of the text
			0	b) do not use the K-W-L chart. It is used only in reading class
			1	c) fill in the missing information in the chart as it is found in the text
				d) ________________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
5	10	pl		71. You are going to read a long passage in your science textbook. This passage is going to tell how some things are alike and how they are different. How would you plan to read the passage?
			0	a) read it the same as all other passages in the book
			2	b) take notes on a chart while reading it to identify the way the things are alike and how they are different
			1	c) read it slowly to detect the main ideas
				d) ________________________________
1	16	pl		72. If you had to write a brief paragraph about a chapter in your science textbook, what plans would you make after you found the main idea and useful details?
			2	a) summarize the main ideas and details into a paragraph that tells the most important things
			0	b) check with the teacher to see how long or how many words the paragraph had to be
			1	c) copy the sentences in which the main ideas are found into a paragraph
				d) ________________________________
5	10	r		73. You have read a science passage and completed the alike-different chart, but most of the chart is empty. What do you do next?
			1	a) re-read passage to find the missing information
			0	b) stop and hand the chart in to your teacher, likely other students are having trouble too
			2	c) check the science passage to see if the text is a compare/contrast structure
				d) ________________________________

TI Protocol Number	Strategy Number	Metacogntive Component	Score	
4	15	e		74. How can you tell if you are getting the most important ideas when you read a science textbook?
			1	a) check with friends to see what they think
			2	b) ask myself questions, try to answer questions in the book or check clues given in the book
			0	c) wait to see what my score is on the chapter test
				d) ______________________________
1	16	r		75. You are writing a summary of a science passage and you decide it's too long, repeats itself and contains too much detail. What do you do next?
			1	a) leave it for the teacher to correct and then use his/her suggestions to make changes
			0	b) leave out the last two sentences
			2	c) go over my paragraph and highlight the most important points, leave out unimportant ideas, and rewrite it using what remains
				d) ______________________________

APPENDIX D

INDIVIDUAL TAPED STUDENT INTERVIEW QUESTIONS

The following pages contain the seven protocol question sets that were used for the pretest and posttest individual taped student interviews. Pretest and posttest task introduction and directions are also included. The taped interview questions are cross referenced with the metacognitive test such that the metacognitive component probed by the item is indicated with the appropriate letter, d = declarative, p = procedural, c = conditional, pl = planning, e = evaluating or monitoring, r = regulation, ap = application and a dash - means that the item was not included on the metacognitive test. The taped interview questions are also cross referenced with the appropriate strategy number for the Desired Image of an Efficient, Successful Reader of Science Materials.

Pretest taped interview introduction and directions to the student:

Hello_______

My name is ___________

Today I would like to talk to you about science textbooks, science reading and learning. I will ask you some questions and I'd like you to answer them as best you can. There are no right or wrong answers. I will not ask you any questions about what you are learning in your science books. If the question is not clear, please feel free to ask me to explain it further for you. We will refer to this book (refer to text) if we need to. It will take about 15 minutes. I will be taping our conversation so please speak loudly and clearly. Any questions?

Posttest taped interview and directions to the student:

Hello. Today I would like to talk to you again about science textbooks, science reading and learning. I will ask you some questions as we did before and I'd like you to answer them as best you can.

Protocol 1 (Strategies 9, 16, 16 self-management, 8)

PKm Item Number	Strategy Number	Questions Asked
43d	9	From what sources (places) do you get information when you are reading science textbooks?
63p	9	Do you use information in your head (information that you know about science) when you read your science textbook? How do you use information in your head?
45c	9	Why do you use information in your head when you read your science textbook. What if your knowledge and the textbook knowledge do not match?
56d	16	Sometimes the teacher will ask you to summarize what you have read. What does it mean to summarize?
21p	16	How do you summarize?
52c	16	Should you summarize what you have read? Why? When?
-pl	16	If you were asked to summarize this passage (p. 210-211), how would you plan (intend) to do it?
-e	16	Would you check to find out if you were summarizing correctly? How would you check to find out if you were summarizing the important points?
-r	16	If you found out you were not getting the summary correct, what would you do?
44c	8	If your science experiment result did not agree with the science textbook, what would you do and why?

Protocol 1 (cont'd.)

PKm Item Number	Strategy Number	Questions Asked
4d	8	Should you believe everything you read in your science textbook? Why? Why not?
9p	8	How is knowing that text in science books (what is written in science textbooks) is someone's view (ideas) of what is true influence (affect) how you read your science textbook?

Protocol 2 (Strategies 6, 12, 13, 11, 11 self management, and 11 application, which was on a posttest interview only)

PKm Item Number	Strategy Number	Questions Asked
46p	6	What can you do when the reading becomes more difficult?
19d	6	Should you check to see if you understand what you are reading? Are there any times when you should check more often than you usually do? When? Why?
34c	6	Are there times when it becomes difficult to understand what you're reading? What makes you realize it is becoming more difficult?
35d	12	What topic in science would you find easiest to understand? Why?
32p	12	If you are reading about a science topic and you realize you don't understand it, what should you do?
42c	12	Some students like to have group discussions before they start reading about a new topic. Why?
25d	13	Are there things on the page of your science textbook that may be useful to you as you are reading? What are they?
8p	13	How and when do you use them?
50c	13	The authors of textbooks put pictures, diagrams and definitions in your science books. Why are they there?

Protocol 2 (cont'd.)

PKm Item Number	Strategy Number	Questions Asked
33d	11	Is knowing why (the reason) you are reading important? How does knowing why you are reading help you?
16p	11	Are there things you can do if you are reading and you don't understand what a sentence is about? What are they?
47c	11	How would you decide which things to do? When would you (check other sentences around the difficult sentence)?
-pl	11	If you were asked to read this passage (p. 210-211) to get an overview (general idea), how would you (go about) plan (intend) to do it?
-e	11	Would you check to find out if you were getting the overview correct? How would you check to find out if you were getting the overview correct?
-r	11	If you found you were not getting the overview correct, what would you do? This application question was asked only on the posttest interview. Main Idea Chapter 16 open to pages 322-324
-ap	11	I'd like you to find the main idea in these three pages and tell me what it is. How did you get that? What did you do to come up with that? Did you change your mind as you went?

Protocol 3 (Strategies 17, 17 self-management, 4, 1, and 17 application, which was posttest interview only)

PKm Item Number	Strategy Number	Questions Asked
38p	17	What should students be thinking about when they are reading? What could someone do to help them think about what they are reading?
49d	17	What does it mean to self question? What is someone trying to do when they self question?
20c	17	Should students self question as part of reading science textbooks? When? (Why would you want to check your understanding?)
70pl	17	If you were asked to use self questions to help you understand this passage (p. 210-211), how would you plan to do it (what would be your plan)?
64e	17	Would you check to find out if the self questions were helping you understand? How would you check to find out if you were understanding better (using the self questions)?
65r	17	If you found out that the self questions were not helping you to understand better, what would you do?
42d	4	What might students who are particularly (very) interested in a topic in their science textbook do?
55p	4	Are there things you could do if you wanted to find out more information about a topic in your science textbook? What are they?

Protocol 3 (cont'd.)

PKm Item Number	Strategy Number	Questions Asked
15c	4	Students who are interested in a science topic read additional information about that topic. Why? When do you check out library books on a science topic? Any time other than for assignments?
28d	1	What is involved (goes on) in making sense of a topic in your science textbook?
6p	1	How could you help other students in your group understand a topic in your science textbook?
10c	1	If you thought a topic in your science textbook was going to be difficult to understand, what could you do before you started reading to help you understand?
		This application question was asked only on the posttest interview.
		KWL Ch 16, Chapter Opening, p. 318, have p. 319 covered
-ap	17	We're going to start a new chapter and we are going to do a KWL.
		What does K stand for? What would you put in the K category?
		What does the W stand for? What would you put in the W category?
		What would you use the L column for?

Protocol 4 (Strategies 15, 15 self management, 21, 21 self-management and 15 and 21 application, which were post interview only)

PKm Item Number	Strategy Number	Questions Asked
57d	15	When you are reading do you try to figure out the main idea of what you're reading? How does figuring out the main idea help you in reading (science)?
26p	15	How do you find the main idea? What hints do you use?
51c	15	Why do textbook pages have titles, headings and illustrations? When do you use them?
69pl	15	If you were asked to read this passage (p. 210-211) and pick out the main ideas, how would you plan to do it?
74e	15	Would you check to find out if you were correctly picking out the main ideas? How would you check?
67r	15	If you found you were not getting the main idea correct, what would you do?
31p	21	What is something you can do to remember information?
37d	21	Some readers make mental pictures of what they are reading. How is this useful?
14c	21	Would you suggest to someone to make mental pictures of what they are reading? What reason would you give them for doing that? If they asked when they should do it, what would you tell them?

Protocol 4 (cont'd.)

PKm Item Number	Strategy Number	Questions Asked
-pl	21	If you were asked to make mental pictures of what you were reading to help you understand better, how would you plan to do it?
-e	21	Would you check to find out if you were understanding better? How would you check (to find out if the mental pictures were helping)?
-r	21	If you found that mental pictures were not helping, what would you do?
		These application questions were asked only on the posttest interview.
		Main Idea Chapter 16 p. 322-324
-ap	15	I'd like you to find the main idea in these three pages and tell me what it is. How did you get that? What did you do to come up with that? Did you change your mind as you went?
		KWL Chapter 16 opening p. 318, have 319 covered
-ap	21	We're starting a new chapter and we are going to do a KWL. What does K stand for? What would you put in the K category?

Protocol 4 (cont'd.)

PKm Item Number	Strategy Number	Questions Asked
		What does W stand for?
		What would you put in the W category?
		What do you use the L column for?

Protocol 5 (Strategies 19, 5, 10, 10 self-management and 10 application, which was posttest interview only)

PKm Item Number	Strategy Number	Questions Asked
18p	19	If you are reading a science textbook and you don't know what a sentence means, what could you do?
13d	19	Sometimes readers look back or ahead when they read science textbooks. How is that helpful? Is that cheating?
58c	19	When should you look back and ahead in your science textbook? Why?
12d	5	Readers often check to see if they understand what they are reading. Would that be a useful thing to do? Why?
60p	5	What could you do to check and see if you understand what you are reading? How could the questions at the end of the chapter/passage be used?
7c	5	Is it important to see if what you're reading makes sense? When should you do this?
5d	10	Are sentences in paragraphs in science textbooks arranged in any special order? How?
41c	10	Should you make notes the same way for all paragraphs? Why? Why not? When you come to a paragraph that describes a problem and solution (cause and effect), what do you do?
54p	10	Sentences in paragraphs are put together in different ways. Some are used to describe, some are put in chronological order, and some compare and contrast ideas. What should you do as you make notes for different types of paragraphs?

Protocol 5 (cont'd.)

PKm Item Number	Strategy Number	Questions Asked
71 pl	10	If you were asked to use (put together) the organization/ structure of a paragraph (e.g. cause and effect) to help you understand, how would you plan to do it?
68e	10	Would you check to find out if you understood better? How would you check to find out if you were using the structure to help you understand?
73r	10	If you found out that the structure/organization of the paragraph was not helping you to understand better, what would you do?
		This application question was asked only on the posttest interview.
		Text structure (cause and effect) Chapter 16, p. 322-324
-ap	10	Scan these pages. Based upon what you've done so far with this book, how do you think these paragraphs are organized?
		How are these sets of paragraphs organized?
		I think this is organized around cause and effect. How would you use that statement to make sense of these pages?
		What is the cause?
		What is the effect?

Protocol 6 (Strategies 14, 3, 3 self-management, 7, and 3 application, which was posttest interview only)

PKm Item Number	Strategy Number	Questions Asked
1p	14	What do you do when you come to a big word in your science textbook that you don't know?
29d	14	What is someone doing when you see him/her sounding out words, using context and looking for root words (e.g. plate in platelets)?
36c	14	Sometimes the teacher tells the students to use context, break up words, and look for root words. Why does the teacher do that?
30d	3	Are there times when you don't understand what you read in your science textbook? What would you say are the reasons you don't understand?
53p	3	What should you do if you don't understand? What if you think it's the textbook? What if you think it's you?
40c	3	If you don't understand what you're reading, it could be because the textbook is poorly written or it could be you. Is it important to know if the reason you don't understand is you or the text? Why? Why not?
-pl	3	If you were having problems understanding what you were reading, how would you plan to find out if the problems were caused by you or caused by the textbook?

Protocol 6 (cont'd.)

PKm Item Number	Strategy Number	Questions Asked
-e	3	Would you check to find out if you had (figured out) correctly identified the cause of the problems? How would you check to find out if you had correctly identified the cause of the problems?
-r	3	What would you do if you found out that the problems had to do with the textbook? What would you do if you found out that the problem had to do with you?
11d	7	Are words in a science text just words? What is important about them? How are labels in your clothing or record like science words?
2p	7	When you come to a new science word, what do you do to make sense of the word?
59c	7	Would repeating the word out loud several times help you understand a new science word? Why? Why not?
		This application question was asked only on the posttest interview.
		Text Structure (compare and contrast) Ch.15 P. 301-302
-ap	3	Scan/Skim these pages. Based upon what you've done so far with this textbook, how do you think these paragraphs are organized?
		How are these sets of paragraphs organized?
		I think this is organized around compare and contrast. How would you use that statement to make sense of these pages?

Protocol 7 (Strategies 18, 18 self-management, 2, 20))

PKm Item Number	Strategy Number	Questions Asked
62d	18	Sometimes students are asked to read critically. What does it mean to read critically?
3p	18	How do you read critically?
39c	18	Is it important to read critically? Why? Why not? If you come to the statement "In my opinion...", what would you think or do?
-pl	18	If you were asked to read a passage that had some words or sentences missing, how would you plan to read it?
-e	18	Would you check to find out if you were filling in the blanks correctly and making some sense out of it? How would you check?
-r	18	If you found that you were not filling in the blanks correctly, what would you do?
23d	2	What is the main goal of reading?
61p	2	If understanding is the main goal of reading, is there something you should do before you start reading? What is it?
27c	2	Should you stop and think about why you are reading?
48d	20	Is there a difference between reading and reading to remember? What is the difference?
17p	20	If you were reading a science textbook, what could you do to remember detailed (e.g. p. 210) information?

Protocol 7 (cont'd.)

PKm Item Number	Strategy Number	Questions Asked
22c	20	Sometimes readers outline what they are reading. Is that a useful thing to do? Why? When should you do it?

APPENDIX E

THE PRE- AND POST-CONCEPTUAL TESTS

The post-conceptual test differed from the pre-conceptual test only in that it contained two transfer short-answer questions (items 20 and 21). These two items were drawn from material that was not covered in the study but was part of the science textbook used in the study.

INTRODUCTION

Pre-conceptual test directions:

This is a test to find out what you know about the science material that you will be studying over the next weeks. It is a pretest and I would like to find out how much you know before you start to study. Do not expect to know a lot of the answers. Please do the best you can.

Post-conceptual test directions:

This is a test to find out what you have learned in your science classes over the last several weeks. Please do the best you can. It will probably take 30-45 minutes to finish. Do not rush. Work at a pace that suits you. You will be given enough time to finish the test.

Name ______________________________ Grade ______________

Science Test on Endocrine System, Nervous System and New Generations

Complete each statement below by underlining the correct term in the brackets.
(1 point each)

1. The pancreas produces insulin and (adrenaline, epinephrine, glucagon, thyroxin) to maintain the balance of blood sugar.

2. The (adrenal gland, thyroid gland, pancreas, parathyroid gland) produces hormones which help the body deal with emergencies.

3. A(n) (sensory nerve, motor nerve, interneuron, transmitter nerve) carries messages from the brain to the muscles.

4. The brain is made up of neurons and (electron, protective, association, glial) cells.

5. (Sexual, Asexual, Genetic, Chromosomal) reproduction involves sex cells from two parents.

6. (Annuals, Conifers, Hybrids, Perennials) are plants that develop seeds in cones.

Complete each statement below with the correct term from the list. Not all words will be used.
(1 point each)

axon	pituitary	genes	homeostasis	parathyroid
DNA	internal	synapse	embryo	external
egg	neuron	sexual	cerebellum	germinate

7. The endrocrine glands help maintain a state of balance called ________________ .

8. The ________________ glands control the body's use of calcium.

9. A gap between nerve cells is called a(n) ________________ .

10. Another name for a nerve cell is ________________ .

11. The earliest state in the growth of an organism that is a result of sexual reproduction is called a(n) ________________ .

12. When seeds are planted, they begin to grow or ________________ .

13. Describe how endocrine glands regulate certain organs without regulating all organs. (3 points)

____

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____

14. Big is better! Does this saying apply to endocrine glands? If so, why? If not, why? (3 points)

____

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15. Describe how the skeleton, the brain's structure and people protect the brain from damage. (5 points)

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16. How do your senses help to keep you safe? (3 points)

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17. Why are seeds more likely than spores to produce new plants? (2 points)

____

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18. How are the life cycles of all living things alike? (2 points)

____

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____

19. Explain how some plants reproduce from underground stems and roots. (3 points)

____

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____

20. Compare asexual and sexual reproduction of a plant like strawberries. What is different between the strawberry off-spring of asexual and sexual reproduction? (5 points)

21. Why do off-spring of two biological parents have some traits common with each parent and may have some traits that neither parent exhibits? (4 points)

APPENDIX F

TEACHER QUESTIONNAIRE AND TEACHER INTERVIEW

At the end of the study the teachers were asked to complete a form indicating the strategies they had used during their teaching. This form also included lesson titles and the corresponding strategy that was intended to be used.

Individual teacher interviews were held at the end of the study. The questions that guided the interviews are present on the following pages.

The teachers were asked to complete this form at the end of the study.

UNIT 5		
Chapter & Lesson	**Strategy to Use**	**Strategy Used and Comments/Reflections**
Chapter 12 opening Pages 236-237	KWL	
Lesson 1 Pages 237-238 Chemical Messages	Main Ideas	
Lesson 2 Pages 239-243 Location and Structure of Glands	Compare-Contrast	
Lesson 3 Pages 244-248 Functions of Glands	Compare-Contrast	
Lesson 4 Pages 249-251 When Glands Do Not Work Properly	Cause-Effect	
Journey Highlights & Journey Review	KWL	
Chapter 13 opening Page 258	KWL	
Lesson 1 Pages 259-264 The Brain	Compare-Contrast	
Lesson 2 Pages 265-268 The Spinal Cord & The Peripheral Nervous System	Description	

Chapter & Lesson	Strategy to Use	Strategy Used and Comments/Reflections
UNIT 5 (cont'd.)		
Lesson 3 Pages 269-270 The Nerve Cell	Description	
Lesson 4 Pages 271-273 The Senses	Teacher Choice	
Journey Highlights & Journey Review	KWL	
UNIT 6		
Chapter 14 opening Page 282	KWL	
Lesson 1 Pages 283-285 Life Cycles	Teacher Choice	
Lesson 2 Pages 286-292 Life Cycles of Seed Plants	Main Idea	
Lesson 3 Pages 293-295 Life Cycles of Mosses & Ferns	Cause-Effect	
Lesson 4 Pages 296-297 Plant Stems and Asexual Reproduction	Teacher Choice	
Journey Highlights	KWL	

TEACHER INTERVIEW

Introduction

Aim basically to determine if and how successfully research-based strategies translate into real-life teaching situations.

Briefly reviewed purposes of study.

To see if student success had anything to do with/relationship with:

1. L.S. à la Witkin cognitive based
2. L.S. à la Hanson personality based
3. Overall reading levels à la teacher ratings
4. Explicit strategy instruction

In successful strategy teaching and implementation, three important factors emerge:

1. the initial teaching, which involves modeling of the strategy and justification, i.e., the why, when, where and how
2. next, the phase of guided practice and repeated uses and student personal management, i.e., independent completion of the strategy
3. evidence of ownership and continued and appropriate use of strategies

Questions to the teachers during individual interviews:

1. How did you use ____________ in the science course?
   strategy
2. How did you interpret the ___________ strategy?
3. How did you go about ensuring the strategy use once you initiated it?
4. Do you have any evidence that the students are independently using the strategies? What? Where?

5. What is your reaction to the time given to the chapters and units?
6. Did you have a "comfort level" with the strategies?
7. Did you have a "comfort level" with the content?
8. Please comment upon the in-service.
9. Please comment upon the Pkc2 test.
10. Please comment upon the text and the teacher guide.
11. Are there any other comments you would like to make?

APPENDIX G

Table G1

T-tests of Field-Dependent Styles for Males with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions.

Variable LPI Category Styles and Functions	N	M	S.D.	t	df	2-tail probability
SF-Category	17	62.29	11.60	1.17	16	.259
ST-Category		58.18	14.37			
SF-Category	17	62.29	11.60	4.27	16	.001
NT-Category		41.94	11.01			
SF-Category	17	62.29	11.60	.40	16	.694
NF-Category		59.65	18.41			
ST-Category	17	58.18	14.37	2.86	16	.011
NT-Category		41.94	11.01			
ST-Category	17	58.18	14.37	-.21	16	.835
NF-Category		59.65	18.41			
NT-Category	17	41.94	11.01	3.78	16	.002
NF-Category		59.65	18.41			
S-Category Perception	17	60.24	10.85	1.78	16	.094
N-Category Perception		50.79	11.69			
T-Category Judgment	17	50.06	5.19	4.02	16	001
F-Category Judgment		60.97	7.19			

Table G2

T tests of Field-Dependent Style for Females with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions.

Variable LPI Category Styles and Functions	N	M	S.D.	t	df	2-tail probability
SF-Category	14	71.57	15.64	2.81	13	.015
ST-Category		58.36	12.93			
SF-Category	14	71.57	15.64	6.07	13	.001
NT-Category		31.86	10.76			
SF-Category	14	71.57	15.64	1.27	13	.226
NF-Category		61.14	18.95			
ST-Category	14	58.36	12.93	5.70	13	.001
NT-Category		31.86	10.76			
ST-Category	14	58.36	12.93	-.34	13	.741
NF-Category		61.14	18.95			
NT-Category	14	31.86	10.76	5.36	13	.001
NF-Category		61.14	18.95			
S-Category Perception	14	64.96	11.33	3.04	13	.010
N-Category Perception		46.50	11.53			
T-Category Judgment	14	45.50	8.11	4.95	13	.001
F-Category Judgment		66.36	8.12			

Table G3

T-tests of Field-Dependent Style with Paired Samples of the LPI Dominant Styles and Dominant Perception and Judgment Functions.

Variable LPI Category Styles and Functions	N	M	S.D.	t	df	2-tail probability
SF-Dominant	14	76.57	11.86	1.07	18	.298
ST-Dominant	6	70.83	8.26			
SF-Dominant	14	76.57	N.A.	N.A.	N.A.	N.A.
NT-Dominant	0	N.A.				
SF-Dominant	14	76.57	11.86	-1.01	23	.322
NF-Dominant	11	80.82	8.18			
ST-Dominant	6	70.83	8.26	N.A.	N.A.	N.A.
NT-Dominant	0	N.A.	N.A.			
ST-Dominant	6	70.83	8.26	-2.40	15	.030
NF-Dominant	11	80.82	8.18			
NT-Dominant	0	N.A.	N.A.	N.A.	N.A.	N.A.
NF-Dominant	11	80.82	8.18			
S-Dominant Perception	14	71.61	7.71	N.A.	N.A.	N.A.
N-Dominant Perception	2	72.25	1.77			
T-Dominant Judgment	0	N.A.	N.A.	N.A.	N.A.	N.A.
F-Dominant Judgment	9	70.50	5.13			

Table G4

T-tests of Field-Independent Style for Males with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions.

Variable LPI Category Styles and Functions	N	M	S.D.	t	df	2-tail probability
SF-Category	9	45.44	25.78	-1.59	8	.151
ST-Category		58.78	15.08			
SF-Category	9	45.44	25.78	-.45	8	.664
NT-Category		52.78	24.89			
SF-Category	9	45.44	25.78	-1.83	8	.105
NF-Category		67.89	12.78			
ST-Category	9	58.78	15.08	.49	8	.640
NT-Category		52.78	24.89			
ST-Category	9	58.78	15.08	-1.14	8	.285
NF-Category		67.89	12.78			
NT-Category	9	52.78	24.89	2.29	8	.051
NF-Category		67.89	12.78			
S-Category Perception	9	52.11	16.95	-.72	8	.490
N-Category Perception		60.33	17.13			
T-Category Judgment	9	55.78	8.96	.15	8	.883
F-Category Judgment		56.67	8.66			

Table G5

T-tests for Field-Independent Style for Females with Paired Samples of LPI Category Styles and Category Perception and Judgment Functions.

Variable LPI Category Styles and Functions	N	M	S.D.	t	df	2-tail probability
SF-Category	8	75.50	10.97	2.97	7	.021
ST-Category		53.88	12.24			
SF-Category	8	75.50	10.97	4.59	7	.003
NT-Category		37.75	18.11			
SF-Category	8	75.50	10.97	4.41	7	.003
NF-Category		54.75	9.13			
ST-Category	8	53.88	12.24	1.72	7	.130
NT-Category		37.75	18.11			
ST-Category	8	53.88	12.24	-.17	7	.870
NF-Category		54.75	9.13			
NT-Category	8	37.75	18.11	1.96	7	.091
NF-Category		54.75	9.13			
S-Category Perception	8	64.69	5.40	4.22	7	.004
N-Category Perception		46.25	7.40			
T-Category Judgment	8	45.81	7.89	3.64	7	.008
F-Category Judgment		65.31	7.59			

Table G6

T-tests for Samples of SF Category Style with Changes in Conceptual Knowledge (ΔPKc), Metacognitive Knowledge (ΔPKm), Metacognitive Awareness (ΔPKma) and Metacognitive Self-Management (ΔPKmsm).

Variable	Group	N	M	t	df	2-tail probability
ΔPKc	Low SF-Category	22	13.18	0.74	53	.461
	High SF-Category	33	12.24			
ΔPKm	Low SF-Category	22	-6.91	-0.31	53	.761
	High SF-Category	33	-5.30			
ΔPKma	Low SF-Category	22	-5.09	0.01	53	.990
	High SF-Category	33	-5.15			
ΔPKmsm	Low SF-Category	22	-1.82	-1.31	53	.195
	High SF-Category	33	-0.15			

Table G7

T-tests for Samples of ST Category Style with Changes in Conceptual Knowledge (ΔPKc), Metacognitive Knowledge (ΔPKm), Metacognitive Awareness (ΔPKma) and Metacognitive Self-Management (ΔPKmsm).

Variable	Group	N	Mean	t	df	2-tail probability
ΔPKc	Low ST Category	34	12.71	-0.08	48	.939
	High ST Category	16	12.81			
ΔPKm	Low ST Category	34	-8.38	-0.16	48	.872
	High ST Category	16	-7.38			
ΔPKma	Low ST Category	34	-8.09	-0.34	48	.738
	High ST Category	16	-0.31			
ΔPKmsm	Low ST-Category	34	-0.29	0.44	48	.660
	High ST Category	16	-1.06			

Table G 8

T-tests for Samples of NT Category Style with Changes in Conceptual Knowledge (ΔPKc), Metacognitive Knowledge (ΔPKm), Metacognitive Awareness (ΔPKma) and Metacognitive Self-Management (ΔPKmsm).

Variable	Group	N	Mean	t	df	2-tail probability
ΔPKc	Low NT Category	82	11.88	-1.90	84	.061
	High NT Category	4	16.25			
ΔPKm	Low NT Category	82	-3.28	0.17	84	.863
	High NT Category	4	-5.00			
ΔPKma	Low NT Category	82	-3.13	-0.10	84	.919
	High NT Category	4	-2.25			
ΔPKmsm	Low NT Category	82	-0.15	1.00	84	.321
	High NT Category	4	-2.75			

Table G9

T-Tests for Samples of NF Category Style with Changes in Conceptual Knowledge (ΔPKc), Metacognitive Knowledge (ΔPKm), Metacognitive Awareness (ΔPKma) and Metacognitive Self-Management (ΔPKmsm).

Variable	Group	N	Mean	t	df	2-tail probability
ΔPKc	Low NF Category	27	12.70	0.30	52	.762
	High NF Category	27	12.33			
ΔPKm	Low NF Category	27	-3.41	-0.36	52	.723
	High NF Category	27	-1.70			
ΔPKma	Low NF Category	27	-2.70	-0.23	52	.822
	High NF Category	27	-1.78			
ΔPKmsm	Low NF Category	27	-0.70	-0.56	52	.579
	High NF Category	27	-0.07			

Table G10

Percentage Distribution of Scores for Pretest Taped Interview Questions (TI1) and Posttest Taped Interview Questions (TI2) across the Seven Protocol Sets and for the Metacognitive Domains Investigated.

Ques. No.	N	Pretest TI1			Posttest TI2			Ques. No.	N	Pretest TI1			Posttest TI2		
		Score			Score					Score			Score		
		0	1	2	0	1	2			0	1	2	0	1	2
P1	12							P2	12						
9d		8	83	8	0	92	8	6P		17	83	0	8	92	0
9p		42	8	50	25	50	25	6d		17	58	25	25	67	8
9c		17	67	17	8	75	17	6c		17	58	25	8	58	33
16d		67	33	0	25	50	25	12d		8	67	25	25	50	25
16p		42	58	0	25	58	17	12p		0	100	0	0	100	0
16c		58	33	8	25	50	25	12c		17	83	0	8	33	58
16pl		42	50	8	17	67	17	13d		17	33	50	0	42	58
16e		17	58	25	0	83	17	13p		17	67	17	17	75	8
16r		17	83	0	8	92	0	13c		8	92	0	0	100	0
8c		0	75	25	8	67	25	11d		42	58	0	58	42	0
8d		8	83	8	8	42	50	11p		0	100	0	0	83	17
8p		33	50	17	42	25	33	11c		42	50	8	17	67	17
								11pl		92	8	0	75	25	0
								11e		33	67	0	33	58	8
								11r		33	67	0	17	75	8
								11app					8	67	25

Table G10 (cont'd.)

Ques No.	N	Pretest TI1			Posttest TI2			Ques. No.	N	Pretest TI1			Posttest TI2		
		Score			Score					Score			Score		
		0	1	2	0	1	2			0	1	2	0	1	2
P3	12							P4	12						
17p		17	83	0	25	75	0	15d		50	8	42	8	17	75
17d		42	50	8	8	83	8	15p		8	92	0	0	92	8
17c		42	58	0	25	67	8	15c		0	100	0	0	50	50
17pl		58	42	0	50	33	17	15pl		75	25	0	17	33	50
17e		58	33	8	50	50	0	15e		42	42	17	50	50	0
17r		33	58	8	0	7	25	15r		33	67	0	25	75	0
4d		25	50	25	17	17	67	21p		0	100	0	8	92	0
4p		0	25	75	8	17	75	21d		42	50	8	33	67	0
4c		0	75	25	8	67	25	21c		33	67	0	35	67	8
1d		33	50	17	22 5	50	25	21pl		33	58	8	75	25	0
1p		0	25	25	17	58	25	21e		58	17	25	67	25	8
1c		8	83	8	8	67	25	21r		8	67	25	17	58	25
17app					8	83	8	15app					25	8	67
								21app					25	42	33

Table G10 (cont'd.)

Ques No.	N	Pretest TI1			Posttest TI2			Ques. No.	N	Pretest TI1			Posttest TI2		
		Score			Score					Score			Score		
		0	1	2	0	1	2			0	1	2	0	1	2
P5	11							P6	12						
19p		0	100	0	0	72	27	14p		0	100	0	8	50	42
19d		36	55	9	18	46	36	14d		17	42	42	25	8	67
19c		27	46	27	18	55	27	14c		25	75	0	8	42	50
5d		27	46	27	18	55	27	3d		8	50	42	8	92	0
5p		18	82	0	0	100	0	3p		8	83	8	8	92	0
5c		36	55	9	18	73	9	3c		25	42	33	33	25	42
10d		64	36	0	46	55	0	3pl		42	50	8	33	42	25
10c		64	36	0	73	18	9	3e		42	58	0	42	42	17
10p		36	64	0	55	46	0	3r		25	67	8	17	83	0
10pl		64	36	0	73	18	9	7d		33	67	0	33	67	0
10e		18	73	9	73	27	0	7p		17	67	17	17	67	17
10r		9	82	9	9	82	9	7c		58	17	25	25	58	17
10app					82	18	0	3app					67	33	0

Table G10 (cont'd.)

Ques No.	N	Pretest TI1			Posttest TI2		
		Score			Score		
		0	1	2	0	1	2
P7	11						
18d		100	0	0	82	0	18
18p		100	0	0	100	0	0
18c		46	46	9	36	55	9
18pl		36	64	0	27	46	27
18e		9	73	18	27	55	18
18r		27	64	9	0	91	9
2d		27	55	18	0	55	46
2p		36	55	9	46	55	0
2c		36	64	0	0	91	9
20d		36	64	0	36	64	0
20p		9	82	9	18	73	9
20c		64	36	0	36	46	18

Note:
P denotes protocol
d denotes declarative
p denotes procedural
c denotes conditional
pl denotes planning
e denotes evaluation
r denotes regulation
app denotes application

VITA

Surname: HOLDEN Given Names: Trudy Georgene

Place of Birth: St. John's, Newfoundland, Canada

Educational Institutions Attended:

Memorial University of Newfoundland

University of Victoria

Degrees Awarded:

B.A. (Ed.)	Memorial University of Newfoundland	1970
M.Sc.	Memorial University of Newfoundland	1975

Honors and Awards:

Memorial University of Newfoundland Fellowship 1970-72

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Relationships Among Learning Styles, Metacognition, Prior Knowledge, Attitude, and Science Achievement of Grade 6 and 7 Students in a Guided Inquiry Explicit Strategy Instruction Context.

Author ____________________________________

Trudy Georgene Holden
November, 1995