STUDENTS' AUTOBIOGRAPHICAL MEMORIES OF ONE-TO-ONE INSTRUCTIONAL CONVERSATIONS: A QUALITATIVE ANALYSIS OF THE SOCIAL PSYCHOLOGICAL LEARNING PROCESS

by

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ABSTRACT

Martin's (1993) theoretical perspective on the role of episodic memory in learning from individualized instruction was the focus of the current investigation. Through the use of qualitative methodology, two children's episodic memories of their tutoring experiences were examined in detail to determine any possible episodic mediational effects on the children's learning from tutoring. Findings indicated that changes in student's knowledge, documented throughout the sessions, were mediated by students' recollections of tutoring sessions, or of related experiences outside tutoring sessions. Possible indicators of what made certain learning experiences particularly memorable were (a) logical or conceptual links to prior knowledge, (b) information that was of personal interest or significance to the students, (c) information that was inconsistent with previously held understandings, and (d) active participation of the students in learning activities.

Students differed slightly on the type of information they recalled. One student reported remembering more conceptual (56.2%) information than factual; while the other student recalled more factual (78.5%) than conceptual information. Reported episodic memories were compared with transcriptions of the tutoring sessions to determine accuracy of reported memories. Comparisons indicated that students were able accurately to recall the original tutoring exchanges 80 percent of the time. The remainder of reported

episodic memories were deemed inaccurate, since portions of specific content, such as the name of a planet or place, were inconsistent with information contained in the actual transcripts.

Further research to assist in the exploration of possible mediational effects of episodic memory on student learning from teaching might examine students' background experience and prior knowledge, and their mental processes during relevant classroom experiences. In particular, attention to students' misconceptions and inconsistencies in understanding, as these are ameliorated during learning experiences, might assist researchers and educators to better refine our knowledge of the role of episodic memory in learning from instruction.

In fond memory of my mother
whose gifts of encouragement and perseverance
will always be with me

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CHAPTER ONE: INTRODUCTION

To what extent is students' subject knowledge embedded in autobiographical memory? Are students' memories of one-to-one instructional conversations effective in helping them to learn? Do students' memories of these instructional experiences facilitate student learning outside of tutoring sessions? Moreover, what can instructors do to improve the effectiveness of instruction if autobiographical memory plays a part in learning?

This introductory chapter provides a rationale for an empirical, qualitative examination of how autobiographical memory might mediate learning from one-to-one tutoring sessions. In addition, the theoretical model on which this study is based is described briefly, together with some of the research that supports it. The middle portion of this chapter deals with the significance and limitations of using qualitative methodology to study episodic memory. Lastly, an overview of the thesis is presented.

A Rationale for Research on Episodic Memory and Learning From Instruction

Research that closely examines what students remember as important about instructional conversations, the meaning that they give to these conversational events, and how they use this episodic information to learn and internalize knowledge may enhance our understanding of how interactive instruction facilitates student learning. Although episodic memory recently has been studied in psychological research (Paivio, 1986; Tulving, 1985), scant attention has been given to this phenomenon as it relates to education and student learning (Martin, 1993). By closely examining students'

autobiographical recall of such instructional contexts, insight may be gleaned into how students' personal memories facilitate learning from instruction. Lapadat and Martin (1994), and Martin (1993) recently have suggested that naturalistic inquiry into episodic memories of students might tell us more than research conducted in laboratory settings, where memory tasks are "relatively uninspired" (Martin, 1993, p. 170).

Current theories of learning and memory in education have tended to focus on students' declarative and procedural memories of learning from instruction. Little appears to be known about how or if students' episodic memories of conversations with teachers and instructional events might facilitate their learning. Moreover, it is difficult to assess how these instructional experiences might help to facilitate learning outside of the classroom (Martin, 1994).

According to Martin (1993), models of episodic memory and how it might mediate learning from teaching have not been studied widely in educational research. Martin incorporates Tulving's (1983, 1985) ternary theory of memory and Paivio's (1986) dual coding theory of mental representations to explain how further educational studies that focus on episodic memory might enhance our understanding of how students learn from instruction.

Tulving's Ternary Memory System Theory

Tulving (1983) proposes that there are three distinct memory systems which are interrelated. These memory systems are (a) *semantic* memory, (b) *procedural* memory, and (c) *episodic* memory. Tulving describes his ternary classification of memory systems as a *monohierarchical* arrangement. In his own words,

> the system at the lowest level of the hierarchy, procedural memory, contains semantic memory as it's single specialized subsystem, and semantic memory, in turn, contains episodic memory as it's single specialized subsystem. In this scheme, each higher system depends on, and is supported by the lower system or systems, but it possesses unique capabilities not possessed by the lower systems. (Tulving, 1985, p. 387)

Tulving explains that each memory system has capabilities that are unique and that are not characterized by the lower, foundational memory system. For example, procedural memory contains mental representations that are directions for future *action.* These mental representations are divorced from information about the past and are learned through our experiences of connecting stimuli and responses (Martin, 1994). A blueprint of how to drive a car, or how to walk are examples of procedural memory. The semantic memory system contains mental representations that are *factual* or *conceptual.* These facts or concepts are free from particular actions, and from the personal, experiential attributes commonly associated with episodic memory. Examples of semantic memory would be our knowledge that trees are made of wood, or that the sum of one and one is two.

Mental representations in episodic memory are characterized by information about "personally experienced events and their temporal relations in subjective time and the ability to mentally travel back in time" (Tulving, 1985, p. 387). The rememberer must be present or be an active player in an event in order for the memory to be episodic. My recollection of a feeling of euphoria when I read the

letter that informed me of my acceptance into graduate school is an example of an episodic memory.

Although Tulving admits there is some overlap among the three memory systems, he maintains that episodic memory can be distinguished from semantic and procedural memory. Episodic memory is autobiographical in that it contains a descernible imprint of the experience of the rememberer. The idea that episodic memory can be distinguished in this way is critical to the present research effort.

It should be noted that the term "episodic memory" is used interchangeably with "autobiographical memory" throughout this thesis and is intended to have the same meaning. Also, the terms "declarative memory" and "semantic memory" are used interchangeably to refer to the same memory system.

The present research seeks to examine students' episodic memories as possible mediators of their learning from one-to-one instruction or tutoring.

Paivio's Dual-Coding Theory

Dual coding theory seeks to hypothesize about the functional and structural characteristics of mental representations. Empirical evidence in support of this theory, as well as further implications with respect to the study reported in this thesis, will be detailed further in chapter two.

Paivio (1971, 1991) proposes that there are two memory systems that are separate but interconnected. These memory systems are verbal and non-verbal (or symbolic). The verbal memory system stores incoming and outgoing information that is linguistic (such as

spoken and written language). The non-verbal system stores input that is perceptual, imaginal, and sensorimotor (such as our thoughts, meanings given to thoughts, images, and sensori-perceptions). The non-verbal input is coded from all sensory processes: hearing, vision, smell, touch, and taste. The primary assumption is that these two classes of mental representations operate as specialized subsystems to deal with incoming environmental stimuli. Structurally, these systems are different in the way they organize representational units. Functionally, each system can operate independently or simultaneously. When these systems are active simultaneously, one system's activity may initiate activity in the other.

In essence, Paivio's dual-coding theory serves as a useful description of how verbal and non-verbal information is stored in our memories. According to this theory, one could speculate that students' autobiographical memories of instructional and *extra*instructional occurrences are processed in verbal and non-verbal structures. One-to-one instructional contexts are composed primarily of verbal discourse and symbolic representations. Paivio's hypothesis of conceivable interconnections between nonverbal and verbal memory systems is thus relevant to the present hypothesis that episodic memories of students serve as mediators for student learning from instructional events and conversations. More will be said about this mediational hypothesis in chapter two.

Episodic Memory as a Possible Mediator for Constructing and Reconstructing Knowledge

In this thesis, I attempt to conduct an investigative analysis of learning from tutoring in relation to autobiographical memory. The study I report is based on Martin's (1993, 1994) mediational theory of human change. According to this theory, human change occurs when one's personal theories are altered by engaging in new conversations that provide the individual with alternative thoughts and experiences. Our existing personal theories are the beliefs we hold about our environments, ourselves, and others, and are shaped by the social-cultural conversations we experience throughout our lives. Some of our perceptions of these experiential conversations are embedded in our memories, and may be maintained until such time as we encounter new information or experiences that stimulate our use of such memories in the reconstruction or revision of our personal theories. Conversational exchanges between a teacher and student during instruction might facilitate student learning inside and outside of tutoring contexts.

The theory as it relates to knowledge construction accents the student's internalization of instructional events and conversations through the vehicle of episodic memory. Internalization, in episodic memory, of events and conversations in learning contexts may be used by students to reconstruct their existing knowledge. Of particular relevance to the current study are investigations of episodic memory and classroom learning, and of episodic memory and psychotherapeutic change.

Research on Episodic Memory and Classroom Learning

Qualitative research in support of autobiographical memory as it relates to classroom learning has been conducted by Nuthall and Alton-Lee (1990, 1992, 1995). These case studies of detailed accounts of students' learning from instructional contexts provide information on the thoughts, beliefs, and memories of pupils. This work suggests that the context in which information is learned assists in forming children's personal accounts of instruction and subject matter.

However, a study conducted by Lapadat, Martin, and Clarkson, (1993), provided only sketchy evidence that students' autobiographical memories mediate learning from career education videotapes. Moreover, in another study by Lapadat and Martin (1994), the episodic memories of university students were examined in relation to the declarative content of university lectures. Results indicated no reliable support for connections between number of personal memories recalled and learning outcomes as indicated from quiz scores. However, these researchers reported that their findings may have resulted from a small sample size, and from design flaws that prevented precise understandings of the context of individual students' episodic memories. Therefore, these investigators advocate further exploratory research in this area that might help to refine existing theory.

Research on Episodic Memory and Psychotherapeutic Change

While it is clearly evident that counselling differs from learning from instruction in both context and content, research on clients'

memories of therapy sessions may shed light on how students' memories might potentially mediate learning from instruction. Several studies have focused on clients' and counsellors' recollections of important therapeutic events in counselling (Cummings, Hallberg, Martin, & Slemon, 1992; Cummings et al. ,1992; Martin, Cummings, & Hallberg, 1992; Martin, Paivio, & Labadie, 1990; Martin & Stelmaczonek, 1988). Results of these studies, in which clients recalled important therapeutic events immediately following therapy sessions, suggest that: (a) through conversation, clients elaborate their personal theories of their problems and themselves, and (b) clients often revise their personal theories based on the therapeutic conversation and their memories of it (Martin, 1994).

This research may be of particular relevance to the present study as a basis for hypothesizing about possibly similar results with respect to the memories of students and instructors for conversations and events during tutoring. How teachers affect their students in one-to-one instruction may be determined partially by what students recall as most important from tutoring sessions. Similarly, what instructors perceive and remember as important events in tutoring sessions may provide further insight into how tutoring works to stimulate student learning. The current study seeks an in-depth, qualitative description of students' episodic memories of one-to-one instructional contexts.

Significance of Qualitative Educational Research on Episodic Memory

Martin (1993) advocated further research that deals with how students' episodic memories might mediate their learning. In his

preliminary work in this area, Grade 6 students were probed for their episodic recollections for instructional events during geometry classes. Students' responses provided an abundance of information about their interests, feelings, and reactions to classroom events. Given that these responses are laden with such personal elaborations, Martin proposes that:

> 1. Human learners remember specific details of events and experiences associated with classroom teaching and learning.
> 2. These episodic memories mediate revisions to learners' procedural and semantic knowledge and affect the attitudes and feelings that learners associate with such knowledge.
> 3. Instruction can be designed and delivered in ways that enhance learners' episodic memories for instructional events and information. The rationale for these instructional manipulations is that more extensive episodic memories will mediate superior retention and use of relevant procedural and declarative knowledge as well as the strengthening of supportive attitudes and feelings. (Martin, 1993, p. 179)

Research on episodic memory in educational contexts is of possible value for several reasons (Merriam, 1991). First, investigating students' episodic memories of a natural, instructional setting might yield information that could have been missed in labratory-based experimental studies on episodic memory. Second, a specific understanding of how episodic memory works to mediate learning might be achieved through in-depth analysis of details of events as they occur in their natural setting. Third, an examination of the meanings students give to the events they remember may

yield new information about how or if episodic memories are associated with declarative information. Further qualitative case study research that studies children's episodic memories of one-to-one tutoring sessions likely will permit a much more exacting analysis of relationships between students' relevant personal theories and their memories for, and understanding of, instructional content than was possible in the group-design studies of Lapadat and Martin (1994) and Lapadat et al. (1993).

Overview of the Study

In this research, a number of questions are addressed.
1 (a) What do students remember as significant from one-to-one instructional events? (b) How do they understand these events?
2 (a) Do students make use of these memories and their content outside of the tutoring sessions? (b) How do students make use of these recollections?

Two qualitative case studies were undertaken to investigate the foregoing questions. The purpose for choosing descriptive case study research was to conduct an examiniation of one-to-one instruction that might capture a rich interpretation of the highly personalized, memory-mediated learning engaged and experienced by students.

Participants were two children, one boy and one girl from an elementary school in the Lower Mainland of British Columbia. Each student participated in six videotaped tutoring sessions on space exploration. Each session was conducted according to a session plan. During the first session, an open-ended assessment was conducted to assess students' background knowledge of space prior

to the tutoring sessions. In addition, a semi-structured assessment keyed to session topics was conducted during the first two sessions to access students' existing knowledge relating to the specific session topics. Sessions were concluded with assigning between-session activities, adding "amazing facts" to notebooks, or reviewing the previous session's videotape.

The between-session activities were recorded in written journals ("Amazing Facts about Space") that were kept by the students. In total, there were twelve videotaped instructional conferences, and two journals, one from each student, of weekly recordings of between-session thoughts or activities pertaining to the instructional sessions about space exploration. Post-session notes were recorded by one of the research assistants in the study, who also acted as the tutor.

Each session began with a memory probe, which was an open discussion of memorable experiences the student recalled during the preceding week that were related to the space unit. Students were also probed at this time for their memories of significant events from the previous week's session.

Analysis in this study was an ongoing process. The initial plan was to review transcripts from videotapes and audiotapes for comments, occurrences, and content that are recurring or particularly "telling" of the students' experience of the instructional sessions or between-session activities. In particular, the researcher paid close attention to students' memories of significant events from sessions. Each episodic memory was recorded on file cards and the actual event recalled was located in the transcript of the previous session or

sessions. A rich description of each such event was then written on the file cards. The data then were sorted into categories.

Finally, detailed descriptions were prepared of students' memories of significant experiential events from instructional sessions and between-session activities, along with supportive quotations from the transcripts, journals, and field notes. Moreover, perceptions and interpretations of how these events contribute to student learning as a result of one-to-one tutoring were analyzed and summarized.

Limitations of the Study

A case study design was chosen for two reasons. One was to examine children's episodic memories of instructional events in an intensive way that preserves individual meanings. The other was to examine empirically the possibility of children's episodic memories as mediators for constructing knowledge, again at a level of individual meaning and context. Such interpretive research aims at the explication of meaning and conceptual understanding. However, as with any study, questions about the reliability and validity of the data considered need to be addressed.

In this particular study, data were analyzed and summarized by a different researcher (me) from the individual who actually conducted the tutoring sessions and interviews. This arrangement leads to possible problems of interpretive validity in that the second researcher must somehow interpret the initial investigator's experience. Thus, the task of capturing the subjective perceptions of the different individuals (tutor, students, researchers) became a major challenge to me as I conducted the work herein.

The generalizability of the study also poses problems and challenges in that it involved only two participant learners. Possible replicability in this investigation was enhanced by a detailed explanation of the theoretical underpinnings of the study, and by thoroughly detailing how the study progressed and how the data were analyzed and summarized (Chapter 3). More studies of this nature are needed to establish the external validity of the claims presented from this research.

Summary

In this introductory chapter, certain areas of theory and research on learners' autobiographical memories of instructional events are highlighted. Few studies have focused on the ways in which students learn as a result of one-to-one instructional conversations and activities. Research on tutoring may provide information about how episodic memory might play a mediational role in how students learn as a result of one-to-one instructional conversations and interactions.

Furthermore, understanding more about how students' episodic memories act as facilitators of student learning outside of tutoring sessions may lead to a consideration of new instructional techniques to make teaching more effective. To date, few studies have investigated what students view as significant occurrences in instructional contexts (Martin, 1993). It is hoped that further research in this area will shed light on what teachers and students think about, do, and say that is effective in promoting student learning.

Qualitative research on episodic memory might enhance and compliment other, experimental studies of episodic memory in educational and other contexts. Previous writing and work on autobiographical memory and classroom learning has proposed improved qualitative methodologies capable of capturing student meaning and understanding at more individual levels of analysis.

On the basis of this introduction, the following work and possible yield are entertained. First, an initial, detailed assessment of students' prior knowledge as it relates to personal memory, together with detailed analyses of actual instructional interactions, may uncover how autobiographical memory might facilitate or hinder learning. Second, data collected from a weekly log, or journal in which students recorded related activities experienced outside of instructional sessions, or any instances where they discussed or thought about what they had learned from the previous tutoring session, may also enable us to identify intended changes in student learning and understanding.

Chapter two provides an in-depth examination of literature that deals further with episodic memory as a possible facilitator of knowledge construction. Theoretical templates and appropriate methodological approaches are examined in more detail as a backdrop to the current study.

CHAPTER TWO: LITERATURE REVIEW

This chapter presents a review of the literature on episodic memory as a possible mediator for learning from instruction. Martin (1993) suggests that, although many theorists and educators have investigated how declarative and procedural memory may influence learning from instruction, the recognition of episodic memory as a possible individualized mediator for students' acquisition of new knowledge has been overlooked in much of the contemporary research in education. Only since the early 1990s has the concept of episodic memory received specific attention in research that examines learning from instruction (Lapadat, Martin, & Clarkson, 1993; Lapadat & Martin, 1994; Martin, 1993; Martin, 1994; Nuthall & Alton-Lee, 1993; Nuthall & Alton-Lee, 1995; Prupas, 1993). However, the current literature review failed to yield detailed information concerning: (a) qualitative analysis that examines episodic memory as a possible mediator/facilitator of students' aquisition of new understanding, (b) how episodic memory acts as a facilitator both inside and outside of instructional settings, and (c) what meaning students give to their newly formed cognitive constructions.

In order to provide a historical context from which to view current theoretical and methodological advances in research on episodic memory and learning from instruction, this chapter opens with a brief overview of the general trends in the early mediational studies of learning from educational and psychological interventions. In particular, attention is given to studies of episodic memory as a

possible mediator to assist individuals in changing their perceptions and beliefs through counselling. Following this discussion is a more detailed review of recent theories and studies relating specifically to episodic memory as it relates to learning from instruction. Finally, some methodological considerations relating to the study of learning from instruction are discussed.

Brief History of Episodic Memory and Psychotherapeutic Change

Researchers seeking to answer the question, "How does change occur in clients as a result of psychotherapy?," have conducted intensive studies examining the role of episodic memory and client change during counselling. Martin (1994) writes that

> psychological therapy is a unique form of conversation that attempts to alter the personal theories about themselves, others, and their own life circumstances that clients have acquired through their participation in other (previous and ongoing) intimate, social, and cultural conversations. (p. 22)

According to Martin, clients' memories of conversations in therapy enable them to internalize new and more adaptive theories about themselves and their situations.

Several studies have empirically explored the mediational functions of autobiographical memory (Martin & Stelmaczonek, 1988; Martin, 1994; Martin, Cummings, & Halberg, 1992; Martin, Paivio, & Labadie, 1990). This literature suggests that clients in counselling typically recall as important, events that enhance their personal awareness and enable them to alter or elaborate their personal theories through the use of figurative language. Moreover, clients

tend to recall as important the conversational contributions of the therapist more than their own.

In a study by Ashcraft (1989), individuals' memories from counselling sessions were examined to determine whether or not the memories accurately reflected tapes of the actual sessions. The results of this study were that clients' memories of session events were rather inaccurate. Other studies that investigated clients' recollections of therapy sessions were those by Cummings, Hallberg, Martin, and Slemon (1992), Martin, Paivio, and Labadie, (1990), and Martin and Stelmaczonek (1988). In these studies, clients' memories of counselling sessions were highly accurate, with only 5% to 10% of recollections inaccurate. Interestingly, the most frequent error in these studies occurred when clients recalled contributions to the therapeutic discussion as their own, when in fact, the statements recalled were made by the therapist.

The preceding studies suggest that one's personal theories about oneself are revised through the process of psychotherapy. It appears that this phenomenon can be partially attributed to autobiographical memory, which bridges past and present (or alternative) information about oneself. Clients' self-conceptions undergo revision during the context of therapy. This research is relevant to the present study as a basis for hypothesizing about learning from individual instruction.

Episodic Memory and Educational Psychology

As his theory applies to psychoeducational settings, Martin (1993) believes that effective classroom teaching emphasizes the important aspects of a lesson through ensuring that students encode

the information as experiential and episodic. To explain this mediational theory, an explanation of episodic memory as put forth by Endel Tulving, (1993, 1985) is described. Following this, Alan Paivio's (1986) dual-coding theory is presented and discussed.

Tulving's Memory Theory

Three separate memory systems are described by Tulving (1983). These memory systems are called (1) *procedural* memory, (2) *semantic* or *declarative* memory, and (3) *episodic* memory. The most general or basic memory system is procedural memory, which serves as a foundation for semantic memory, a more specialized subsystem of procedural memory. Semantic memory serves as a foundation for episodic memory, which again is a specialized subsystem with qualities the others do not possess. Episodic memory is the most personalized memory system and is enveloped and encased by semantic and procedural memories. Each memory subsystem has capabilities unique to that system, that are not embodied by the other foundational systems.

Procedural memory contains mental representations which provide blueprints for future actions. These blueprints are divorced from any detailed information about the past. Semantic memory representations are described as schemes of one's surroundings which are detached from personal emotions or attitudes associated with these descriptions. Episodic memory is the only type of memory that also contains an individual's *personal experience* of an event. These personal experiences are inclusive of one's attitudes, perceptions, feelings, and actions associated with the world. As a

result, the subjective content of a memory is what makes episodic recollections different from the other two types of memory.

Unlike the other two types of memory, episodic memory is associated with the knower's attitudes and perceptions. In this way, episodic memories can link past, present and future experiences to form a sense of "self." It seems that this integration of past knowledge and autobiographical experience can direct and motivate an individual onto future courses of learning. One's autobiographical motivation to learn cannot be divorced from instructional settings, or from how we make sense of new knowledge. In order to make the role of episodic memory in learning seem plausible, one must account for how non-verbal events are represented in memory. Alan Paivio's (1986) dual-coding theory provides such an explanation.

Paivio's Dual-coding Theory

Paivio's (1986) theory of mental representations is based on the assumption that verbal (linguistic, symbolic) and non-verbal (perceptual, imaginal, sensorimotor) inputs are represented and stored in separate, interconnected systems of memory. The non-verbal system holds imaginal information in addition to visual information and includes input from any of the senses (hearing, seeing, smelling, tasting, and so forth).

According to Paivio's (1986) theory, individuals actively encode and construe incoming verbal and nonverbal information. This suggests that students in instructional settings are capable of revising and reconstructing their memories, knowledge, and experience in light of new information. In view of this position, a teacher's instructional words and actions provide the means for

students to engage in knowledge construction. In this way, teaching exposes students to a wide range of possibilities from which to add new information to previously held conceptions.

Paivio's (1986) dual-coding theory allows that students' episodic memories of classroom/tutoring experiences and extracurricular experiences may be retained in verbal and nonverbal forms. Instruction is, for the most part, a conversation aimed at helping students to create new knowledge about a given topic. This rendering of plausible relationships between verbal and nonverbal information is applicable to Martin's (1993) construal of episodic memory as a facilitator of knowledge construction, mediating between students' personal perceptions and instructional experiences.

Both Paivio (1986) and Tulving (1983) offer theories of memory that appear directly relevant to understanding how memory processes and structures facilitate knowledge construction in students. These processes seem to highlight students' verbal and nonverbal memories of past and present instructional experiences.

Studies of Episodic Memory and Classroom Learning

Bloom (1992) examined how the interrelated processes of personal experience, emotion, metaphor, and the interpretive frameworks of children affect the nature of their knowledge construction. In his study, nine grade five students and eight grade one students participated in unstructured interviews during an activity that involved observing earthworms. Results indicated that the episodic memories of children seemed to act in the following way:

> (a) establishing a contextual foundation; (b) establishing a comparative association; (c) establishing a comparative basis for an inference; and (d) providing material for elaborating and story-telling. (p. 403)

Nuthall and Alton-Lee (1993) analyzed childrens' utterances in a classroom setting to determine their cognitive and emotional responses to classroom lessons. Their study allows us to understand better the importance of attending to the context of the classroom. They propose that the consequences of culturally constructed classroom learning may mean that (1) some children may refuse to learn the legislated curriculum since it is too foreign to them, it does not belong to them, and therefore is rejected form personal understanding; (2) some children may believe the curriculum is something to be memorized in order to avoid humiliation; (3) some children may adopt the curriculum by identifying with it, and reject their personal experiences and beliefs; and, (4) other children may feel comfortable with the curriculum, perhaps empowered by it.

In another study by Nuthall and Alton-Lee (1995), children in social studies and science classrooms were given long-term and short-term achievement tests to assess their learning. Students were then asked to inform the researchers about how they remembered relevant classroom experiences, and how they answered the test questions. Findings were that 30%-50% of student responses to test items were based on recollections of classroom experiences, and 15%-24% were based on recollections of related experience and knowledge.

In a few instances, students recollected information from the classroom experiences that were not evident in lesson plans and tape recordings of the relevant classroom lessons. Interestingly, in most cases, the students attributed these false recollections to the teacher as the primary source of the information recalled. The intrusion of "false recollections" has been identified in research on the effects of schemas on memory for text (Pritchard, 1990; cf. Thorndyke, 1977).

> It is likely that students acquire, from years of repetitive experience, a generic schema for classroom learning activities that includes the teacher as the primary source of knowledge. (Nuthall & Alton-Lee, 1995, p. 213)

There appears to be growing support among researchers for the view that learning involves multiple parallel processes, of which only a few come forth into consciousness (cf. Baars, 1988; Dennett, 1993; Ramsay, Stitch, & Rumelhart, 1991). Nuthall and Alton-Lee (1995) describe their view of three types of memory content that students utilize when retrieving and deducing information in response to test questions. First, they believe that episodic memory plays a role in helping students recall the physical and temporal characteristics of the learning experience. This type of memory appears to consist of the specifics of what was done, heard, seen, and said. More generally, however, overviews of the activity or experience are also included. For example, "I saw that," or "we did it together." Secondly, there appeared to be information about mental processes and emotions that occurred during the learning experiences. For example, some children reported their inner feelings about class activities such as being "bored" or "surprised." Finally, there was

evidence of semantic recollection from the learning experience. This included specific examples and other information that the students remembered. Broad summaries of the type of knowledge involved also were reported by the students.

Nuthall and Alton-Lee (1995) suggest that memory for an idea or concept consists of parts or segments of the original learning experience. In addition, the three types of memory are multi-layered and inter-related. Given this, it seems theoretically possible that an episodic memory can trigger further episodic or semantic content, and that labels or names can trigger further details that in turn trigger additional semantic information.

In a study by Lapadat and Martin (1994), university students were asked for events that "stood out" for them during the lectures. Their results indicated that students found imaginally elaborated information to be more memorable than verbally elaborated information, both immediately following the lecture and at a three month follow-up. These findings support Paivio's (1986) dual-coding theory that elaborations of imaginal content during learning experiences help students to remember episodic and semantic information. On the other hand, Tulving's (1983) theory that episodic recollections would assist students in remembering semantic information from the lectures was not supported by the results in the Lapadat and Martin (1994) study. Moreover, these researchers found that approximately half of the students in their study recalled content and events that could not be located in the original lectures.

In another study by Lapadat, Martin, and Clarkson, (1993), students taking career education mini-courses were studied to see

whether their memories of two career information videotapes differed. One videotape was used in counselling centers and the other was purposely chosen based on the visual and experiential content of the film. Results indicated that students preferred the affective, experiential videotape, but no reliable difference could be found for accuracy of recall for either tape, or for reported memories of visual or verbal content.

Nuthall and Alton-Lee (1993) designed three distinct studies in which observations and recordings of classroom activities were analyzed. A model of student learning was derived from analysis of the data. The model was then tested by determining how well it predicted student learning based on the outcome of students' test scores. The following principles comprise this model of student learning.

1. Each time a student encounters topic-relevant information or is involved in a topic-relevant experience, a representation of that information or experience is stored in a working memory for a limited period of time.
2. A representation stored in working memory becomes connected, through the process of semantic integration, with other semantically related representations in the working memory.
3. If a representation in the working memory does not become integrated with other semantically related representations, it is lost from the working memory.
4. Once a sufficient number of semantically related representations become integrated into a single structure in

working memory, this specific knowledge construct becomes established in general (long-term) memory. (p. 813)

Other conclusions were that students constructed inner mental representations from their classroom experiences that included information abundant with elaborations and semantic associations. Moreover, each student's thinking at any given time was characterized by each individual's prior knowledge and experience.

A Qualitative Methodology for Researching Learning and Memory

As this study is designed to examine further how episodic memory possibly mediates student learning from tutoring, the main points of methodology thought to influence such a research effort are addressed below.

Research on teaching and learning has traditionally focused on objective, experimental paradigms to examine classroom actions and teacher effectiveness, in an optimistic attempt to uncover a "science" of instruction (Nuthall & Alton-Lee, 1990). More recently, increasing support for research that investigates many additional factors that influence student learning from instruction has emerged (Alton-Lee, Nuthall, & Patrick, 1993; Dembo, 1991; Martin, 1993; Merriam, 1991). Alternative research methods that obtain information about students' and teachers' personal experiences may address other problems of concern to educators. In this sense, it would seem that traditional, behaviourally-focused experimental methodologies are limited with respect to understanding the complex interactions that take place between teachers and students. Instead, the view that many different research methodologies can be adopted

to study educational contexts has been supported by most contemporary researchers (e.g., Borg, 1991; Martin, 1993; Nuthall & Alton-Lee, 1990). In accordance with this perspective, research methodologies can be chosen appropriately based on the problem under investigation.

As mentioned earlier, Martin (1993) points out that research that takes into account the functions and characteristics of children's episodic memories may enhance our understanding of how students learn from educational settings. In particular, research that focuses on the personal significance of classroom memories may reveal that episodic memory may act to mediate between a student's prior knowledge and experience, participation in classroom activities, and new learning from these activities. In accordance with this view, Nuthall and Alton-Lee (1990) also advocate qualitative research that takes into account students' episodic memories, since significant levels of episodic content were apparent in their studies of students' learning from teaching. The current research effort was intended to examine fully the possible role of episodic memory as facilitator/mediator of student learning from individualized instruction. In order to do so, the qualitative research methodology outlined in the next chapter was chosen.

CHAPTER THREE: METHODOLOGY

The current investigation was primarily concerned with how children's episodic memories might facilitate or hinder learning from instruction. The research hypothesis that there is a connection between children's episodic recall and classroom learning was explored. This chapter looks at the research methodology employed in the study to address the foregoing hypothesis.

The methodological approach employed adopted a broader perspective of the learning process than that typically considered in research on teaching. Consideration was given to the sorts of experiences students undergo both inside and outside of classrooms that might contribute to their construction of knowledge. In addition to learning during regular instruction, students might engage in learning activities outside of these formal instructional settings. Therefore, the methodology adopted included data collection from the actual tutoring sessions and from a journal of between-session, informal activities possibly relevent to student learning.

Procedures and Methods

Permission was granted by the ethics committee at Simon Fraser University to conduct the reported research. Permission was also granted from the School District from which participating students were drawn, as well as from the students and their parents. Students were informed during the first session that all of the information gathered for the study would remain confidential. The study was conducted in a spare room, at an elementary school in the lower mainland of British Columbia. The session plans designed for the study were created by one of the researchers (not the author)

who also acted as the tutor. The same individual was primarily responsible for data collection. Two pre-instruction questionnaires (see Appendixes A and B) were administered during the initial portions of the first two sessions, to assess the students' prior knowledge of space exploration. Six experimental tutoring sessions were taught and all sessions were videotaped and audiotaped.

At the onset of each session, with the exception of the first, students were interviewed for their episodic memories from the previous session(s). Students were instructed to keep a between-session journal of any activities or conversations related to space exploration. Students also kept an "Amazing Facts About Space" booklet that was completed during some of the later sessions. The number of autobiographical memories each participant reported for each session was recorded. Each memory recalled was located in transcriptions of the previous tutoring sessions and in videotapes of the sessions to facilitate determination of significant themes in the instructional events recalled. The specific procedures followed in offering and collecting data from each of the two series of tutoring sessions are displayed in Tables 1 and 2.

Table 1

Outline of Procedure for Each Session (Anne)

Session	Description
First Session	Introduction - Assessment - New topic (Space, the solar system, the Earth & planets, and the Moon) - Wrap-up
Second Session	Memory probe - Between-session activities - Assessment New topic (The history of space exploration) - Wrap-up
Third Session	Memory probe - Between-session activities - New topic (More about space) - New topic (Building spacecraft to explore space) - Amazing facts about space - Wrap-up
Fourth Session	Memory probe - Between-session activities - New topic (The American space shuttle program) - Amazing facts about space) - Wrap-up
Fifth Session	Memory probe - Between-session activities - New topic (Canada's role in space) - Amazing facts about space - Wrap-up
Final Session	Memory probe - Between-session activities - New topic (Designing a lunar settlement) - Final assessment - Debriefing

Note. Sessions were approximately forty minutes in length.

Table 2

Outline of Procedure for Each Session (Karl)

Session	Description
First Session	Introduction - Assessment - New topic (Space, the solar system, the Earth & planets, and the Moon) - Wrap-up
Second Session	Memory probe - Between-session activities - New topic (The solar system, continued) - New topic (The history of space exploration) - Amazing facts - Wrap-up
Third Session	Memory probe - Between-session activities - New topic (Space travel in modern times) - Amazing facts - Wrap-up
Fourth Session	Memory probe - Between-session activities - New topic (Building spacecraft and travelling in space) - Amazing facts - Wrap-up
Fifth Session	Memory probe - Between-session activities - New topic (Space stations, more about the space shuttle, astronauts) Amazing facts - Wrap-up
Final Session	Memory probe - Between-session activities - New topic (Space stations/ Lunar settlement) - Final assessment - Debriefing

Note. Sessions were approximately forty minutes in length.

Each reported autobiographical memory was also investigated to determine if the content of the memory contained indications of new or different knowledge than what the student demonstrated during the prior knowledge assessment. Students' reported episodic memories were sorted using index cards, and a detailed description of the original event was constructed. Cards of similar content were then sorted into categories and analyzed for how, or if, the student's episodic recall facilitated student learning.

Participants

Students. Students were two children: one twelve-year-old boy (Karl) in grade seven, and one eleven-year-old girl (Anne) in grade six. These individuals, with the consent of their parents, volunteered to participate in the study and had the option of discontinuing their involvement at any time. In this thesis the names of the students have been changed.

Tutor and researchers. The tutor/researcher who collected the data held a Ph.D. in the Psychology of Education. The present author completed the analysis and and compiled the results.

Data

Data were collected during the regular school year and consisted of six videotaped tutoring sessions for each child. Audiotapes were recorded from the videotapes, and sessions were transcribed by a research assistant. Each session was conducted according to a session plan. The remainder of the data were collected from written journals, "Between-session Activities" (Appendix C), "Amazing Facts about Space" (Appendix D), and one drawing from Anne of a "Lunar Settlement" (Appendix E). The combined data from the two students

yielded twelve videotaped instructional sessions, two journals of weekly recordings of "Between-session Activities" pertaining to space exploration, two "Amazing Facts about Space" booklets, and two drawings of a "Lunar Settlement." Data collection also included post-session notes written by the tutor following each of the sessions (Appendix F).

Assessments

Pre-instruction measures. During the first three tutoring sessions, learners were asked a series of standard questions to assess their prior knowledge of space and space exploration. The pre-instruction measures consisted of an "Open-ended Assessment" and an "Assessment Keyed to Session Topics."

Open-ended assessment . During the first session, an Open-ended Assessment (Appendix A) was conducted to assess the students' *general* background knowledge of space and space exploration. The Open-ended Assessment consisted of four general questions. Questions were geared toward collecting information about why students found the topic of space interesting, what they knew about astronauts, space, and space exploration, where they believed they learned this information, and what they would like to learn during the course of the space study. Responses to each question were probed further for additional information.... ("Tell me more about..."). Once the Open-ended Assessment was complete, a semi-structured Assessment Keyed to Session Topics was conducted to access students' existing knowledge relating to the specific session topics.

Assessment keyed to session topics. The Assessment Keyed to Session Topics (Appendix B) consisted of more specific questions related to space exploration, and was intended to collect information about students' prior knowledge of the specific content covered in the instructional sessions. The students were asked the *specific* assessment questions during the initial sessions, immediately following the general assessment. In total, there were fifty assessment items, keyed to particular session topics.

Post-instruction measures. During the last session, students again completed the Assessment Keyed to Session Topics questions. These questions were used as an overall post assessment of knowledge aquired, and of changes in students' understanding of space and space exploration from the commencement of tutoring.

Session Plans

The six session plans followed a similar format for each student. The first two sessions were composed of an introduction, assessment, new topic, and wrap-up. The remaining four sessions were made up of memory probes, between-session activities, new topics, and wrap-ups.

The content of session plans was as follows: Session #1 explores the solar system - the earth, sun, planets, and moons; Session #2 deals with the history of space exploration and early astronomers; Session #3 is geared toward spacecraft and how they operate; Session #4 looks at space travel and astronauts; Session #5 covered individual astronauts and the sorts of experiments they conduct; Session #6 explores the future of space exploration and the possibility of space station settlements.

Between-instruction activity journals. Students were requested to record their thoughts, conversations, and activities pertaining to space exploration in a journal between the weekly tutoring sessions. Whenever the students forgot to use their journals, they were encouraged by the tutor to do so.

Probes for episodic memories. Each session began with a memory probe, which was an open discussion of memorable experiences the student underwent during the previous week's session. Students also were probed at this time for their memories of between-session activities related to space. For example, the tutor might ask, "What ideas or activities that we did last session, or that you learned about or did since I last saw you really stick out in your memory?" Responses to this question were probed for specific content, words, actions, and so forth. She then might ask, "Why do you think you remember that?," and "What was it about that idea or activity that made it stand out?" The tutor continued to ask if anything else was remembered until the student could think of nothing else.

Transcript Analysis Procedure

Analysis of transcriptions of the tutoring sessions began with highlighting the content of the transcripts into units. These units consisted of (a) prior knowledge; (b) episodic memories; and (c) new understanding. Each unit was highlighted with a different colour for organizational purposes, and to determine if there were overlaps in events recalled by students, and indications of new understanding. Once these overlapping occurrences had been located, the verbatim episodic memories were written on index cards. An elaborated

written description of the memory was then added to the card, as well as a brief description of the manner in which the memory seemed to facilitate the student's new understanding. Cards were then sorted into categories based on emerging themes in each student's recollections and indications of new understanding. Episodic memories that were deemed to contain new, declarative content were analyzed further using a system adapted from Nuthall and Alton-Lee (1993)(See table 3).

Table 3
System of Episodic Memory Analysis Developed from Nuthall and Alton-Lee (1993)

(A) Type of Information Recalled	Description
Factual	Identification of factual information, such as names of places/people, events that took place, and descriptions.
Conceptual	Memory of an abstract concept such as the distance between planets.

Medium
a) instructional conversation; b) readings/book; c) video; d) diagram/map; e) student writing or drawing f) student activity during session; g) student activity outside of session.

(B) Learning Process	Description
Accuracy	a) Information is correct b) Information is both correct and incorrect (Teacher corrected) c) Information is incorrect (Teacher corrected at time of recall)
Relevance to student	How student perceives information important, or why it was retained.
Consistency with prior knowledge	Is information different or the same as knowledge gathered during prior assessment.
New understanding	Does recollection of event appear to indicate new understanding?

CHAPTER FOUR: FINDINGS

In this chapter, a detailed qualitative analysis of how episodic memory might facilitate learning from tutoring is provided. The analysis begins with a presentation of the two cases and concludes with descriptions of how both students utilized their episodic recollections to learn new information. For clarity, the results are organized into two sections: (1) descriptions of students' episodic memories, and (2) processes of student learning facilitated by their episodic memories. A description of the students' between-session activities as they relate to the students' learning is also presented.

During the initial exploratory stages of analysis, a set of categories was developed to code and organize relevant information. Although the categories were mainly derived from the current data, some of the categories are similar, as will become apparent, to those created by Nuthall and Alton-Lee (1993, 1995). Indeed, the conceptual, theoretical work of these authors provided a general framework for several of the interpretations presented herein. Their studies describe the development of a model to explain how students use their episodic and semantic memories to construct knowledge.

Each student's recalled autobiographical memories were written on index cards, one memory to a card. All of these cards were then sorted into categories. Categories were created according to (a) factual or conceptual memory content (b) the likely source of origin of the memory (medium), and (c) level of accuracy when compared to transcripts of the original tutoring sessions. The memories were considered particularly relevant if they appeared to reveal new understanding on the part of the learner.

Description of Anne's Autobiographical Recollections of Instructional Sessions

Of the episodic memories Anne recalled, approximately 56.2 percent were of conceptual content and the rest were of factual content (Table 4). An example of a memory with conceptual content is when Andrea recalled reading a chapter on the dark side of the moon.

> Anne: ...that the moon is going around the Earth, you never, see the other... like they call it the "dark side" because, um, the Earth is rotating and the moon is rotating, and the moon takes about 28 days to go around the Earth, and in the same time, it takes about that long to do a full rotate, and so you always see the same side of the moon.

Given Anne's interest in science and pre-existing conceptual knowledge, as indicated during the prior knowledge assessment, it was not surprising that her recollections were slightly more conceptual than factual.

In this particular study, the students reported various mediums (Table 5) as likely sources of their episodic recollections (illustrations, diagrams, videos, drawings, readings, etc.). Mediums in the current study are described as the learning sources that were associated with a particular student recollection. For example, Anne tended to report memories of reading between tutoring sessions. Other memories Anne reported originated in experiences of building and discussing spacecraft models, and the instructional conversation from the previous week's tutoring session. Interestingly, most of her recollections were of experiences where she was conversing either with the tutor, her friends, or her father, in conjunction with another

activity (drawing, watching a video, or the unraveling string ball activity).

All recorded memories were categorized according to level of accuracy when compared to the original transcript of the original tutoring sessions. These categories were accurate, inaccurate, and both accurate and inaccurate. Of course, it is assumed that there is no true indication of the complete accuracy or validity of the students' memory responses since there is no way of unveiling students' private autobiographical processes (Nelson, 1993). However, students' memories of their learning experiences can be compared to transcriptions of the actual tutoring sessions. Memories of between session activities or conversations were not included in this portion of the analysis, since there was no way to check the validity of memories of these occurrences. There were three categories established to determine accuracy of recalled learning experiences: (1) *accurate,* defined by a match between the reported memory and the actual recollected events as located in the original transcript from the previous week's session, (2) *inaccurate,* defined by no match found between the student's reported memory and the actual transcript, and (3) both *accurate and inaccurate,* defined by a match between the student's reported memory and the actual occurrence in the transcript, with the exception of at least one misremembered response. For example, a student might recall correctly most of the relevant information, but report "Mars" as the closest planet to the sun, instead of "Mercury."

Anne's episodic recollections, when compared to the actual transcripts, showed that 80 percent of what she recalled was

remembered accurately. On the other hand, approximately 20 percent of her episodic recollections were both accurate and inaccurate, meaning that in general she remembered correctly, but displayed some minor inaccuracies as well. For example, misremembering a name (such as the name of a person, place, or planet).

Memories were considered accurate if the reported memory could be located in the transcripts of the tutoring sessions, and accurately reflected the conversation between the tutor and student. Memories were considered both accurate and inaccurate if most of the content of the conversation was remembered accurately, but specific details were inaccurate, such as the name of a planet or place. Once again, memories that were reported from video or reading sources were not included in this description since the original sources were not available to me.

Descriptions of Karl's Autobiographical Recollections of Instructional Sessions

Karl recalled information that was mostly factual (78.5%) as opposed to conceptual (21.4%). An example of a memory categorized as factual was when Kenny recalled looking at some pictures of the ancient Mayan temples with the tutor.

> Karl: Venus was one of them. I think it was the one they thought was the evil god and they had to sacrifice things for it.

Interestingly, Karl reported that he was particularly interested in the "fantasy" aspects of space during the prior knowledge assessment,

yet most of his memories from the tutoring experiences are of factual content.

Although Karl admitted during the onset of several sessions that he did not do most of the readings between the sessions, he recalled the content of the readings on the three occasions that he did do the reading. Karl conveyed this information when asked for his memories of space related activities from the previous week's session or out of session activities. Another recurring pattern for Karl was his recollections of activities during the sessions in which he was actively involved. He had three episodic recollections of building the spacecraft model with the tutor, as well as one episodic recollection of drawing an "amazing fact" about space.

Karl's episodic recollections were mostly accurately recalled (80%), although a few recollections, while mostly accurate, displayed specific details that were incorrect, such as names of certain planets, places, or people (19%). Findings for both students were the same in this regard.

Table 4

Percentage of factual and conceptual information recalled in students' episodic recollections

	Memory content	
Individual student	Factual	Conceptual
Anne	43.7	56.2
Karl	78.5	21.4
Mean	61.1	66.9

Table 5

Classification of the source of episodic recollections

	Individual Student Instances	
Medium	Anne	Karl
Instructional conversation only	3	0
String solar system with peers	1	0
String solar system with tutor	0	1
Reading alone	7	3
Watching video with tutor	1	1
Looking at diagram/pictures with tutor	2	2
Drawing of "amazing fact" with tutor	1	2
Building model/discussing model with tutor	3	3
Video game alone	0	1
Conversation with parent	1	0
Conversation with friend	0	1
News	0	1

Table 6

Percentage of episodic memories that were accurately recalled

	Accuracy of Recollection		
Individual student	Accurate	Inaccurate	Both A and I
Anne	80	0	20
Karl	81	0	19
Average	80.5	0	19.5

Note. Accurate and inaccurate (A&I) category signifies memories that contained information that was correct, but recollection of a specific detail that was incorrect. For example, naming "Pluto" as a planet in the inner solar system.

Descriptions of Learning

The data suggest that students' prior knowledge affects how new information is generated and constructed. When students are engaged in learning activities, representations of their encounters are stored in their working memories (Nuthall & Alton-Lee, 1993). It seems that new experience and information are related to the already existing knowledge that the students possess. For example, in session two, Karl mentions his misrepresentation of the number of planets with rings.

> Karl: And I remember that there are three planets, *not two,* that have rings on them.
>
> Tutor: Uh, huh. Okay, do you remember which ones those were?
>
> Karl: Saturn, Uranus and Jupiter?

Near the end of the first session, Karl states that he has learned that there are three planets that have rings. He also indicates that he had a previously held notion that there were only two planets that had rings. The tutor and Karl were looking at an atlas of the solar system, and discussing the orbit of Pluto as different than the other planets. Karl remarks:

> Karl: I learned one thing today. I thought that there were two planets that had rings.
>
> Tutor: And now you know there's actually ....
>
> Karl: Three.
>
> Tutor: At least three, yeah. They don't know for sure about Neptune, but it doesn't seem to have any.

Martin, (1993) and Lapadat and Martin (1994) suggest that autobiographical recollections might be an important mediational vehicle for the retention of declarative information when students become aware of their own conceptual misunderstandings, which then are corrected by the instructional activity.

Nuthall and Alton-Lee (1986,1993) compared students' recollections of classroom experiences with detailed observations and recordings of actual classroom events. This inquiry revealed that what students reported were interpretive representations of the classroom occurrences. The following segment is an example of an "interpretive representation" from the data.

> Tutor: What do you remember about the last session?
>
> Karl: Uh, making the string solar system I think was about the only thing I can remember. And that was to show me the distance of the planets, and how close together the "inner solar system" is to the sun and to the planets close to it, and how far away the "outer solar system" is.
>
> Tutor: Okay. And why do you think you really remember that so well?
>
> Karl: I've had it in my bag thinking that I have to unwind it someday.

This example illustrates what was happening in the mind of the student at the particular time of learning, as well as the student's personal thoughts and reflections between sessions. This example represents the possibly unique ways in which episodic and semantic information may be stored and connected in a learner's memory. For this reason, it seems that understanding the precise ways in which

the new knowledge is relevant to the student is of paramount importance to understanding the role of episodic memory in learning.

Another example is Anne's recollection of looking at a poster of several different satellites with the tutor .

> Anne: ...And, then we looked at a poster and it had all of the different satellites that have gone up into space. And the most interesting one that I remember is the one.... it was really big and I think it was going to go up in 1995 or 96, and it looked like it had scaffolding going out in different directions... and in the center it had these capsules or modules and there were four different ones, and the different countries had made their own modules and they were going to put them together, and they had, I think two of the rooms were for science experiments.

Anne states in her recollection that she remembers one particular satellite on the poster as "interesting" or relevant. She also gives several reasons why she finds this satellite particularly appealing: "it's really big, it's being launched in 1995 or 1996, different countries had a role in putting it together, and two of the rooms are used for science experiments."

Consistent with the findings of Nuthall and Alton-Lee (1995), the current study seemed to reveal that the students' reports of constructive and episodic memories were enhanced by the tutoring experience, particularly when the experience was rich with elaborations and semantic associations. One such semantic association appears in a discussion the tutor and Karl were having of

"Stonehenge." Karl speaks of his prior understanding of "Carhenge," a replica of Stonehenge made of car parts.

> Karl: And for those people who can't get to "Stonehenge," there's "Carhenge"....
>
> Tutor: What's that?
>
> Karl: Somebody looked at "Stonehenge" and he took cars and made them into the same shape and everything as "Stonehenge."

Perhaps Karl's prior understanding of "Carhenge" was utilized as a basis for associating new information about Stonehenge. During the course of his tutoring experience, it seems likely that Karl encountered information about Stonehenge that 'triggered' other associated relevant information. To this end, it seems that the nature of the interaction between a tutor and student is shaped by the student's prior knowledge, as the conversation unfolds. Moreover, Karl's understanding of Stonehenge is cumulative, so that the acquisition of new knowledge is ongoing. This example also illustrates the possibility of confusion and misunderstanding when new information is connected with existing information in a student's memory.

Memorability of Events

As I read over the transcripts, I tried to examine certain aspects of the tutoring sessions for their "memorability" (for what made certain events more memorable to particular students). On a few occasions, students were asked by the tutor what made certain aspects of the sessions more memorable. On one such occasion, Karl reported why certain activities were memorable for him.

Tutor: Why do you think those particular things are the things that you remember best about the last session?

Karl: Well, I remember the toys just because I like them. And the model - I know I remember that....

Tutor: Why?

Karl: Because I was looking forward to doing things with it because I want to be able to work with something.....it helps me to remember it when I do something.

Tutor: Any other thoughts that you have on why those things are more memorable for you?

Karl: The picture that you showed me of the different parts that drop off the spaceship....the reason that that stuck out in my mind is because I've never really known what parts they could reuse. I always thought it just all came down up like until a couple of years ago when I started watching the news and I learned little bits about it.... And I guess the other bits I just remembered, no real reason....

This example demonstrates that for Karl, the tutoring experience was more memorable because: (a) he had a strong positive feeling about the toys, (b) he enjoyed the active involvement with building the spaceship models, and (c) the fact that some spaceship parts are reusable was something that surprised him.

Other interesting occurrences in the transcript were when the students were able to recall the relevant information in general, but were unable to recall specific details.

Karl: And there were four planets in the 'inner solar system' or whatever it was called. There was Earth, there was Mars, ...(pause)...not Pluto...

Tutor: No, not Pluto.

Karl: I can't remember the other two.

Tutor: Anything else stick out from that book?

Karl: All the other ones are in the "outer solar system."

Tutor: Right.

This instance shows that Karl is able to describe the inner and outer solar systems, and two of the planets in the inner solar system, but forgets the names of the other planets.

In another example, Anne recalls various facts about "Stonehenge," but forgets the name.

Anne: Yeah, uh in Chapter two, they were talking about the different kinds of things that people would use to look up at the stars, and they were talking about the "Temple of the Sun," and the..... I can't remember what it's called....the big stone blocks that were kind of in a circle....

Tutor: Oh, Stonehenge.

Anne: Stonehenge, that's what it is..... and how they had these bumps in it and little holes.....I think it was 58 holes that it had. I don't remember (inaudible) but they were saying that it might have something to do with the Stonehenge and what they were doing, what they were using it for. But they were saying they never left any clues behind about what they were actually doing with it and so the scientists are just kind of taking guesses at what they were using it for.

Both of the foregoing examples indicate that the students were able to recall most of the relevant information, but could not remember particular details (e.g. formal names or labels) to describe the information.

Comparison of Recollected Events Between Students

The students' recollections differed slightly when they were compared on type of information recalled. Anne recalled slightly more information that was conceptual (56.2%) than factual (43.7%), whereas Karl recalled more information that was factual (78.5%) than conceptual (21.4%).

However, both students generally remembered events from the sessions that involved more than just the instructional conversation alone. As described in Table 4, the students remembered many of the specific activities that were planned during the course of the sessions. For example, the students often recalled information that involved the use of visual aides, such as readings, diagrams, pictures and videos. Another well remembered phenomenon was activities where the students were directly involved, such as making the string ball solar system, drawing the amazing facts, and building the spacecraft models.

For the most part, both students accurately recalled information and activities from the sessions. In only a few of the recollections, did students recall information accurately, but confused a word or the name of something -- for example, the name of a planet, or the name of an ancient telescope. In such instances, students remembered the majority of the content correctly.

One important outcome of the current study is that each student's experience was unique. Although the students were exposed to lessons of similar content and participated in the same activities, their recollections, and their descriptions of recollections were markedly different. Moreover, each student's responses to the prior knowledge assessment were unique. As a result, each student learned new information that was unlike the other.

Between Session Activities

In addition to episodic recollections of tutoring experiences, students also reported memories of between session experiences that were related to the topic of "space exploration." The most frequent sources of these between-session reports were (a) reading books, (b) conversations/activities with peers and parents, (c) watching the news, and (d) playing a video game about space. In one such recollection, Anne reports unraveling a "string ball" of the distances between the planets.

> Anne: Well, I really enjoyed doing that string ball thing.
>
> Tutor: Oh, yeah?
>
> Anne: And at recess, we went out and.... like on Wednesday we went out and did it. And we started from the undercover area and it went all of the way across the field.
>
> Tutor: Wow.
>
> Anne: And, yeah, so we had all of these kids running in and underneath and everything, but it worked. So it's pretty far away, like between the planets, like it's just..... what was it? half an inch, uh, a million kilometers for every half inch?

Tutor: Yeah, actually I think it was a million miles because that's kind of an older book and so they talk about miles and inches.

Anne: O.K. so it was in miles. It's pretty far away.

In this instance, it appears that Anne's episodic memory of unraveling the string balls during recess enabled her to conceptualize the great distances between the planets.

In another such instance, Karl recalls a conversation he had at a friend's house while looking at a poster of the solar system.

Karl: (writing in his 'between-session' journal) Do you know how to spell inaccurate?

Tutor: Uh, i-n-a-c-c-u-r-a-t-e.

Karl: It was very "inaccurate" - we saw a poster of the solar system and I talked about it with a friend and it was very inaccurate.

Tutor: In what sense?

Karl: Uh, it only had one planet that it showed had rings.

Tutor: Oh, yeah?

Karl: And the one thing I can't blame because like most of the time Pluto is the furthest planet away...

Tutor: So it showed it as being the furthest planet away?

Karl: Yeah. And some of the planets in the outer solar system were tightly together... like it showed the distance and it was like way too close than what it was supposed to be.

Tutor: Okay, a lot of people make that mistake -- they think they're all just sort of about the same distance apart, don't they?

Karl: And Earth and Mars they had miles away.....

Tutor: Oh, really?

Karl: They were like way too far apart.

Tutor: Isn't that interesting.

Karl: Everybody thinks that Mars is way out there.

Tutor: Well, it's a long way, but not compared to the outer solar system.

Karl: And then...

Tutor: Where did you see this poster?

Karl: Uh, at a friend's ...Colin's

Tutor: Oh, yeah, at his house.

Karl: His brother had it on his wall.

This autobiographical report was particularly notable because Karl was able to point out discrepancies between the poster and information he had learned during the course of the tutoring sessions. During the initial two sessions, Karl and the tutor watched a video about space and looked at a diagram in a book of the solar system. During the course of their discussion, Karl learned that there are *three* planets with rings, that Neptune is currently orbiting closer than Pluto, that there are varying distances between the planets, and the meanings of the terms "inner and outer solar system." Interestingly, this new knowledge may have "gelled" when he discussed and viewed the poster with his friend.

The above findings indicate that changes in student knowledge, documented throughout the sessions, were based in part on students' mediated recollections of tutoring sessions, or of related experiences outside of sessions. Students differed slightly with respect to the

type of information they recalled. Anne recalled more conceptual (56.2%) information than factual; while Karl recalled more factual (78.5%) than conceptual information. Comparisons of reported episodic memories with transcriptions of tutoring sessions revealed that students were able to the recall original exchanges 80 percent of the time. The remainder of memories were considered inaccurate, since specific content, such as the name of a planet or place, were inconsistent with the exchanges in the original transcript.

In the next chapter, a discussion of the mediational means by which episodic memories of tutoring experiences enhance the generation of new knowledge is presented. Also, critical reflections on the use of qualitative methodology to understand the role of episodic memory in learning from instruction are offered.

CHAPTER FIVE: DISCUSSION

In this chapter, I summarize conclusions from my work based on Martin's (1993) theory (that includes episodic memory as a partial mediator of new knowledge) of how students learn from instruction. Evidence from qualitative analysis that examines episodic memory as a possible mediator for students' aquisition of new understanding from tutoring is presented, as well as findings that support how episodic memory facilitates learning outside of instructional settings. Factors affecting the memorability of particular tutoring (or other) events are discussed. Also, further discussion of the types of information recalled by each student and the level of accuracy of recollections is undertaken. Finally, brief critical reflections on this research and suggestions for further related studies are presented.

Conclusions Based on Findings

The findings of this study suggest that students revise their existing knowledge, at least partially, through the mediation of memories of conversations with tutors. This conclusion follows from a close examination of the student/tutor conversations in the transcripts. Close comparison of students' prior knowledge, as indicated by assessment, and transcripts of the actual lessons and post-lesson interviews, revealed that changes in student knowledge were clearly documented throughout the sessions, and were based on students' recollections of conversations in prior sessions, or of memorable experiences out of sessions.

Themes that emerged as possible indicators of what made certain portions of conversations and experiences particularly memorable were (a) logical or conceptual links to prior knowledge, (b)

information that was of personal interest or significance to the student, (c) information that was inconsistent with previously held understandings, and (d) learning activities that involved active participation from the students.

Documentation of in and out-of-session activities revealed consistent, ongoing experiences and conversations related to space exploration that presumably supported and elaborated students' existing and emergent knowledge of space. Nuthall and Alton-Lee (1995) found that while the majority of student responses to test questions were from original classroom experiences, some of the students reported recollections of out-of-class experiences, such as related knowledge learned from books, television, and conversations with others. These out-of-class recollections, much like in-class recollections, were often cued by the test item. Moreover, in some cases, students were able to answer test items based on deductions from prior knowledge that were conceptually or logically related.

How students' episodic memories facilitate learning is indirectly determined by the students' original learning experience and background knowledge (Nuthall & Alton-Lee, 1995). In the present study, the students' acquisition of knowledge during the tutoring sessions included the ways in which the students were able to identify and connect their new experiences with existing knowledge. Furthermore, students reported memories of original learning experiences that revealed new information that was discrepant or inconsistent with their previous knowledge ("I thought there was only two planets with rings," or the student who had a previous conception of "Carhenge," a replica of "Stonehenge" made of cars).

This finding may indicate that educators could be more effective if they were initially to focus on the individual student's conceptions or misconceptions of a particular topic. For example, teachers might encourage their students to generate their personal experiences, memories and feelings in relation to a specific curriculum topic, perhaps in a fashion much like the practice of "brainstorming."

To this end, teachers should probably focus less on specific skill or fact building as a means of facilitating learning, and more on an understanding of learning processes and how students change and develop their personal and general knowledge. We know that what teachers do to promote revision and expansion of a student's knowledge can vary tremendously across different classrooms and students, and may display drastic differences among learning environments. This variation depends greatly on the prior life experiences of the student(s) and the teacher, the students' learning difficulties and strengths, the teacher's beliefs about learning, and so on. Since these extensive variations exist, it seems implausible and unrealistic to prescribe a certain "way" to teach or a generalization of what a classroom necessarily "looks like."

Bloom, (1992) declares that

> as science educators in western societies, it is difficult to divorce ourselves from the right (scientific) answer syndrome, which tends to see learning science as positivistic and/or empirical in nature. The alternative to such a view involves seeing learning as a holistic, organic and natural process. To take advantage of such a process in the classroom necessitates (a) recognizing , by teachers and

> students, the different contexts of meaning and their various components and how they affect the various knowledge development processes (e.g. categorizing, inferring, elaborating, and story-telling); (b) facilitating the use of these components and processes of contexts of meaning; (c) valuing children's idiosyncratic products; and (d) analyzing (with or by students) these products in terms of their contextual and multiple perspective understandings. From this point of view, the process of inquiry not only looks at the object of study, but also at how ideas are formulated and used. (p. 412)

In studies by Alton-Lee and Nuthall (1992) and Nuthall and Alton-Lee (1993), knowledge that was abundant in semantic and episodic content was strongly associated with varied and complex classroom activities. The present investigation supported this finding, in that the students regularly recalled experiences where they were actively involved in an activity (such as drawing or building a space model, or discussing a diagram with the teacher). The students also reported a high percentage of episodic recollections of related out-of-session events in which they were actively involved.

Analysis of the students' self-reported episodic recall showed that newly acquired knowledge was closely associated with the original learning experience ("the picture you showed me of the different parts that drop off the spaceship....," "I was talking to my dad and he said... I can't remember the words he said, um, they kind of burn on fuel.... when it gets so hot that the little tiny molecules explode it

makes more heat"). This appeared to be true of both students regardless of whether the recollection was of the tutoring session or of out-of-session activities. These findings are consistent with those of Nuthall and Alton-Lee (1995). Students' interview responses in this study revealed that they recalled the physical details of instructional experiences as well as the relevant content. Moreover, the current data suggested that one-to-one instructional conversations enabled students to express and engage themselves in the topic at hand. This clearly differs from typical classroom instruction, where students do not have that same one-to-one time with the teacher.

Students in the current investigation differed with respect to the type of knowledge that each remembered. Anne reported remembering slightly more conceptual information than factual information, and Karl reported more memories of factual than conceptual information. Prior knowledge assessments for both students indicated that Anne had a personal interest in topics related to science and Karl had a personal interest in the "fantasy aspects" of space. This finding may imply that, for Karl, the desired match between personal preference and episodic recollection of new declarative information contained in the tutoring sessions was more elusive than it was for Anne.

Reported episodic memories of tutoring sessions were checked with the original transcripts. Findings suggested that students accurately recalled the original experiences at a level of 80%. The remainder of memories were remembered accurately, but specific details, such as the name of a planet were recalled incorrectly. This

finding suggests that students were able to remember specific details of the original learning experiences, but sometimes forgot or confused the specific content associated with the experience.

Critical Reflections

The validity of self-report data has been criticized by Nisbett and Wilson, (1977). They argued that self reports could not be used as valid data about the cognitive processes that induce behaviour. They maintained that when individuals attempt to describe the mental processes that guide their behaviour, they base their descriptions on socially acquired theories about mental processing. They argued that individuals do not have direct access to the underlying cognitive processes that direct their behaviour. Another problem, proposed by Garner (1988), is that even if individuals had some level of awareness of their mental processes, they may not be able to report them accurately. Children, in particular, may not have sufficient vocabulary to describe their memory processes, or may not even understand what they are asked by researchers to do.

Nuthall and Alton-Lee (1995) believe that self-reports can be better substantiated if

> students are asked to report on specific rather than generalized mental processes that are within a context of observational and objective data that can be used as a source of validity and consistency of their reports. (p. 188)

Moreover, Alton-Lee and Nuthall (1992) also maintain that the private speech of children is inevitably based on the social conditioning of mental processing (p.189) (Vygotsky, 1962). Therefore, if students' self-talk is used to pilot their acquisition of

learning and memory, the private speech of children can be a meaningful part of classroom experience. Consistent with the current findings, Nuthall and Alton-Lee, (1993, 1995) found substantial differences in the content knowledge learned by different students. They believe that variability among individuals' background classroom experience, and prior knowledge likely account for such differences.

Another finding by Nuthall and Alton-Lee (1995) was that, in addition to recollections of in-class discussions and activities, children also reported using out-of-class memories to help them answer questions on a test. They reported that the most common out-of-class sources were television, books, and conversations with family and peers. The relevance of memories of life experiences to instruction and knowledge construction needs to be recognized. It seems difficult to imagine how instruction might connect to students' everyday, extrainstructional experiences without taking into account students' personalized memories of these past experiences. With this in mind, students' episodic recollections of past knowledge and experience enables them to discuss their knowledge and generate new knowledge in the instructional context. It would also seem that these memories of past knowledge and experience might directly motivate, or not motivate a learner to seek new information about a given subject, depending on the nature of the episodic recollection. A common example is the student who is unmotivated and uninterested in the classroom. One could hypothesize, based on the former premise, that this particular student has had personal past

experiences in the classroom, or with learning in general, that were perceived by the learner as unsuccessful or somehow aversive.

The current research demonstrates the value of descriptive, qualitative methods of inquiry to examine intensively how episodic memories are used by students to facilitate learning from tutoring. Without such a detailed description of autobiographical memory and knowledge construction, important and unique individual and contextual factors in such mediated learning would have been neglected. In order to try to understand precisely how children learn from tutoring experiences, it was necessary to collect data continuously throughout the complete space exploration unit. Without such continuous documentation, it would be difficult to make sense of the unique context and cumulative nature of the students' tutoring experiences.

Only two students were included in this research, largely as a result of the need for extensive individual study. As a result, this research has yielded information about how episodic memory has facilitated learning in these two individuals, rather than generalizations about the knowledge acquisition dynamics of a greater number of students. Nuthall and Alton-Lee (1992, 1993, 1995) claim that such analysis provides a solid basis on which to develop an explanatory model or theory of the way students learn from classroom experience. If so, then perhaps this explanatory theory can be generalized conceptually to the experiences of other students in other contexts. It is hoped that other investigators will employ this and related methodologies to further explore Martin's

(1993) theoretical perspective on episodic memory as a facilitator/mediator of knowledge construction.

The most obvious limitation to this research was that separate individuals collected and analyzed the data. This aspect of the study is problematic since I was faced with the burden of interpreting the initial investigator's experience. Fortunately, detailed post-session notes were left for me to examine. Also, it is clear that the reports given by the participants in the current study do not necessarily reflect those of other students in different tutoring situations.

Another possible problem is that the methodology employed captured students' experiences and memories only for a selected period of time. Long-term retention of students' autobiographical memories and constructed knowledge might be explored in a follow-up study and might yield potentially important and different results. A follow-up study of this type might reveal the extent to which students' autobiographical memories of instructional events are retained and used over time periods that extend well beyond initial teaching-learning encounters.

The pre- and post-questionnaires, as well as the eliciting of students' episodic memories, were unlikely to reflect fairly the total amount of knowledge the students possessed or acquired during the course of the study. Furthermore, the post-session questionnaires for Karl were not completed in full because of unavoidable time contraints during the last session. As a result, complete post-session assessments for both students were not available to compare with pre-assessment questionnaires as an overall measure of the learning that took place during the course of the tutoring sessions. Thorough

documentation of pre- and post-measures would have yeilded an objective, substantiated description of the knowledge aquired for both students during the course of the study. Nevertheless, until we better understand how individuals acquire knowledge and access their memories, a more thorough appreciation of this process will be difficult to conceptualize and access.

Further research to assist in the exploration of a possible mediational theory of episodic memory might involve further studies of students' personal background experience and prior knowledge, and their mental processes during relevant learning experiences. In particular, attention focused on students' misconceptions or inconsistencies in understanding, as these are ameliorated over time, might help to understand better specific mediational roles of episodic memory. This is conceivable since students actively construe and organize information. Since knowledge is also socially constructed, the discourse that inevitably unfolds in classrooms, or between students and teachers, or students and students, becomes encoded and restored in the memories of students. These socially-based classroom conversations may facilitate episodic mediation that assists students in revising their previously held theories of knowledge. Such memory representation can be held in both verbal and non-verbal systems.

In order for Martin's (1993) mediational hypothesis to be warranted, certain classroom activities and events must be shown to be highly memorable to individual students because of the personal, autobiographical relevance of such events. It is this relevance to the individual learner, that distinguishes the mediational role of episodic

memory in learning. In this sense, students must perceive the personal importance of the instructional discourse or detect that the new information is discrepant with, or an enhancement of, their current understanding of the topic at hand. In particular, classroom events may be most memorable to learners if the experiences are perceived as applicable to their interests, knowledge, or of help to them in some way. In light of these considerations, teachers may need to spend considerable time monitoring students' pre-existing and evolving knowledge.

For this reason, more studies of this nature are required to demonstrate further and extend the current findings. Further studies that initially examine a few students' episodic recollections in learning situations, followed by similar studies of small groups or entire classrooms of students might help to develop and enhance our present understanding of the role of episodic memory in learning from instruction. Moreover, studies that examine closely the possible motivational aspects of autobiographical memory, in the context of learning from instruction, may help educators better to understand and assist students who are seemingly unmotivated or having trouble learning curriculum content.

In conclusion, the current study was successful in demonstrating a viable method of examining autobiographical memory as a facilitator of learning in one-to-one instructional situations. Clearly, this form of investigation has a place in our attempts to broaden our understanding of student learning from teaching.

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APPENDIX A: Open-ended Assessment

As you know, we will be working together for six weeks studying about astronauts and space exploration. First of all, I'm interested in finding out a little about why you picked this topic for our project and what you already know about it.

1. Why did you think this would be an interesting topic to learn more about?

2. What do you know about astronauts, space and space exploration? Tell me everything you know. (Probe: Tell me more about....)

3. How did you learn all those things about astronauts, space And space exploration? (Probe: Reading? TV? School? Travel/tours? Video games? Someone else?)

4. Is there any specific thing to do with astronauts, space and space exploration you'd especially like to learn about during out time together?

APPENDIX B: Assessment Keyed to Session Topics

Now I'm going to ask you some more specific questions about things to do with space exploration. They're quite detailed, and if you have a lot of ideas about a question, that's okay. Or if you're not sure about something, you can speculate, or say whatever you sort of remember. Or you can say you don't know.

Session #1

1. Let's say we could leave Earth and go anywhere we wanted out in space. What would we find out there?
2. Explain what the solar system is.
3. What can you tell me about the sun?
4. Tell me about the planets in our solar system.
5. What makes Earth different than the other planets?
6. Tell me about the Moon.
7. Are there any other moons anywhere? Explain.
8. How do you think our solar system -- the sun, planets and moon began?
9. Why do you think that?

Session #2

10. When did people first get interested in exploring space?
11. What kinds of things did early astronomers do?
12. When did people first send spacecraft up into orbit?
13. What parts of our solar system have we explored with spacecraft?
14. Explain what you know about exploration of our moon.

15. Explain what you know about exploration of the sun and planets.
16. Tell me about sending astronauts to the moon. (When? Who? How did they get there? What did they do?)
17. What is the surface of the moon like?
18. What do you think will be the most important and interesting goals for space exploration in the future?

Session #3

19. What different kinds of spacecraft have been sent into space? (Names? Describe?)
20. How are spaceships launched?
21. What are the risks in launching a spaceship, during space travel, and in coming back to Earth?
22. What path does a spaceship travel when leaving Earth, and when landing on a moon or on a planet? Why?
23. What makes a spaceship go, turn and stop?
24. What was special about the Apollo missions? Explain.
25. Tell me about any spacecraft disasters that you know about.
26. What do you think spacecraft of the future will be like?

Session #4

27. What kind of equipment is carried in unmanned spacecraft?
28. During launching and liftoff, what do astronauts in a spacecraft experience?
29. Once the spacecraft escapes Earth's atmosphere and gravity, what do astronauts experience?
30. Talk about how astronauts traveling through space do everyday things like eating, sleeping, and going to the bathroom.
31. What features do spaceships have to keep astronauts safe?

32. How do astronauts breath in space?

33. When astronauts walked the moon, what were their space suits like?

34. Tell me about astronauts' stays on space labs.

35. How long does it take a spaceship to go from Earth to the moon?

Session #5

36. How do people become astronauts?

37. Can you tell me the names of some female astronauts, and what they did/ are doing?

38. Can you tell me the names of some male astronauts and what they did/ are doing?

39. When an astronaut is traveling in a spacecraft, how does he/she spend most of his/her time ?

40. Tell me about types of experiments or research that astronauts and space scientist here on Earth do.

41. Tell me about the Canadian space program Canadian astronauts.

42. Tell me about Roberta Bondar and what she did.

43. If you were an astronaut, what do you think would be the most exiting and interesting thing about it?

Session #6

44. When do you think people will begin to live in space, either in space stations, or in colonies on the moon or on another planet?

45. What do you think space station settlements will be like?

46. If you were designing a space station for people to live on, what features would you include? Why?

47. What do you think a settlement on the moon or on another planet will be like?

48. How would you design a settlement on the moon; what features would you include? Why?

49. What do you think of people traveling to other parts of the universe beyond our solar system? What would it be like?

50. Are there any other things about space exploration that you know about and would like to tell me?

APPENDIXES

APPENDIX C: Journals of Between-session Activities

Karl's journal of between-session activities

March 12

Saw poster of solar system, I talked about it to a friend. It was very inaccurate.

March 20

Watched Star Trek the Next Generation.

March 30

plaed Hitchhiker, it has something to do with space. I keep dying.

April 6

Read article from: Sky above and worlds beyond, Judith Herbest, 1983

Anne 's record of between-session activities

Jan 20

recess - unwound the string solar system with some friends

Jan 20

Talking to Dad about stars - how they burn

Sat Jan 30

read Judith Herbst book chap 4

read chapter 3 up to p. 42 on Feb. 5, 6, 8

read the rest of chapter 3 and chapter 2 up to page 19 on February 15/93

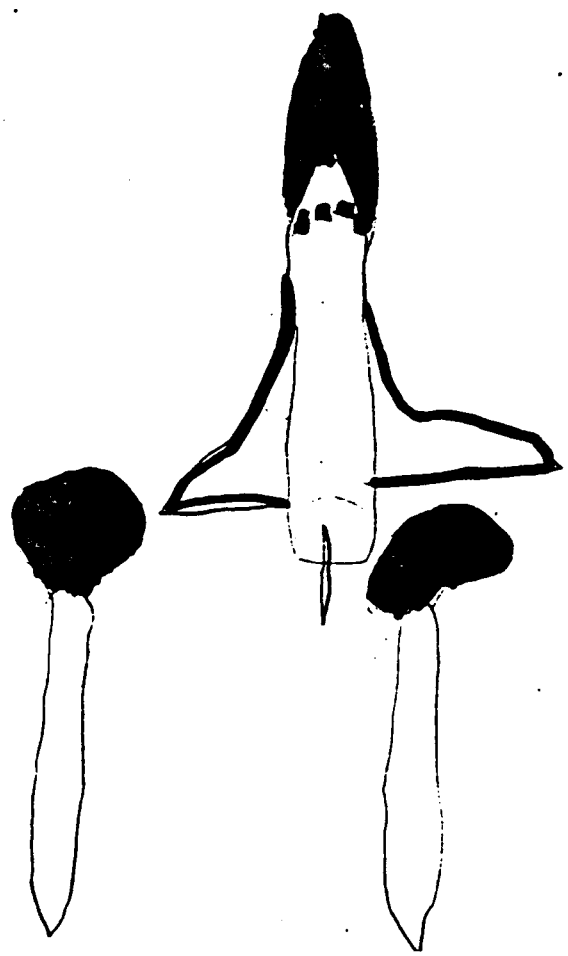
Sunday Feb. 21/93

read chapter 2: YES, WE HAD NO TELESCOPES and informatin sheet: THE CANADIAN SPACE AGENCY NEWSBULLETIN

APPENDIX D: Journals of "Amazing Facts"

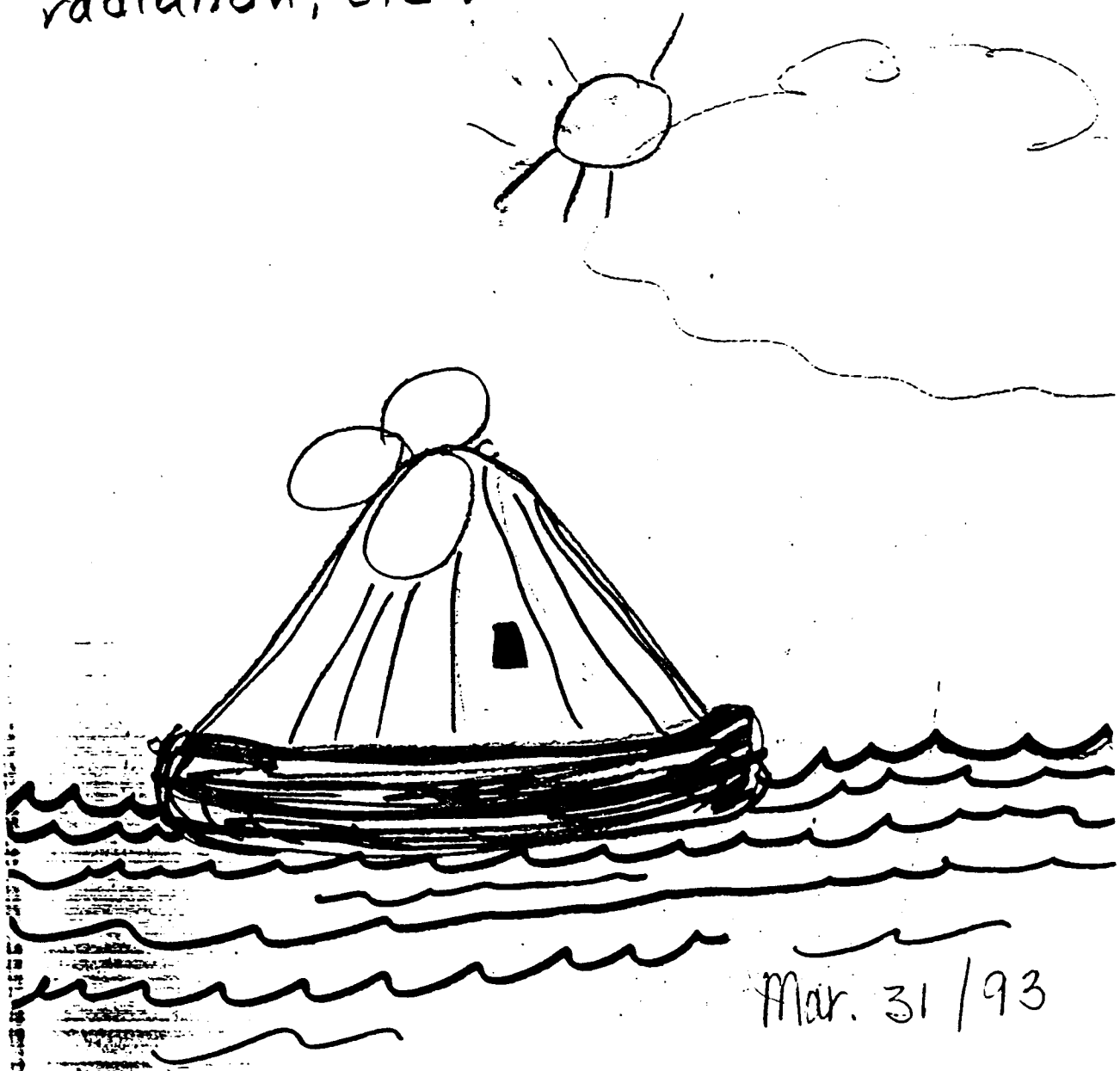
93-03-31

An amazing fact about space is that we can send four pieces of spacecraft up and get three back in reusable shape.



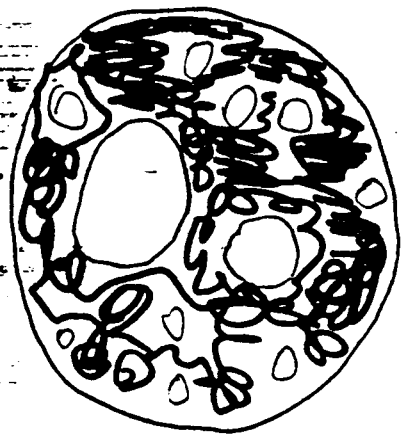
"Amazing Facts about Space" book

It's amazing that we have managed to send people into space and get them back to Earth safely, considering all the complications of designing spacecraf and all the hazards that there are in space (pressure, temperature, (lack of) ^oxygen, radiation, etc.)



Mar. 31/93

An amazing fact about space is that even from earth you can see craters on the moon, and then name it.



March 29, 1993

Mar 24/93

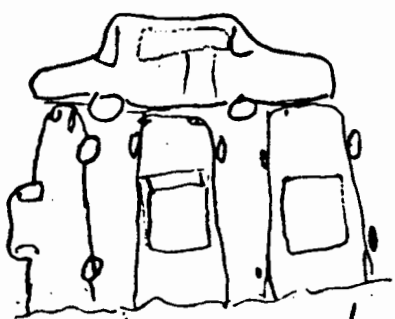
It's amazing that we have sent so many space probes and satellites out into spac and just left them there, floating aroun or crashed on the surface of the moon o planets. Pretty expensive space junk.

An Amazing Fact about Space

It's amazing that even as long ago as 4000 years, people were able to figure out and predict the movement of the sun, moon, planets and stars.

teb3193

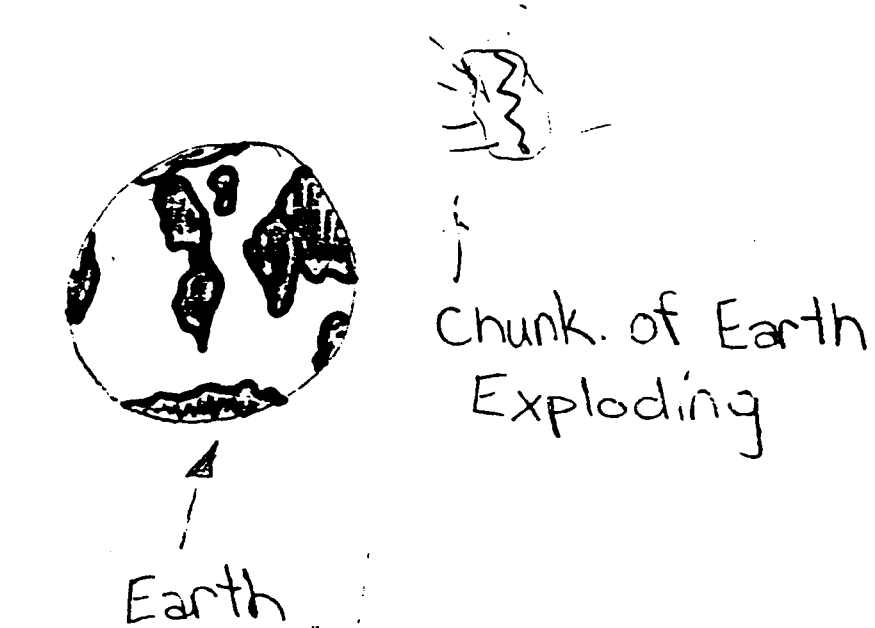
Stonehenge



Carhenge!

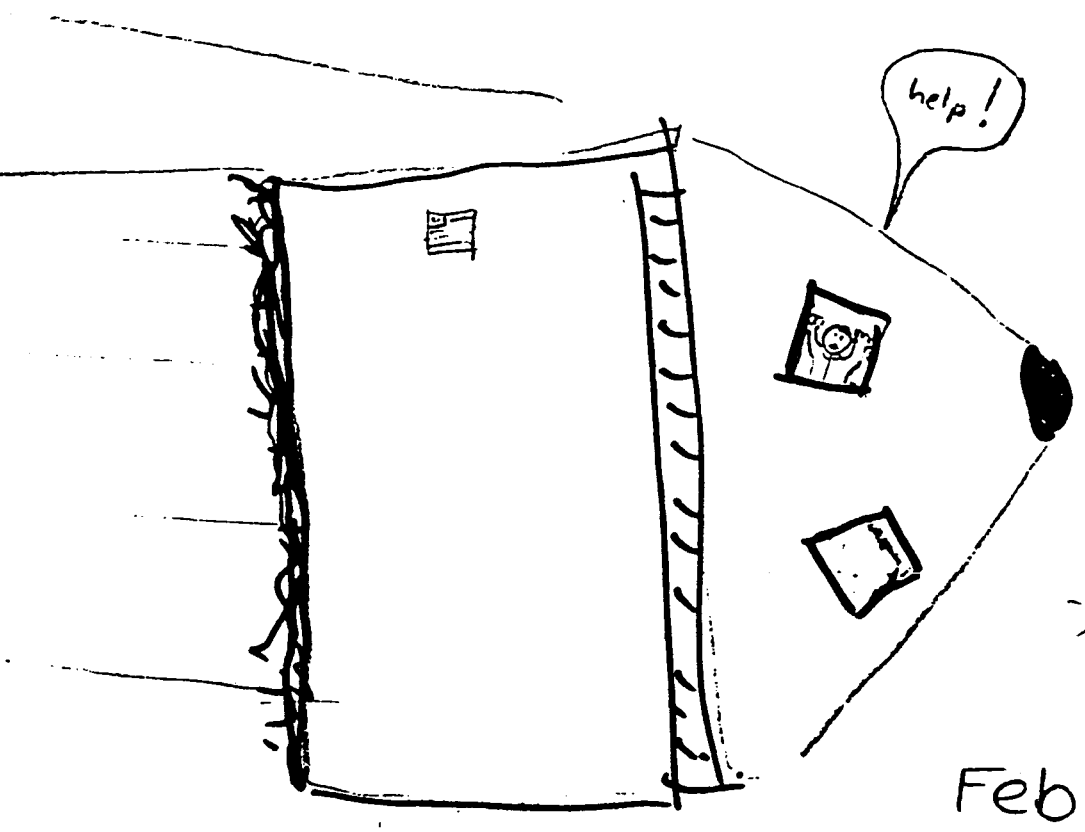
Amazing Fact:

That the moon might have been formed by a chunck of earth but the earth's Roche Limit ~~Theory~~ contradicts the Tidal Theory because going through the Roche Limit would make a cunck of earth, like the moon, explode. They say that the moon then might have been formed by millions of little particles sticking together.



February 10/13

It's amazing that the Americans sent so many people out into space without any way of rescuing them until the recent development of the space shuttle program.



Feb10/93

Amazing fact:

That NASA managed To send Apollo missions to the moon and get the people back to Earth safely again, given all the complicated maneuvers (sp?) they had to coordinate, all while considering: gravity, atmosphere, pressure, air to breathe, flight paths, and rotation of the earth and moon. -Also that so many pieces were left behind.

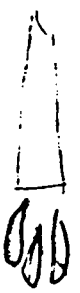
1)

Saturn5 rocket blasts off

2)

first stage Separation

3)



ignite engines to leave orbit

4)

lunar module & command module continue to moon

5)

command module orbits moon & Lunar module with Buzz Aldrin & Neil Armstrong

6)

landing gear of lunar module acts as launch pad

7)

lunar module meets command module; astronauts transfer

8)

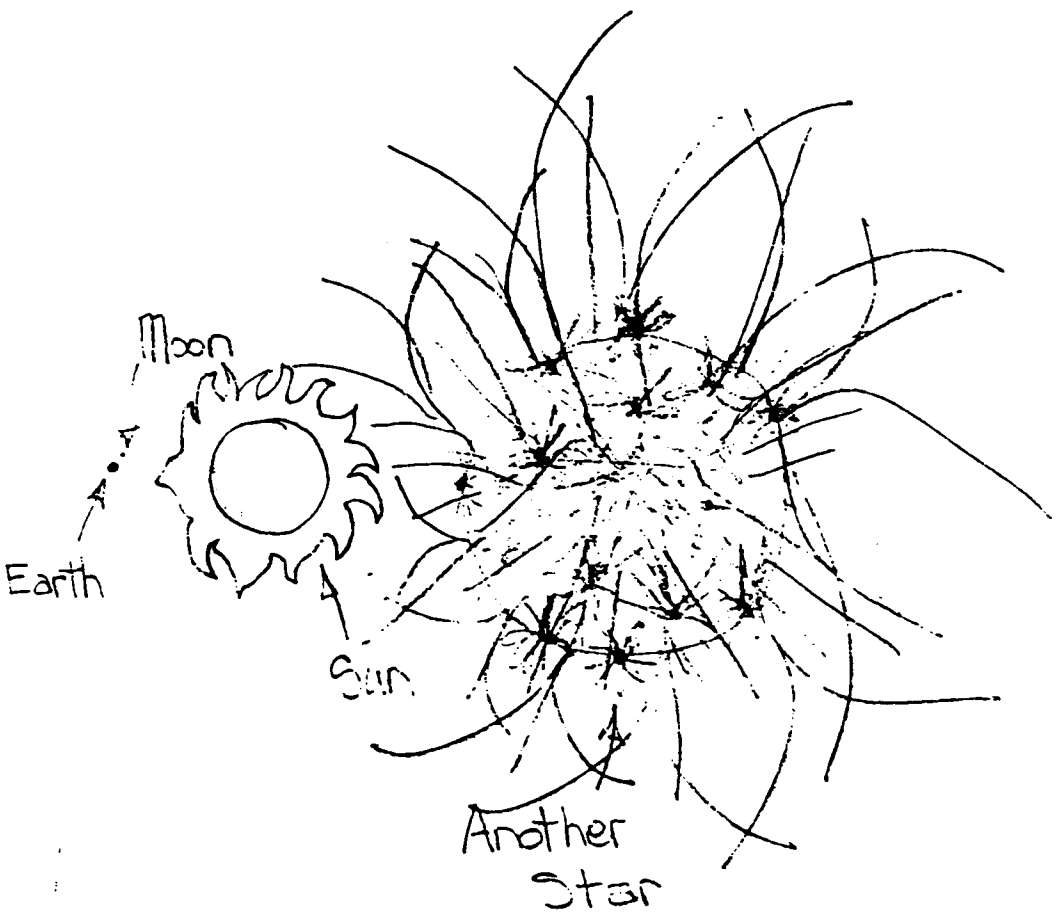
trip back to Earth

9)

separation command module splashes

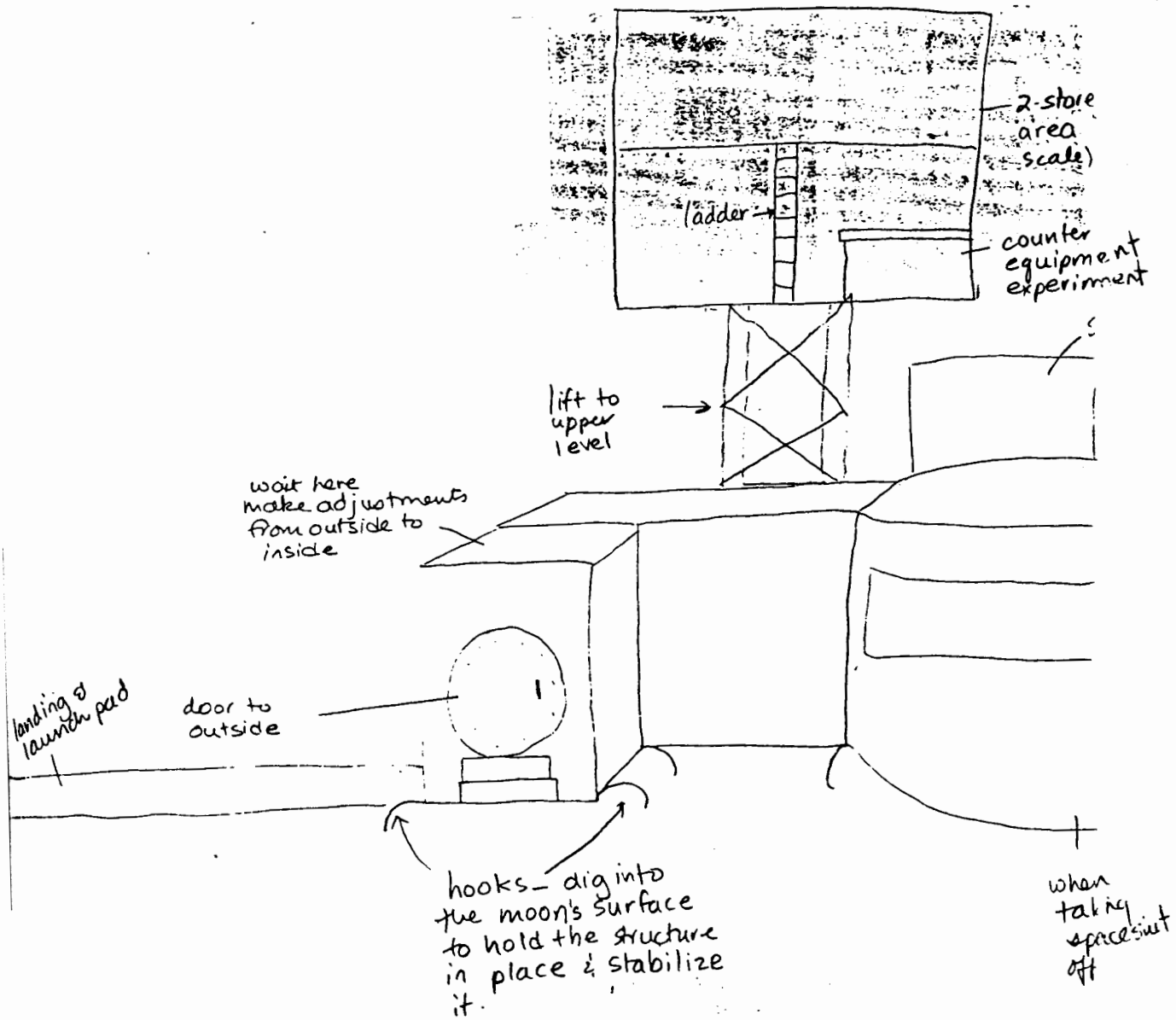
Amazing Fact:

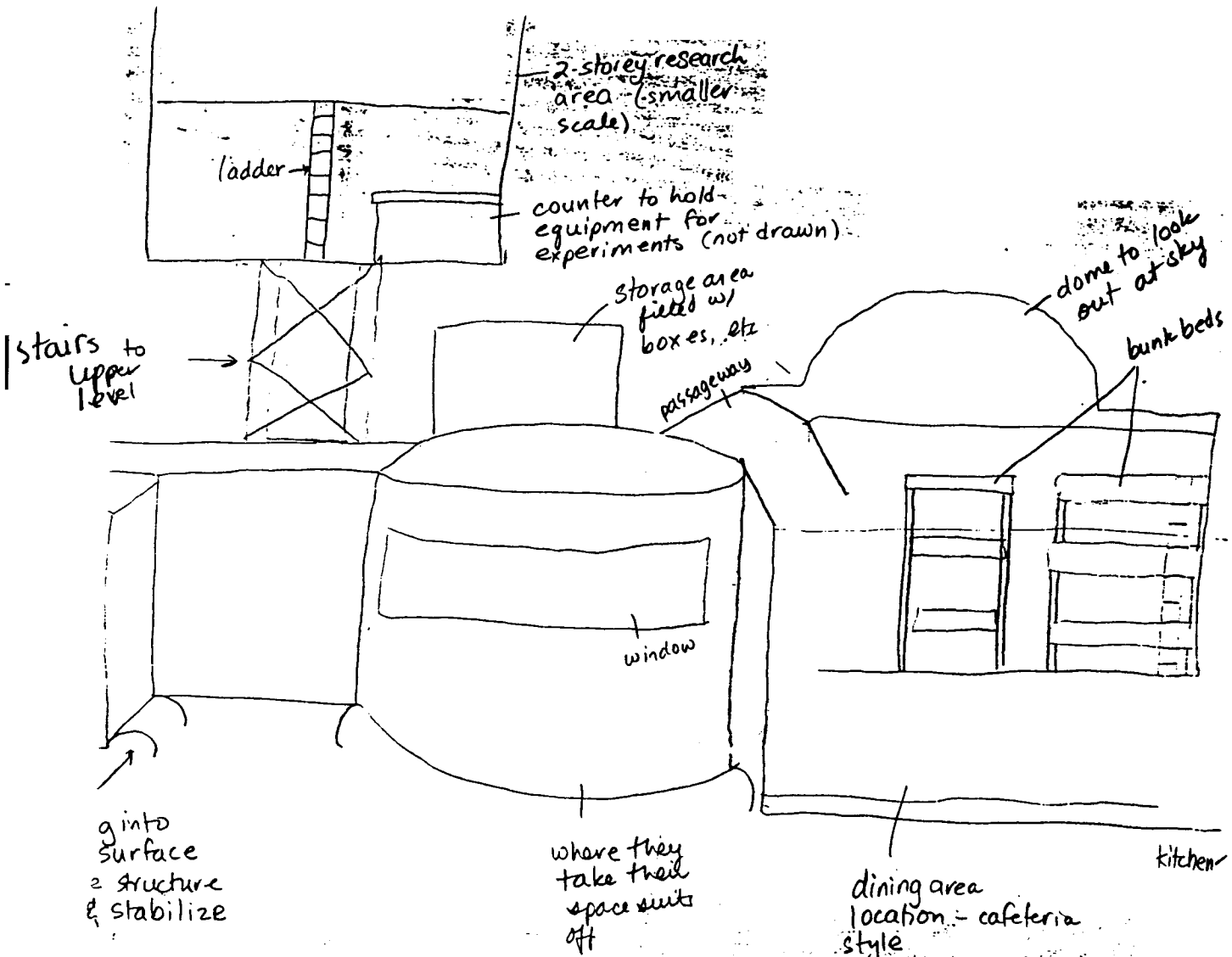
That if the sun was a basketball, compared to another star, the other star would be a house! And that you can look at a star and actually be seeing it 4 1/3 light-years ago instead of when you are looking at it!



February 7th 13

APPENDIX E: Drawings of a Lunar Settlement




2-storey research area (smaller scale)
ladder
counter to hold equipment for experiments (not drawn)
storage area filled w/ boxes, etc
dome to look out at sky
stairs to upper level
passageway
bunk beds
window
g into surface
2 structure & stabilize
where they take their space suits off
dining area location - cafeteria style
kitchen

APPENDIX F: Post-session Notes

Post-session Notes - [redacted] - Session #1 **93/01/20**

Started today with a little overview about the project, consent, issues, etc., then spent most of the session doing the background knowledge assessment. I started with some fairly open-ended questions about why [redacted] was interested in this topic, and what she already knew, and where she had previously learned about space and space exploration.

Then I moved on to more specific questions keyed to the material I expect we'll address in each of the six sessions — 50 questions in all; about 8 or 9 for each session. This took a LONG time — in fact, we stopped after Q #35 (just prior to the Session #5 set of Q's). At this point, it was 9:50 — just 10 minutes of the session were left for the learning activities. [redacted] answered most of the questions quite thoroughly; thus, this assessment took much longer than I had expected. I'll finish the remaining Q's next week.

[redacted] knew quite a bit about certain topics — e.g. satellites orbiting the Earth, and what kinds of functions they serve, and about the sun, its hotspots, solar flares, and the radiation given off by the sun (they apparently studied the sun last year in a grade 5 science project). There were also some interesting misconceptions and gaps in her knowledge — e.g. "solar system" is the process of how we get energy from the sun, and stars are tiny — much smaller than our planets, though a little bigger than they look. She didn't believe the scientific explanations about how the solar system was formed — as everything is so complex — God must have made it. She seemed very interested in the details of equipment and scientific studies, but not very interested in science fiction or speculative or fantastic ideas (space aliens, etc.).

Note: All names have been blacked out.

After the questions, we watched 5 minutes of the video "In the Beginning – The Miracle Planet" — a portion near the beginning describing the solar system and showing the planets — then we looked at the Atlas of the Solar System p. 8 showing the relative size of the planets, sun and moons of planets — which [redacted] seemed to find very interesting. I talked a bit about the shape of the solar system, orbits, and the fact that Pluto isn't always the most distant planet, and some theories about how our solar system was formed.

Then our hour was up, but I kept [redacted] a bit longer (with her agreement) and we made a "string solar system" as described in the Judith Herbst book — chapter 4. 153 feet of string, with each 1/2 inch representing a million miles. We didn't have time to take it outside and stretch it out, but [redacted] took it along. At recess, I encountered [redacted] and a bunch of friends coming back into school with the string partly rolled and [redacted] enthusiastically informed me that it stretched all the way to the end of the school yard and beyond.

When [redacted] left, I gave her a notebook and asked her to jot down anything she did in the next week (watch movie, read) related to space or space exploration, or any ideas she had about space, and to date it. Also, I gave her the Herbst chapter 4 as optional reading (more about the planets and solar system).

Overall, I felt pleased with the session. The only problem was that we spent too long. I'll have to be very attentive to the time next session. [redacted] seems like a very nice girl and a serious enthusiastic student. We seemed to "click" although the endless Q's certainly didn't facilitate rapport development. Perhaps I should eliminate some questions when I do the final Q's in the final session, and when I do the sessions with [redacted]??

Also, the Hi-8 tape I had was only 60 minutes so I missed taping the part of the session when we measured the string for the string solar system. I'm not sure when it ended — have to check. I need to get some more tapes from [redacted]. Camera worked fine — no problems.

There wasn't much instructional dialogue during the making of the string solar system (untaped) except I defined "inner" and "outer" planets, and [redacted] noted how much closer together the inner planets were, and how very far away the outer planets were.

Post-session Notes - [redacted] - Session #2 **93/01/27**

Session went very smoothly today. I was careful to end by 10:00. Our topic was the history of space exploration. I began by probing [redacted] memory of last session (including related activities she may have engaged in between sessions). She particularly remembered the "string solar system" and commented that it really made clear how far apart the planets were. Also she recalled the diagram in the Rally McNand Atlas showing the comparative size of the planets and moons. — Recalled that Jupiter was really large, and that Mercury was closest to the sun. She said that she especially remembered these things because they were "hands-on" and because they were visual. She also mentioned the video — but didn't say anything specific about what she remembered from the video.

*Note: she might have learned things from the video (e.g. how Jupiter looks; how big Saturn's rings are) but not actually recall it spontaneously in a memory probe as "standing out". Things people learn or remember given a particular cue or context (whether declarative, procedural or episodic) simply might not be mentioned as "standing out" in the context of an EMQ. Memories are very context-bound. That might be a problem with the methodology we are using. — Must be careful to be conceptually clear about what we consider "a memory" to be.

Also, following from this thought, I wonder if I should have probed more vigorously for additional memories? I didn't want to risk prompting her or suggesting events/ideas she wouldn't have otherwise recalled. But it's hard to know how much to probe for, e.g., once she mentioned a memory, such as the string universe, I probed further, asking Q's such as "what did you remember about that?" or "why do you think that activity really stands out in your memory?" But I avoided asking "what did you learn from that?" Should I have avoided that Q?

I also asked [redacted] about between-session activities and she mentioned unrolling the string solar system last Wednesday at recess, and talking to her dad last Wednesday evening about how the sun "burns". (*Note: look up info on the sun because I don't recall that much about it. This is an especially strong area of prior knowledge for [redacted] so I should try to build upon it.)

Anyways — she hadn't noted these 2 between-session activities in the notebook I gave her, so I entered them to model a way to do so and encouraged her to make notes of any activities/ideas re: space between this session and next. Also she hadn't read Herbst chapter 4 (very busy with school projects) and I repeated that it was completely optional — to read if interested.

(By the way, I like the Herbst book quite a lot. She tucks lots of "facts" and ideas into each chapter, but writes in an engaging, enthusiastic narrative sort of way — almost like reading a novel. Also, the reading level is probably quite appropriate for [redacted]s age and the content is fascinating — fun bedtime reading for me, too.)

Then we finished off the remaining assessment questions #36–50.

Today's session could be described as following a "transfer of knowledge" approach. I talked a lot. (Too much, I think. I need to give [redacted] openings to talk and follow her lead a bit more.) Also, I control the materials, pace, and topics too much. One thing I did in this session to try to counteract that tendency of mine, was, near the end when we were looking at maps and photos of the moon, I gave the atlas to [redacted], let her go through them at her own pace, initiating comments and Q's. She seemed very interested in the way the craters on the moon were formed — I wonder if I should bring that video in again (The Beginning – The Miracle Planet) and show a segment involving meteors etc? The video is quite dramatic, but I wouldn't want to spend a whole session showing the whole thing. Also, it wouldn't fit very well with the topics I've anticipated for upcoming sessions.

*A general Q — how much should I stick to planned topics (each will form a fairly coherent unit and "cover the content" initially assessed), and how much should I deviate to pursue queries, interests, and misconceptions that don't integrate well with planned topics?

Anyways, I'm all out of order. We started by talking about ancient peoples and their interest in the stars — Mayans, Aztecs, ancient Britons, Native N.A. Indians, ancient Greeks — specifically:

- why they were interested in the stars/sun/moon/planets
- how they found out about them
- remaining monuments.

I tried to associate all this with the ideas that 1) the stars appear to move E to W across the sky every night — because of the Earth's rotation 2) different planets, stars and constellations are visible in different seasons because of the Earth's orbit around the sun.

While talking about the 1st 4 civilizations, we looked at corresponding pictures in Herbst chapter 2 of El Caracól (Mayan), Teotihuacán (Aztec), Stonehenge (Britons), and a Medicine Wheel in Wyoming (Native N.A. Indians). I tried to personalize the 1st 2 by talking about my adventures in Mexico.

Then, for the Greeks, I told [redacted] about Philolaeus and his ideas and Heraclides and his ideas and tried to get her to imagine their perspectives, looking up at the sky. (no picture — from Herbst chapter 1)

From this we went on to talking about actually sending space craft into space (1st uncrewed flights). We looked together at a chart on p. 537 of the 1993 Canadian Global Almanac of famous "firsts", beginning with Sputnik in 1957. Again, I tried to personalize it a bit by relating these events to events in my life (as this all happened long before [redacted] was born (!!!), I couldn't relate them to events in her life).

Especially talked about Pioneer 10 & 11 and Voyager 1 & 2 and which planets they visited and that they will eventually leave the solar system. *Note: this would have been a good opportunity to probe [redacted]s memories of the planets' characteristics in context. (I need to try to capitalize on these opportunities.)

Then we talked about "manned" space flights, especially culminating in Apollo 11 to Apollo 17 flights in '69–'72. Especially talked about Apollo 11. Again, as this is an area of knowledge [redacted] has, I should have probed here. Tried to personalize it, again. (Rally McNand Atlas p. 422)

Before talking about the Apollo missions, I had thought we would look at some photos of various lunar probes (Rally McNand Atlas p. 426), but I forgot to do this — however, this would fit neatly into next week's topic *remember to include.

We ended by looking at maps and photos of the moon — I gave [redacted] Herbst chapter 2. For future planning:

- I must photocopy all the pages of materials that we specifically look at each session to help track the source of particular memories (constructions of her understanding).
- Next session, we will start an "Amazing Facts about Space" book. We will both pick out facts or ideas or theories that seem especially amazing, write them down, and illustrate them in the session. The book can also be used for other illustrations — e.g. next session when we talk about space craft, we might draw a diagram or diagrams of particular space craft. Also in the final session, [redacted] can do a picture of the space station, or lunar or planetary settlement. She would imagine building — maybe on large paper — I can reduce a copy for me on the photocopier. I would like to obtain a model of a space craft or satellite that I could bring in next time (would we have time to construct one together?).

Final note — [redacted]s great to work with. I must be careful to avoid doing all the talking. (Note — *I did try to talk more slowly this time.)

Post-session Notes - [redacted] - Session #3 93/02/03

Well, today was the day of technical gliches. The cassette recorder borrowed from the CET recorded the 1st side of the tape, but when we went to flip the tape over, part way through the session, the "record" button jammed — I couldn't get it to work. Furthermore, when I listened to a segment of side #1 afterward, the quality of the recording was terrible. The roar of the internal machine noise almost completely masked our voices. This was inspite of placing the recorder on a soft surface, and directly in front of us on the table.

I need to see about either borrowing a better cassette recorder from the CET — perhaps one with an external mike, or having cassettes made from the Hi-8 master tape.

This brings me to the 2nd glitch — one that's especially bothersome. The Hi-8 tape today also is of poor auditory quality. When I prechecked that everything was functioning, I played back the test section, and was able to hear the voice fine. However, following the session, I played back a segment to check and our voices were very quiet. So, I went to turn up the playback volume, and observed that it was already on maximum. Why were our voices so quiet? I then noticed that recording volume was turned down to 2 (on a scale of 10)! How did that happen? No-one has used the camera since I used it last. Is it possible that it was turned down to that level for every session, and that I just didn't notice it because I never attempted to play it back at a high volume? I am very upset about this and irritated with myself. I believe the data is still adequate, but of poorer auditory quality than it could have been.

Today's session seemed a little "flat". [redacted] was coming down with a cold or flu, and wasn't feeling very well. I was very tired as I stayed up very late last night planning this session.

The content of the session was very interesting and quite complex — I tried to relate the info at several levels to give the session coherence. We began by further exploring the nature of space and the size of the universe.

We talked (specifically) about electromagnetic radiation from the sun, the Van Allen Radiation belts, Solar Wind, cosmic rays, the speed of light, and what it implies about the distance of even the nearest stars. [redacted] always seems to be especially interested in info about the relative size and distance between celestial bodies. I talked about the Van Allen belts and ozone to follow-up on Q's [redacted] had asked last time that I don't feel I addressed very well. The discussion about light years addressed a misconception [redacted] had expressed in the preliminary assessment, and also the fact that the sun is a star, and its size relative to other stars addressed an initial misconception. During this portion, we looked at a picture of the Van Allen belts, and took turns reading aloud a section from Star Hunters. I also tried to use analogies to illustrate new ideas, and to link info to prior knowledge — e.g. previous experiences with magnets and iron filings.

From this, I wanted to make a link with the kinds of hazards and necessities of space travel, in order to get [redacted] thinking about why various space craft were designed the way they were. So I began by asking her — and listed what she said, expanding or clarifying or giving an example where it seemed called for. (In this session, I wrote down a few specific facts, and the list of considerations as we talked about it, so that we could both refer to it as needed — she kept the page.)

We then looked at a diagram of the flight path of Apollo 11, and each part that separated at each stage of the flight. No, 1st we looked at some photos of the Apollo 11 flight and some other mission — and I drew [redacted]'s attention to the need for pressurized space suits, the need for a rocket to launch the space craft into orbit and so on. — Then the flight plan . . .

Then we looked through some photos of robotic space craft e.g. Mariner 10, Venera etc. — commenting on how they designed them to cope with various problems — e.g. high temps. near Mercury, pressure, temp. and sulfuric acid in Venus's atmosphere, and so on.

Then at the end we each picked an "amazing fact about space" and wrote it down and illustrated it. [redacted]'s fact was the size of the sun relative to other stars. Mine was the complexity of coordinating all the

maneuvers that made up the Apollo 11 flight. [redacted] will keep these pages in an "Amazing Facts about Space" notebook.

- ended a bit late
- gave [redacted] the "Amazing Facts" book, a note home, and Herbst chapter 3.
- once again, I observed that [redacted] was not very detailed in the "EMQ" at the beginning, despite my attempts to probe further — few memories stated and very vague.
- next session — the space shuttle program with models!

Post-session notes - [redacted] - Session #4 93/02/10

Okay — first a confession. Usually I write the post-session notes on the afternoon after the session. But this week I didn't have time, so it is now two days after. Session #4 was a very different session than the others. It involved much more doing, and much less talking.

First of all, the memory probe — [redacted] recalled a lot from the previous session. She remembered about the Van Allen belts (though she couldn't recall the name) and the importance of maintaining pressure in space, and the size of the sun relative to other stars. (This was the "amazing fact" she had chosen to write about and illustrate in her "Amazing Facts" book.) She also remembered the fact that on leaving the Earth, the flight path was not a straight line, and that various rockets and boosters dropped off the space vessel at various points in the flight. She recalled that the landing platform of the lunar module became the lift-off platform for leaving the moon. (I had illustrated these things in her "Amazing Facts" book.)

She also had read half of Herbst chapter 3 — the chapter on the moon and was very taken with the theories of the moon's formation talked about in that chapter.

In today's session, we focused on the U.S. space shuttle program, and the reason the session was so different is that I brought in lots of concrete materials and I did far less talking. We started by looking at a picture of the space shuttle at launching in the Star Hunters book. I talked about the shuttle program, and also [redacted] posed several questions (e.g. about what kind of fuel was in the rockets — which I answered rather vaguely, out of ignorance).

We then looked at the two small space shuttle replicas, and [redacted] handled them and asked a bunch of questions. Then I brought out the large boxed model of the space shuttle. We began by looking at the pictures on the box. I talked about "payload" and pointed out the bay, and the stuff that

could go in it. [redacted] pointed out a picture of a satellite that could be carried in the bay.

I asked [redacted] if she had ever made a model before — she had not. She was very enthusiastic about trying. So we got out the instructions (all pictures — no words!) and began trying to figure out where to begin. As I had looked it over beforehand, however, this didn't take long, and we were soon selecting pieces and painting them. We did this rather silently and companionably for about half an hour, then took a few minutes to each add a fact to the "Amazing Facts" book. This made [redacted] late in getting back to class, as she made a lengthy entry and became very involved in illustrating it. Her fact was about the theory of the moon perhaps being a piece of earth that broke off, but that the "Roche Limit theory" contradicted that theory of the moon's formation. She seemed very interested in this because it wasn't a clear-cut "fact". She was surprised that scientists would hold a theory that could be shown to have such a serious flaw.

I wrote about the fact that prior to the development of the space shuttle, the Americans had had no way to rescue astronauts on space missions. I illustrated it with a sad-faced person in a space capsule saying "help".

I don't believe any misconceptions about space were expressed today. Clearly, [redacted] has revised some of her previous conceptions — e.g. that the stars are "tiny". In fact, it seems that the ideas we talk about that are of particular interest to her are those that contradict prior (mis)conceptions, or fill in areas of lack of knowledge of which she was already aware.

I'm also interested to note that [redacted] seems to recall info that she reads about more than things we talk about, look at pictures of, or view on a video. Also choosing a "fact" and writing about it seems to help make it memorable.

The one concrete activity — string solar system — seemed to make a big impression. It will be interesting to see what she recalls of Session #4's very concrete activities.

I have been thinking about how we will analyze and write about these data. It seems to me that the great potential of a theory of episodic memory is how it can help us understand how a learner constructs knowledge. This angle seems far more intriguing than trying to fit episodic memory into "old" "mechanistic" models of memory. Of course, this is why we have been particularly attending to misconceptions, and how they "fit" with the memories [redacted] reports.

Post-session Notes - [redacted] - Session #5 93/02/17

Well, today's session, because of the ongoing problems with the cassette recorder, and also because of my concerns with the volume of the audio on the Hi-8 , I decided to use the piezo-electric external mic on the camcorder. However, when I ran my pre-session check of the equipment, I discovered that no audio was recorded at all. So, assuming the battery was dead, and as [redacted] arrived at that moment, I ended up using the attached mic as usual. (Later, when I had time to take another look at the piezo-electric mic, I discovered it was lacking a battery altogether.) I didn't bother to tape with the cassette today; rather I'll have IMC dub the audio onto a cassette when I have the VHS copy made.

The session, as usual, began with me asking [redacted] what she recalled from last session. Not surprisingly, she remembered painting the space shuttle model. In fact, she was able to recall every single piece that we painted and how it looked, when I probed further. She was confused between what we had done in the session, and what she had read since last session, causing her to "draw a blank" on the rest of the session. Then, suddenly, she remembered that I had brought in two small space shuttle models, and described those to me. Interestingly, one "stray" memory crept in — the idea about the sun being relatively small compared to some other stars (this was actually a topic from Session #3, not #4, and was the "amazing fact" [redacted] had entered in her book 2 weeks ago).

We then talked about between-session space activities — [redacted] had finished reading chapter 3 of the Herbst book, which included a story of an imaginary visit of a tourist to the moon. She also read to the top of p. 19 of Herbst, chapter 2. The ideas that intrigued her were facts in the reading — not the fantasy elements.

Next, we watched the 15 minute video "Canada in Space". The focus of the video was Canada's communication technology — history, why Canada was sending up communications satellites, and how this technology is used for practical purposes. We stopped the video at a couple of points to comment on things.

Next we discussed Canada's more recent accomplishments in space (since 1982), and areas other than communications. We looked at a chart of space accomplishments in a book by Doris H. Jelly (1988) Canada: 25 years in Space, p. 147. Then we looked at a picture of the Canadarm (Jelly p. 131) and talked about it. I tried to explain how it gripped things, and I sketched a picture of a camera — like diaphragm. Then we looked at Jelly p. 139 at a picture of Marc Garneau in the space shuttle, and then we looked at Jelly p. 142 at a picture of the Mobile Servicing System (MSS) to be built by Canada for the space station being planned.

I'm not sure about the order we looked at the next pictures, but I believe it was as follows. We looked at some excerpts from Apogee: The Canadian Space Agency Newsbulletin, (Sept, 1990); — p. 6 Roberta Bondar — and we talked about the kinds of experiments she did; — p. 7 the space shuttle, and the Spacelab module carried in the shuttle bay; — p. 5 another picture of the MSS, and how it could be controlled manually, or from a computer panel inside the lab. Then we looked at a colour photo of Roberta Bondar from a pamphlet, then at a newspaper clipping from Jan. 22 from the Vancouver Sun listing six jobs available at the Canadian Space Agency, and another Vancouver Sun clipping (Jan. 25/93) showing two Soviet cosmonauts leaving for the Mir space station.

From this, we went on to talk about space stations. We looked at the space station poster depicting past and planned space stations, and discussed the different parts, equipment, design, and space craft used.

Finally, we went on to work on the space shuttle model. We glued together all the pieces we painted last day. (Not many — I can see completing the model would take a lot of hours!) We didn't have time to complete an "amazing fact" in the notebook — [redacted] volunteered to add one on her own. I gave [redacted] the Apogee handout (pp. 5-8) to read if she wished.

Next session is our last! We'll do the EMQ as usual, then spend a little while (15 min?) designing an imaginary space station (and/or moon

settlement) of the future — using large paper and pencils and felt pens. Then we'll redo the assessment Q's.

[redacted] delivered a note from her mom in response to the note I sent home after Session #3. She sounds interested in hearing about the results of the project. I wonder whether we should have some sort of post-session presentation to which [redacted] and [redacted]'s parents and teachers can come and hear about the project? What sort of format will be appropriate? Who else should come? How might [redacted] and [redacted] take a role?

Post-session Notes — [redacted] — Session #6 93/02/24

As usual, we started today with a memory probe about what [redacted] recalled from last session. [redacted] talked about watching the video, then she talked about the space station poster — especially recalling the planned space station "Freedom", and then she recalled working on our space shuttle model.

After discussing what she recalled from last session, [redacted] said she had finished reading the rest of the material I had given her. She had read the articles from Apogee, and commented about the MSS (Mobile Servicing System) which she mistakenly labelled "Canadarm" and how it would help build the space station to be built. She mentioned that medical experiments done in space might help us find cures for diseases. She talked about "space rust". She mentioned she had finished reading the rest of chapter 2 of Herbst and commented about Stonehenge and how scientists don't know exactly how it was used.

Then I asked [redacted] to describe what a settlement on the moon would be like, and what features it should have, and how she would design it. Then I gave her a large sheet of paper and asked her to draw her design for a lunar settlement. Once she got started, I asked her to explain what she was drawing as she drew it, and to explain why she designed it that way. I will photo-copy her drawing and annotate it.

She drew her moon settlement very carefully, starting with a round hatch-like door and airlock, a passageway, and a cylindrical room in which to take their space suits off. This room had a narrow rectangular window. Then she drew a scaffolding-like structure to take people up to a 2-level research lab. This had a lift in it. She drew a ladder in the research lab for getting up to the 2nd level, as ladders are more space-efficient than stairs. She explained that there would be a lot of apparatus for doing experiments in there, and drew a counter. Then she drew a rectangular storage area. Then she drew a passageway and a domed sleeping area, with 3-tiered sets of bunks. In front of this, she sketched in the location of the dining area in front of the sleeping area, and described it as having tables and chairs, but

no waiters — diners would have to get their own food "buffet-style" or "cafeteria-style". She noted where the kitchen would be located. Then she drew a landing and launch pad near the door — so that reusable space craft could arrive with supplies (esp. air) and leave again.

Many of the ideas about how the space settlement might be designed seemed to come from the narrative in chapter 3 of Herbst about a fantasized visit to the moon — e.g. the airlock, and the area for suiting up and taking space suits off, and the domed roof to look up, and the dining room idea. Other ideas seem to have come from our session on space stations — e.g. the scaffolding-like lift to the upper levels, the cylindrical area, the mail-slot shaped window, and the importance of having a research module.

Then we went on with the 50 questions that we had done at the beginning of our session. I found it interesting to note how ideas we had talked about found their way into her answers. For example, she now described the sun as a star, which is not as big as some other stars, and she recalled the multistage space craft going to the moon (i.e. the Apollo series — although she did not label it as such). But actually, what I was quite interested to note — amazed, in fact — was that so many of the ideas she had reported from session to session had disappeared, and new "misconceptions" had crept in. For example, rather than mentioning gravity or atmosphere, she described the Earth as having "force fields" around it (a term which she did not seem quite satisfied with), and she seemed to have confounded this with the Van Allen belts. Also, she seemed to think there was lots of pressure out in space which had to be kept out with space suits so people wouldn't explode. And so on. This reinforces my observation in my previous work with grade 2 students learning about chipmunks is that one of the very interesting things about misconceptions is not how they persist, or how to ameliorate them, but rather how they are created or constructed during learning. I was astonished to note that ideas and themes that were reported in quite a detailed, accurate way one week after sessions had disappeared or mutated. Of course, this was a different context — I was posing a list of questions which she had to answer, rather than asking her to recall a previous session and describe what she remembered.

One final note — after the Q's, we did a "debriefing". By the way.. I used the piezo-electric mic today and the sound quality seemed excellent. Also, I read the camcorder manual, and it seems that the audio had been set correctly at the earlier sessions — the recording level dial that I had been concerned about is only necessary to set for manual adjustments — I have been using automatic audio level all along so that dial wasn't relevant.

All-in-all, our last session was very interesting. [redacted] would liike to be involved in a presentation to her parents and teacher, and perhaps other students.

If I brought the space shuttle model in (after [redacted]'s sessions are finished) she said she would be very interested in working on it at noon hour, etc.

Post-session Notes - [redacted] - Session #1 **March 3/93**

Well, today I started all over again with a new student — [redacted] s 12 in grade 7. He is also in Mr. [redacted]s class — it is a combined grade 6–7 class. [redacted] came in just as the bell rang and I was fiddling with the VCR, which wasn't working. Together we looked at it and mucked around until I discovered that the connecter cable from the VCR to the T.V. was hooked up incorrectly. — So that was [redacted]s initial introduction to the session (this doesn't appear on the tape as I hadn't turned the camera on yet).

My plan for the session was very similar to the plan for the initial session with [redacted]. However, I decided to watch the time closely and stick to my one-hour time limit. So, if we were short of time, I decided I would save the "string solar system" activity until next session. Also, I planned to add a few more facts and definitions about the solar system that I omitted in the series of sessions with [redacted] in order to make the session a little more coherent, and also to introduce some basic ideas that would be referred to again and again through the sessions (e.g. an explicit definition of "orbit" and "rotation").

So, we began with an introduction — our names, [redacted] s age and grade, what to call each other, a discussion of the nature of the research, a description of what the sessions would be like, and a verbal consent from [redacted] to participate, and his freedom to withdraw at any time. He had no questions for me at this point.

The first question I asked [redacted] was what he knew about the things [redacted] and I had done together in our sessions. He said he knew basically nothing except that we had made the string solar system (and he described it).

I then went on with the open-ended assessment Q's, followed by the assessment keyed to session topics. Overall, my impressions were that [redacted] seemed fairly knowledgeable about space and space exploration (more so than [redacted]), and that he expressed few misconceptions. If he was uncertain about something, he didn't tend to speculate, even though I believe I encouraged him to. (I should look back at both [redacted]s and [redacted]s session #1 tapes and try to determine if my style was substantively different between the two students — did I wait longer for [redacted] to answer? probe more? emphasize more strongly that she ought to guess?)

Also, another interesting difference (I can't help but compare this 2nd time round!) was that while [redacted] was especially interested in the specific scientific facts and theories, and details about equipment and why it was made that way, [redacted] was somewhat more interested in fantasy and futuristic stories about space. For example, he plays video games of a space fantasy type (dodging planets and asteroids; shooting bad guys) and watches Star Trek and Star Trek: The Next Generation on T.V., and has seen the Star Wars series. Another example of this is that when I asked him about the features he would include in a space station or lunar settlement if he was designing one, he didn't talk about life support features, structural arrangement, transportation or equipment, but rather about setting it up so tourists could visit from Earth, and planting things to make it more pleasant, and yet keeping it "exotic looking" (my words) so that visitors wouldn't think it was too much like Earth and therefore boring.

One thing that I'm sorry about is that I don't think I probed vigorously enough for the sources of all his current knowledge. He described "T.V." as the main source. I also don't think I questioned him enough about experiences or events associated with memories.

We went on to the session topic — space and the solar system. We began by watching 5 minutes of the video "In the beginning – The Miracle Planet" — which introduced the 9 planets. I asked [redacted] to stop the tape if he wanted to comment on anything, and he did once. After, I probed his reaction to the video, and this led neatly into the other topics I had planned to talk about.

For example, he commented about Saturn's rings and his belief that they were made of gases (a misconception, which I corrected). He was surprised that some other planets also had rings. We talked quite a bit about Pluto (its orbit, its current "closeness" to Earth) and we looked together at pp. 8 & 9 of Atlas of the Solar System. [redacted] seemed to find this quite interesting.

One thing I noticed is that he poses interesting questions — like — how do scientists know how long it takes for our solar system to go around the galaxy? Also, he is quite interactive — we took turns talking and commenting on things, rather than me dominating the talking quite so much. ([redacted] was more reserved.) Also, he has a sense of humor.

We ran out of time so we didn't do the "string solar system" today, nor did I give him Herbst chapter 4 yet. We'll do those things next day. I asked [redacted] to keep a record of his between-session activities re: space.

From what Mr. L. (the principal) had said, I had anticipated that perhaps [redacted] would be very boisterous or outgoing, but I didn't find that to be the case in this 1st session. Also, from Mr. L's comments, I had thought [redacted] would be especially interested in technology (the VCR, the camcorder) but that was not apparent today.

— A very interesting and smooth flowing session today. I'm looking forward to working with [redacted] again next week.

Post-session Notes - [redacted] - Session #2 **March 10/93**

[redacted] and I had our second session together today. Next week is spring break, so we will have a two week gap between today and our third session.

My global impression was that the session went well, but that (as usual) I had prepared too much to cram it all into one hour. Also, I'm finding I really enjoy working with [redacted] He is a charming fellow, and quite willing to actively engage in the conversation or activities. Of course, my tendency is to want to control the flow of talk and each step of each activity myself. I try to hold myself back and let [redacted] take over to the degree he seems to want to — to initiate topics, or take the conversation in directions unanticipated by me.

Of course, this is less "safe" in that [redacted] tends to pose interesting "how" questions that sometimes I don't know how to respond to. For example, today, when we were talking about ancient Greek astronomers and how Heraclides discovered the rotation of the Earth, [redacted] wondered how he really knew the Earth rotated (rather than the sky moving above a stationary Earth as others believed) seeing as he couldn't go out into space and look at the Earth and observe that it rotated. I offered a couple of lame comments about the different between theories and truth, and questioned at what point theories come to seem "true" to us. But, in fact, what was Heraclides' evidence that the Earth rotated? I don't know exactly. Perhaps this sort of thing would be less of a problem if I had greater expertise in this subject area. On the other hand, perhaps the points on which the instructor's ignorance would be revealed would simply be more esoteric. This tension between knowing and not knowing, and who is considered to be a holder of the knowledge and who is a learner is always there. [redacted] sees himself as a holder of knowledge, and is willing to challenge the knowledge of authorities (i.e. me!).

Okay, I'm going to start at the beginning now and discuss the events of the session chronologically. We began with the memory probe of last session's activities. [redacted] remembered a great number of "facts" from the

video and the diagram of the solar system that we looked at in the Atlas. I wonder, however, how many of the things he reported remembering were in fact "new" to him. Recall that he had already possessed a great deal of factual knowledge as shown by his responses to the assessment questions. It makes sense that we are likely to remember things that we already know as they are more firmly anchored (have more elaborations; more associations). Which "new" ideas or facts do people seize upon and recall? It would be very interesting if it turned out that they recall things that fill in missing pieces that they were puzzled about, or if the "new" contradicts a currently held theory or belief, but can't be readily explained away. [redacted] did make a couple of minor errors in stating recalled facts, e.g. he described Jupiter as having rings, and of the 4 planets of the inner solar system, he was only able to recall Mars and Earth.

[redacted] hadn't added anything to his journal. I showed [redacted] a clipping from yesterday's newspaper blaming high tides caused by the moon's closeness to Earth for an accident in which a tugboat pulling a crane on a barge crashed into Cambie Street bridge. [redacted] seemed puzzled at this but didn't specify what puzzled him.

We then went on to make a "string solar system". [redacted] seemed to be quite enthusiastic about this, and while we worked on measuring the string, several points of fact about the solar system came up in conversation. At this point, half the session was over. We talked about how the stars appear to move across the sky.

Then, we went on to talk about the history of space exploration, from ancient times up until Galileo. We looked at pictures in Herbst, chapter two that illustrated El Caracól, the Temple of the Sun, Stonehenge, and Bighorn Medicine Wheel. During this portion, I did quite a lot of talking, and it seemed to me (from [redacted] facial expression and occasional yawns) that he did not find this particularly interesting. I tried to personalize the info, by adding historical and personal anecdotes, just as with [redacted] for this topic.

Then we looked at pictures in Star Hunters of Ptolemy's universe (Earth at the centre), Copernicus, and Galileo. [redacted] seemed to find this much more interesting — the pictures certainly were much more visually interesting (large, in colour, in a variety of formats, as contrasted with Herbst's small, b & w photos). Who was Cleopatra's brother? [redacted] suggested that Ptolemy was the guy, I disagreed, then we looked in the text of Star Hunters to see what they said about Ptolemy. "We know very little about Ptolemy's life before he arrived at Alexandria. Even his nationality is uncertain, but his name suggests that he might have had Greek and Roman ancestors" (p. 39).

I had planned to go on to talk about modern times space travel (uncrewed missions) beginning with Sputnik, but at this point it was 5 to 10. So we each chose an "amazing fact" to write out and put in [redacted]'s "Amazing Facts about Space" notebook. I wrote that it was amazing that ancient people were able to gather so much information about the stars and planets just by observation and record-keeping. [redacted] wrote that it was amazing that we have sent spacecraft to all the planets except Pluto, considering that they are so far away. I also gave [redacted] 2 chapters from Herbst to read if he wishes (chapter 4 & chapter 2), and that ended our session. [redacted] took the string solar system along with him.

One point that came up in our conversation today was whether or not there is life elsewhere in the universe. [redacted] believes there must be. Also, [redacted] seemed quite interested in Mars — the red planet, as he mentioned it several times. Perhaps in analyzing the transcripts of these sessions we ought to do a count of topic initiations by [redacted] and [redacted] as a clue to their interests re: space. Also, there's an interesting chapter on Mars that I read somewhere (where?) that I should copy for [redacted] Herbst chapter 7.

It is interesting to contrast [redacted]'s and [redacted]s learning styles. [redacted] seemed to be the "perfect" student — conscientious, interested in whatever facts were presented, cheerful, hardworking, quiet and passively receptive. By contrast, [redacted] seems much more interactive, proactive, willing to confront or contradict, selective in what he finds interesting, and poses more inferential and theoretical questions (rather than just factual).

I have found both students very enjoyable to work with, although I find [redacted]s style to be more "simpatico". [redacted] of course, is older than [redacted], one grade higher, and has greater knowledge of the subject area.

Post-session Notes - [redacted] - Session #3 March 24/93

Well, there has been a 2 week gap since I last saw [redacted], due to spring break. Overall, I'd have to say I feel somewhat disappointed with today's session. [redacted] was enthusiastic and involved, and technically, everything went well. The problem was the way I structured the session — basically boring — lots of names and dates, but no really interesting concepts or activities. Also, once again, we didn't get through all that I'd planned to "cover", so I'm beginning to worry that we're getting a bit behind on the topics.

Okay, let's start at the beginning. [redacted] came a bit late (he'd been at basketball practice), and then we had to wait through a lengthy P.A. announcement, so we didn't get started until about 9:10. As usual, we started with a memory probe. [redacted] said, at first, that he didn't think he remembered anything except making the string solar system. I asked him why he remembered that, and he said because he was still carrying it around in his bag waiting for a chance to unroll it.

Then he recalled that we had talked about ancient astronomers (he called them "astrologers"), and in particular, he mentioned Stonehenge and the building in Mexico that was circular and had its windows aligned perfectly with the planets [el Caracól]. He recalled that they believed Venus was a god that needed to be appeased (he didn't use the word "appeased"; I can't remember how he phrased it). He also remembered talking about the first uses of telescopes to study the skies.

Regarding Stonehenge and el Caracól, I questioned whether he remembered these facts from our session or from Herbst chapter 2 that I had given him to read. He said he hadn't had time to read either of the 2 chapters I had given him.

I then asked him about between-session activities. (He had volunteered that he had done some things since last seeing me, but that he hadn't entered them in his book yet, immediately upon seeing me, but we had been interrupted by the P.A. announcement.) He took out his notebook

and wrote down that on Friday March 12 he had seen a poster of the solar system at his friend's house, and discussed it with his friend. He commented that the poster had several errors in how it portrayed the solar system. He said Saturn was the only planet shown with rings, and that Pluto was shown as the farthest out, which isn't always true, and that Mars was depicted as being quite far away from Earth while the planets of the outer solar system were shown as being much too close together.

He also wrote down that on the weekend he watched "Star Trek: The Next Generation". I got him to describe a bit about the episode, but it sounds like it was one I haven't seen yet.

One thing I was struck with in this session was what an easy relatively informal way of interacting we seemed to have (considering our respective roles and the fact that we don't know each other well, and that we were being videotaped!). — More joking, and casual asides than in the sessions with [redacted]. Of course, these sorts of aspects make a great deal of difference to the type of instruction and learning that occurs — I know that — yet I was really aware of it again during today's session.

We went onto our first topic — Modern Space Flights (uncrewed). In the 1993 Canadian Global Almanac (pp. 537, 538) we looked at a list of highlights — and talked about those I had underlined. Again, [redacted]'s independent style showed; he scanned the list and commented also on uncrewed flights that grabbed his attention, whether or not they were underlined. This took much longer than I had expected.

I then took out the Atlas of the Solar System (too abruptly?) and reviewed the info about Pioneer 10 & 11 and Voyager 2 & 1 (too redundant). [redacted] commented that one of these (Pioneer 10?) was launched one day prior to (after) his sister's birth. He also pointed out an error — the launch date and date of arrival at Jupiter were listed as identical for one of the Voyager probes. Then we looked at p. 426 which showed pictures of uncrewed lunar probes.

Then I had planned to show pictures and diagrams of Mariner 10, Venera, Mariner 9, Viking 1 & 2, and Voyager, as well as photos of the planets. Somehow, I omitted all this by mistake. Too bad, because I think it would have made the earlier details about these probes much more interesting and memorable. But somehow, the time just continued to fly by!

We went on to talk about crewed space flights — we started with "1st's", then went onto "man on the moon" flights — in particular the Apollo 11–17 missions which landed astronauts on the moon. Then we looked at a series of maps and then photos of the moon. Once again, I wasn't very happy with this segment because I didn't supplement it with photos of space flights as I should have. Nor did it lead to any interesting issues or concepts. This is partly because we ran out of time. I had planned to go on to talking about electromagnetic radiation (what it is, how we have learned about the stars from it, and the dangers it presents to space travellers), then use this to lead into a discussion of why spacecraft are designed the way they are. But as it was, we got bogged down in factual details again.

One thing that was quite interesting was that [redacted] was quite interested in the maps of the moon. He was incredulous that the craters had names, and that anyone could possibly recognize one crater from another, or remember their names. He seems to have a belief that a person can't know something unless he/she goes there and sees it. I asked him "how do people remember the names of things on Earth?" He replied that they read the signs(!). So I said, what if you were off in the bush somewhere — how would you know which mountain was which? (e.g. Mount Robson). He said you'd have landmarks to go by.

I think he kept thinking about this as he looked at the maps because he observed that one particular large crater was depicted on more than one map, and he began trying to identify that particular crater on subsequent maps. He seemed especially interested in the colour of the moon, and the scale of its features. We also talked about craters, and I asked him to speculate about why the moon had so many.

At this point, it was almost 10:00, so we each picked an amazing fact to write about and draw a picture of. [redacted] wrote that it was amazing that people were able to notice craters on the moon and give them names, just by observing through telescopes. In the picture he drew, he jokingly labelled one of the craters "Baitz" after himself (I had joked about that earlier). — Oh yeah, I didn't mention that while looking at the moon maps, [redacted] especially noticed familiar or strange names — e.g. "Copernicus", "Ptolomeus", "Julius Caesar", "Billy".

The amazing fact I wrote down is that so much expensive space equipment has been left out in space floating around as space junk. For next time, I must locate that statistic in the 1993 Canadian Global Almanac specifying the amount of "space junk" out there. Also, we briefly talked about the colour of planets, moons and stars today, and in looking back at it, 1) I have the impression that it is [redacted]s belief that the colours are due to the colour of the soil, 2) this would have been a great opener for introducing notions about the spectrum of light within the wider topic of the spectrum of electromagnetic radiation. Perhaps I can begin next session with these two ideas. But then we'll certainly have to get on with talking about the U.S. Space Shuttle etc. and use the models.

One final thought: perhaps one reason that each topic takes so long is that [redacted] engages the ideas more (than [redacted]). If this is so, he might end up learning more, even though we "cover" less.

Oh yes, Mr. L., the principal, and I were chatting in the hall afterward, and Mr. L. said he'd like to come and observe next session. I hesitated, but didn't really feel I could say "no". Besides, our sessions are fairly easygoing; I doubt it would make [redacted] excessively uncomfortable to be observed (I hope).

Post-session Notes - [redacted] - Session #4 March 31/93

My suspicion about last session being boring was confirmed — [redacted] found it hard to remember anything at all about last session. He remembered what he had written in his "amazing facts about space" book, but didn't remember what I had written, nor anything specific about the session. He recalled that we had looked at some pictures in the "Space Atlas" but wasn't able to specify what the pictures were. He thought maybe we had looked at some pictures of lunar probes, or perhaps, he thought, that had been the time before. I said we had talked about them both of the previous sessions (I was wrong — we only talked about them last time, although I had planned to do that in the session #2 but had run out of time). In any case, when I asked [redacted] to be more specific about what he remembered about the lunar probes, he wasn't able to recall anything.

Since last session, he said he had played a computer game about space called "Hitchhiker". I asked him to describe it and he did, stating that it was a new game, and that he hadn't managed to get past the 19th move yet — he always ended up dead via bricks on the head, etc. [redacted]s description of the game reminded me of Douglas Adams' book The Hitchhiker's Guide to the Galaxy, a book I read a number of years ago. I mentioned this to [redacted] and he said that, yeah, that's what the game was called. Other than the computer game, [redacted] hadn't been involved in any other space-related discussions or activities. Specifically, he hadn't yet read either of the 2 Herbst chapters, not unrolled the string solar system ("it's been too rainy to go outside. . .").

As an opener, I had [redacted] read aloud a paragraph from 1993 The Canadian Global Almanac about space junk. As soon as I mentioned "space junk", he recalled that that was the amazing fact I had written about last week.

Then we went on to discuss electromagnetic radiation from stars (and the sun). I started by posing a question — "Why do planets and stars look the colour they do to us?" [redacted] seemed to believe that we don't see the planets and stars as coloured — only as "bright". I pointed out that,

especially seen through telescopes, they do look coloured to us — e.g. Mars looks red. Regarding the planets [redacted] had 2 correct explanations — Mars looks red because it is red ("yes", I elaborated, "because the soil actually is reddish, it has lots of iron in it), and planets with gases around them look coloured because of their gases (I agreed and gave the example of Jupiter with its stripey clouds).

But [redacted] expressed an interesting misconception about the stars. He said they look bright because they reflect light from the sun. So I pointed out that our sun is actually a star, and that stars are "burning" just like our sun. [redacted] wondered whether celestial bodies (he didn't use this term) had to be quite big to be stars — e.g. if the Earth was too small. So I agreed and talked a bit about mass and pressure and heat.

I then went on to talk about the light spectrum and how stars of high temperatures emit light of shorter wave lengths (e.g. blue) and those of lower temperatures emit light of longer wave lengths (— e.g. red). [redacted] commented that this seemed backwards to him because we think of blue & green as "cool" colours and yellow & red as "hot" colours. It seems backwards to me too! In fact, I checked this fact carefully in my source (Rand McNally's Atlas of the Solar System) when I was planning today's session.

Then I talked about light years and that the light from stars that we see in the sky actually shows us how the stars looked a long time ago. Then I talked about electromagnetic radiation other than visible light and made the point that a range of electromagnetic radiation comes from stars and that scientists can learn about stars by studying it, and also that many of these kinds of radiation are dangerous to us, but that our atmosphere protects us. However, spacecraft that leave the atmosphere are no longer protected.

This led into the topic of what scientists would need to consider when designing spacecraft. I posed the question to [redacted] Once again his view that you can't know about something until you've been there surfaced. He thought that scientists wouldn't really know how to design a spacecraft

because they wouldn't know what to expect in space — e.g. maybe there'd be a dragon up there! (— a whimsical answer). I pointed out that scientists had lots of ways of finding out about space (or at least making good guesses) before they'd actually sent anyone there. But it took lots of really specific probes to get [redacted] to come up with specific issues like the fact that there's no air in space.

He thought of pressure and commented that they'd need to have a pressurized cabin for astronauts. But, like [redacted] he gave the reason that there is lots of pressure in space — a misconception that I attempted to correct.

When I probed about what they'd need to consider design-wise for the purpose of launching, he made the point that the surface of the spacecraft would get very hot during its passage through the atmosphere because of friction, and that the forces of travelling fast through the atmosphere could rip things to pieces (e.g. if you could stick your hand out the window of a spacecraft, it would get ripped off). Both of these (correct) pieces of knowledge he remembered being told by "the guy who came to the school and told them about freeze-dried ice cream". (This display and presentation about space came to the school "a few years ago" and was held in the gym, according to what both [redacted] and [redacted] have said.)

We then looked at some photos in Star Hunters of the Apollo 11 mission, and of early Soviet missions. A discussion of rockets led to looking at the diagram in the Atlas of the Solar System of the Apollo 11 flight path, and I related this to our discussion of rockets, gravity, and space junk.

This led [redacted] to ask whether there isn't a kind of spaceship which can fly in the air and actually land. Yes! — the space shuttle — the topic I had planned to go on to next.

I showed [redacted] the picture in Star Hunters of a space shuttle being launched. He was interested to note that it needed 3 rockets. I commented that the 2 solid rocket boosters were reusable, and they fell back to Earth with parachutes and were recovered, but the other liquid fuel rocket was

not reusable. He wondered why not (I didn't know), and what I meant by solid fuel (I don't really know what they use).

Then I brought out the 2 small space shuttle models, which [redacted] seemed to find quite interesting. We discussed them — [redacted] wondered whether the space shuttle could be launched into space from the Boeing, and I said, no, just for upper atmosphere test flights.

At this point it was about 8 minutes to 10:00, and I realized we wouldn't have time to work on constructing the large space shuttle model. However, I brought it out and we both had a look at it and talked about it. [redacted] said he's not very experienced at making models. Anyways, next week we'll work on it. He commented on the name decals — "Enterprise" and I understood him to mean that it was strange to include the name of the Star Trek vessel, and "Challenger" — he recalled that it was the one that had burned up. I commented that I had looked for information about "the Challenger disaster", but that it was very hard to find any. [redacted] astutely said that they didn't want to publicize it or people wouldn't want to pay to support the space program.

We then each added a fact to the "Amazing Facts and Space" booklet. [redacted] wrote that it was amazing that they could now reuse 3 of 4 parts of the space shuttle and launch rockets (the opposite of my "space junk" fact). I wrote that it was amazing that we could send people into space and bring them back safely, given all the hazards and complications of space travel.

While we were doing this, Mr. L. (the principal) came along with the assistant superintendent of schools and introduced [redacted] and me. He asked me to explain a bit about the project to her. They left and we wrapped up the session, which went a bit too long after all.

On reflecting on this session and others with [redacted], I think that maybe it only seems that we're not "covering" as much material. In fact, this second set of sessions is much more coherent and well-integrated. Ideas and concepts are developed more fully and related to each other, whereas in the sessions with [redacted] I think I tended to jump quickly from

topic to topic, and I didn't always relate the topics to each other, or provide the background info necessary for a more than superficial understanding. On the other hand, it still seems to me that [redacted] and I talked about and did more different things. (Of course, I was less rigorous about keeping to my time frame, so [redacted] and I did actually spend more time together each session.)

I suppose one reason these sessions are different is that now, this second time 'round, I have a better idea about what kinds of confusions and areas of prior knowledge/lack of prior knowledge to expect. Also, as I've mentioned before, [redacted] seems to engage the information somewhat more proactively, which makes a difference. On the other hand, [redacted] seemed more interested in the scientific "how" questions, and also she read the supplementary Herbst chapters, whereas [redacted] has not.

Oh — one last comment — last session was all talking and little doing — also with few visual materials or personal anecdotes. So it's not surprising it was so unmemorable!

Post-session Notes - [redacted] - Session #5 **April 7/93**

Well, what can I say. Today we worked on the space shuttle model. Period. And I had plans to "cram" so many things in today! Oh well — we both enjoyed the session!

Today everything started in a panic. The school secretary was away sick. One thing I have noticed is that when the school secretary is away, most schools fall apart. Anyways, in spite of everything, we managed to start right on time (only to immediately be interrupted by lengthy announcements).

As he entered, [redacted] took out his journal of space-related activities and made an entry. He noted that he had read Herbst, chapter 4. This is the chapter that discusses the solar system, and describes how to make a string solar system.

As usual, I began by asking him what he remembered from last session. [redacted] not only reported quite a large number of specific memories, but was also able to give very clear explanations about why he remembered those things. He remembered the 2 small space shuttle replicas (toys). He described the launch pad model and how the 2 solid-fuel rockets were reusable, but the liquid fuel rocket was not. He described the model carried on the back of the Boeing jet, and mentioned that it was used for upper atmosphere test flights, but that the space shuttle couldn't be launched into space from the back of the jet. He recalled looking at the space shuttle model in the box — said he was looking forward to doing it today. He recalled some pictures we looked at and described them (space shuttle being launched; Buzz Aldrin walking on the moon; footprints on the moon and why they would remain there, the diagram of the flight path of a moon mission and how most of the parts were left out in space, and the picture of the "lunar crawler").

[redacted] then went on to mention that we looked at pictures of all the planets except Pluto. However, I don't think we did; he must be thinking back to an earlier session. Or maybe his reading of Herbst chapter 4 led

him to recall pictures of the planets (from books, or the video we watched the 1st session).

Reasons he gave for recalling these things — he liked the toy space shuttles; he was looking forward to constructing the large model; he remembers things he can do something with; and for some memories, he didn't know why but they just stuck in his mind.

Interestingly, what [redacted] did not report remembering was the stuff on electromagnetic radiation, and the kinds of factors spacecraft builders would have to consider. We spent quite a lot of time talking about these 2 topics (with me doing most of the talking on the first, and him doing most of the talking on the 2nd). However, it was all verbal. No pictures, no concrete models, no drawing activity. I think this has been fairly typical over the sessions — [redacted]s memories seem to be quite firmly anchored in visual images and/or concrete models. However, he also seems to remember discussion (theories, described events) in association with the images/objects.

Then I asked [redacted] to describe what he recalled from the Herbst chapter. He described how "this guy" (a woman, actually) went to see Mercury at dawn at a beach and explained why dawn and beach were necessary. He remarked that Mercury would be visible in November of this year — one of the few times between 1971 & 2000. — Said he wasn't an early riser though!

He commented on how the book described how one could go about locating the various planets in the sky, how they looked and whether or not they were visible by the naked eye or by a telescope. He also talked about the meaning of the planets' names, and how some of them were chosen (e.g. Mars — Roman god of war — named because Mars is red, like blood). He talked a bit more about the colour of various planets, and used the expression "the gas giants" appropriately to refer to Jupiter and Saturn. He said he skipped over the bit about how to make a string solar system.

He didn't report any other space-related activities at this point, but later in the session mentioned he had managed to get further in the Hitchhiker's Guide to the Galaxy video game.

We then went on to work on the space shuttle model. It is amazing how painting and gluing together four wheels and their struts to an airplane body can take a whole hour! Of course some of it has to do with both of us being very inexperienced at constructing models. In my case, some of it was due to the instructions being more or less nonverbal (at the best holophrastic!) and the obscure little diagrams with their letters and arrows weren't particularly comprehensible.

Anyways, we puzzled through it, got paint all over ourselves and the unpainted parts of the model, and filled the room with paint and glue fumes (probably not too great for fetuses). One interesting thing about this activity is that [redacted] and I had basically equal roles, seeing as neither of us is an expert. (I, of course, play the role of expert for most of the other instructional activities, except for, perhaps, the Amazing Facts about Space drawings.) Also, constructing the model does not call for a lot of talking, so we didn't talk much, other than to say things like "Do you think it's dry enough to glue yet?" and so on.

I had thought I might chat about payloads, Spacelab, the astronaut's role in a space shuttle flight, and so on at appropriate moments, but I did not. There simply did not seem to be any moments that were appropriate for that. Perhaps our working memories were overwhelmed with the complex steps of putting the model together — certainly a challenge for both of us. Or perhaps the role of "deliverer of nuggets of information" seemed incompatible with the role of "incompetent model maker". Hmm. . .

So we didn't "cover" any of the stuff about Canada in Space, or Space Stations. I gave [redacted] the 4 pages from Apogee to take away with him to read, and also Herbst chapter 3 (about the moon) and Herbst chapter 7 (about Mars). Also, I sent along with him a note to his mom with the participant feedback form and a photocopy of the consent form.

Next session is our last one!

Post-session Notes - [redacted] - Session #6 **April 14/93**

Last session with [redacted] today. Once again, it was a day in which things did not go smoothly. I was pressed for time to set up before 9:00, and wouldn't you know it — no power! I quickly realized that the electrical outlet in the room was not working, but had some difficulty locating an extension cord to borrow from the school and a functional outlet (2 rooms away). By the time I had run the pre-session camera check, it was almost 10 after 9:00, and [redacted] hadn't arrived yet.

So I went to his classroom to fetch him; he had completely forgotten. Furthermore, on seeing me, he requested that we finish the session early (at 9:30) as his class was going on an outing that morning. I agreed (but wondered to myself how we would possibly get through the final assessment in only 20 minutes).

I started in the usual way — by asking him what he remembered from last session. [redacted] recalled steps in painting and gluing the space shuttle model. I then inquired about between-session activities — he reported none, but then acknowledged that he'd played the Hitchhiker video game some more and was trapped in a spaceship. His answers to these questions were very brief, and he kept glancing at his watch.

So, I started in asking the "final assessment" questions — figuring that in the little time we had, it was better to complete as much of that as possible, rather than taking the time I had planned to look at the space station poster.

I have to say that the questioning was not very satisfactory. I was aware of how little time we had, and also that it was quite possible that I would not have the permission or opportunity to complete the final assessment another day. I very much wanted to complete as many of the questions as possible so that we would be able to compare final knowledge and perspectives with initial ones. On the other hand, I didn't feel I had time to press for details or probe to see why he responded the way he did. It

was a trade-off (once again!) between "coverage" and "detail" (quantity and quality) and quantity seemed to be winning.

Furthermore, [redacted] also seemed very conscious of the time, and provided very brief "bare bones" answers to the questions. He kept glancing at his watch, so the moment it indicated 9:30, I let him go. We had finished only 2 (or 3) of the question sets — unsatisfactorily at that — and hadn't had time for the space station poster or the final debriefing. I asked [redacted] whether he might be able to come for an extra session next week to finish off the questions. He was agreeable and said he'd check with his teacher.

So, I began my packing up. I started by checking the quality of the recording. (It seemed good.) A few minutes later [redacted] returned. His class had already left without him! He suggested we might as well finish the session. I felt awful, as he had seemed very eager to go. He assured me it didn't matter, as he'd gone on the same outing last year.

Anyways, so we did continue on with the session. I decided that since we now had the time, we would take a few minutes to do the other activities I had originally planned, then complete the remainder of the questions last. So I showed [redacted] the model we'd been working on last day. He examined it and we chatted about it, and looked briefly at the diagrams of different payload combinations on the back of the instruction booklet.

Then we went on to look at the poster of space stations. It seemed to me that [redacted] scanned it rather cursorily, and pointed out one or two diagrams (including the space shuttle), but that he didn't seem particularly interested in examining the diagrams in detail, or reading about any of them. My impression was that he didn't find the poster all that interesting (a marked contrast with [redacted]'s reaction). I made sure to point out and comment on the Soviet Mir station, the Soyuz units, the Space Lab, the space station Freedom, and the Mobile Servicing System (being built by Canada).

Then I went back to the question set, and we completed most of the questions (I omitted a few). The pace was a bit more relaxed, although a question-answer format certainly does not lend itself to the kind of comfortable interchange of some of our earlier sessions.

[redacted]'s responses, it seemed to me, were in many cases quite similar to his responses to the questions the first time. As with [redacted], I noticed a few startling misconceptions were expressed. Some of these seemed to have evolved out of our sessions (rather than being prior misconceptions held at the time of the first question set). For example, when I asked [redacted] "What kinds of things did early astronomers do?" he quite accurately described some things we'd talked about (Stonehenge, el Caracól, Ptolemy's model of the universe) but noted that these investigations happened millions of years ago. He also described other galaxies and the Milky Way as part of the solar system. He also said that the sun was not just a star because it's so big and hot.

Interestingly, his persistent theme or belief that we can't know about things until we've been there came up a couple of times — e.g. we don't really know much about the sun because it's too hot to get close to it, and e.g. his question about how scientists could possibly have designed the 1st spaceship without having gone out in space beforehand to find out what it's like.

Also, I was also struck (again) by the contrast between his affective/expressive orientation toward space, and [redacted]'s (and my) more scientific orientation. For example, when I asked him how he would design a space station in session #1, I believe that he emphasized ways of making the space station seem "exotic" and different from Earth so that visitors to the space station would find it interesting. In response to the same question today, he discussed methods of entertainment (e.g. antigravity basketball), and also that it would be important to have a room (e.g. the sleeping quarters) that was just like the Earth (with gravity, oxygen, proper beds, normal food) so that people wouldn't go crazy up there!

Many of [redacted]'s views of space seem inspired by science fiction — e.g. if you wanted to have gravity in a spaceship, you'd just turn on a gravity machine. Also, he wasn't too impressed with the technology that has been developed. For example, the personal thruster system that an astronaut can wear to fly about untethered in space did not seem amazing to him (it did to me!).

We ended with the debriefing. [redacted] posed a couple of final questions, and we discussed working on the model some more at a future time, and doing a presentation for [redacted] and [redacted]'s parents, their teacher, and the principal.

Just to conclude — I want to mention some of the ways in which [redacted] and [redacted] differed, so that we don't get carried away with making misguided comparisons about what each learned.

1) They started with very different content knowledge (breadth, domains, specificity).

2) They have different driving interests and orientations (as noted above, [redacted]'s orientation could be described as affective/expressive, and [redacted]'s as scientific/technical). [redacted] is interested in and familiar with popular sci-fi shows and video games, whereas [redacted] is not.

3) They have a different style of interacting. I have previously suggested that [redacted]'s style is somewhat more passive and [redacted]'s more proactive, but I don't think that's really accurate. It's more that [redacted] was more receptive to listening to, reading about, and posing questions that addressed facts and theories, and that were consistent with the topic at hand. Perhaps [redacted] was more prone to follow divergent lines of thought, and thus his questions seemed "to come from out of the blue".

4) They seemed to have different orientations to learning. I would describe [redacted]'s view as seeming consistent with a transfer of knowledge approach; thus she was very conscientious in reading all

the materials I gave her, and listening carefully. She seemed astonished that scientists would hold theories that had been "proven" wrong (e.g. the Roche Limit theory pertaining to the moon's origin). [redacted], by contrast, seemed to see our sessions as a chance to discuss things and pose some questions, but he did not follow-up by unrolling his string solar system or reading most of the materials I gave him. He strongly preferred "hands-on" activities, videos, and pictures to me telling him things, or him reading things. He seemed to distrust "facts", but rather, held a more relativistic "anything goes" stance.

5) While I used many of the same materials and brought up similar topics for the two students, the "coverage" of the content (and the actual content itself) was quite different for the two students. With [redacted] we "covered" a lot more, due to her style of interaction, the longer sessions, the fact that she read the supplementary materials, and also because she gave shorter responses to the memory probes at the beginning, which gave us more time for new topics. On the other hand, I think I learned from the sessions with [redacted], and reorganized the content in more coherent ways for [redacted] (except right at the end when we ran out of time). Many of the actual activities in sessions were different — e.g. [redacted] watched a 15 minute video on Canada's role in space, whereas with [redacted] I barely touched on Canadian space involvement — I mentioned a couple of things, and we glanced briefly at a couple of pictures.