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As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Janice Ingrid Wizinowich entitled Figures of Speech, Signs of Knowing: Towards a Semiotic View of Science Conceptualization and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctorate of Philosophy.

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10/22/96

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10/22/96

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copy of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Kathy G. Short

Dissertation Director

4/15/97

Date
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Models for science education, rather than paralleling the process of scientific discovery, have traditionally involved the dissemination of information through texts and controlled lab experiences. These have had limited effect in the development of science concepts. Therefore, the focus of this study was to investigate alternative avenues, such as the use of narrative, for science conceptualization. Despite the potential for narrative as an avenue for science conceptualization, for the most part studies involving literature have not explored this relationship. The purpose of this study was to investigate the process of science conceptualization, with a specific focus on narrative.

This was done through a fifth grade classroom based study where learning experiences were created, focused on the concept of interdependence in relationship to water. These experiences included open-ended, hands-on science experiences, literature discussion groups, self-selected research projects and the creation of narrative pieces based on those research projects.

Data sources included: (a) audio and videotaped literature discussion group sessions; (b) audio and videotaped study group interviews and curricular sessions, (c) individual interviews; (d) learning log entries and reflections; and (e) student narratives. Data analysis was conducted within a semiotic theoretical framework and involved the process of retroduction. Retroduction entails a kind of spiraling dialectic between theoretical considerations and data incidences, from which are generated possible
explanations. These possible explanations or abductions, provide direction for further forays into the data. The process of retroduction lends itself to the creation of data analysis chapters that highlight theoretical issues in relationship to the data or "theoretical memos".

Three theoretical memos emerged from this process. Theoretical memo one explores the role of experience in conceptualization; theoretical memo two focuses on the role of analogy and narrative experiences in relationship to intertextuality in conceptualization; and theoretical memo three highlights metaphor in relationship to the intertextual process of transmediation, whereby conceptualization is symbolized through student generated narratives. Together, these memos provide some insights into aspects of the process of conceptualization that are often ignored both in "real" science as well as science instruction. The implications of the study findings are summarized in light of what is known about the discovery process, as compared to what happens in traditional science instruction.
BACKGROUND

This journey begins with a little girl sitting by the fireplace on Saturday afternoon, peering into *The Secret Garden* (F.H. Burnett, 1910). She found her own secret garden under the willow tree and along the tree-lined streets that formed the corridor to another secret garden—the library. The metaphor of the mysterious garden to be nurtured and cherished as a refuge has traveled with me and offered me guidance and sustenance. But *The Secret Garden* was more than symbolic to me; it gave me the confidence and the inspiration to seek other secret gardens, and create my own wonderful gardens. The varied connections I made with this fine piece of literature were of enduring value, and led me to believe in the transformational power of literature in providing metaphorical understandings. These understandings have pushed my thinking beyond the borders of my own experience.

This journey also begins with my teaching experiences in a Montessori classroom in Hawaii. I was influenced in two very broad ways that are represented by opposite sides of the same coin that symbolizes "education for peace". One side of the coin reflects the individualized nature of the learning process and highlights the importance of a learning environment that provides for individualization.

The second side of that coin carries the message that all living things are interdependent. This powerful message was constantly communicated through the communal nature of the Montessori classroom, where respect for, and sensitivity to, both
fellow students and the physical environment focused our day-to-day undertakings. Interdependence became the organizing concept for a personal philosophy and inspired an interest in environmentalism and the beginnings of a holistic educational philosophy.

To me the concept of interdependence translated into the seeking of a curriculum that encouraged learners to see a theme or concept from a variety of angles and approaches. Included in Montessori training in Hawaii was a course called "Cosmic Curriculum". This course involved the development of units that would be integrated into the other curricular areas (practical life, sensorial, math, language). Although I thoroughly enjoyed developing these units, they were organized around themes such as countries or a particular kind of animal rather than conceptual understandings or themes. Therefore, the connections I attempted to make within the established curricular components seemed shallow and artificial. I wanted to gain a deeper understanding of the learning process and find a way to create a learning environment that would encourage deeper understandings.

This desire towards synthesis through the making of connections, as well as my background with literature, nudged me to want to discover more about the relationship between language and learning; it was this last quest that shaped my journey.

The threads of these core experiences were an organizing feature to a journey that was anything but orderly. Although I can see these threads clearly now, as I began my journey they were thoughts and feelings that were expressed in fragmented terms, but pushed me in one direction or another. This document is an artifact of my continuous journey.
The phase that began at the University of Arizona was initially a very confused and jagged one. Most of my formal experience with language and learning was based on Montessori education. The Montessori language program, having been developed in Italian, a fairly phonetic language, was essentially a high quality phonics program, a “bottom up” approach. Children were first taught letter sound correspondences and then progressed to blending sounds into words, sentences and eventually graduating to S.R.A. readers. Therefore, I had a fairly narrow notion of language processes, yet I was uncomfortable with much of the information processing models that seemed to hold sway. Because of their cumbersome specificity, I felt they did not address the idiosyncratic nature I had observed in learners.

However, my introduction to the reading theory of Ken Goodman and the related process of miscue analysis, as well as transactional theory not only broadened how I viewed language, but caused a complete re-organization of my thinking about language and learning. Rather than seeing language as a system to be acquired and stored through a mechanistic process, Goodman (1984) described reading as a “psycholinguistic process” where “…both the knower and the known are transformed in the process of knowing” (p 97). “It is the search for meaning which preoccupies the reader and unifies the use of the strategies and cycles that the process requires” (p 111). The seemingly obvious notion that the main goal for all readers is to seek meaning provided a unified point of departure from my fragmented and decontextualized notions of language and learning.

When I began to think about this study, I was teaching a class in children’s
literature with Kathy Short and participating in a reading research study designed by Yetta Goodman and Ann Marek. Kathy came to the University of Arizona from Indiana University with strong traditions in children's literature and educational research. These traditions place the notion of "storying" in all its different forms (Rosen, 1984) at the center of the educative process. I began to see the metaphorical value of children's literature expanded into all aspects of the learning process. Furthermore, since the essence of the metaphor is connecting previously unconnected ideas (Rosenblatt, 1988), the making of connections could be considered the essential activity of learners within the meaning making process.

Kathy's (1986, 1988) research focus, centered on collaborative classroom-based explorations with "storying" at its core, provided me with many gentle lessons in the symbolic essence of cognition and the intertextual nature of our thinking processes. I was introduced to the work of semiotic scholars such C. S. Peirce, whose notions of thinking were centered on the construction of signs. Kathy guided me through strategies that stretched my thinking and made me begin to look at text, literature, and meaning making in new ways.

I also discovered the literature that would help me explore the symbolic and connective nature of the learning process. Two authors, in particular, who influenced my thinking, were Jean Craighead George and Gary Paulsen. Both of these authors have created narrative that has the potential for the exploration of science concepts in a way that speaks to adolescents. The main characters of these novels are faced with survival
situations that demand complex problem solving in a natural environment and as such are realistic profiles of conceptualization. I was particularly struck by this idea after reading Gary Paulsen's *Voyage of the Frog* (1989), in which an adolescent boy is blow off course in the process of scattering his uncle's ashes at sea. In order to return home, it was necessary for him to employ all of his navigational knowledge. I wondered what kinds of meanings might be constructed by readers and about the interplay between the narrative and conceptual aspects of the story, between the aesthetic lived through experience and science conceptualizations.

I was able to engage in an initial exploration of this interplay within the reading process through my involvement in a research study using retrospective miscue analysis. Through an N.C.T.E. (National Council of Teachers of English) grant, Yetta Goodman, Ann Marek, and four graduate students, including myself, began a research project that involved using miscue analysis as basis for metalinguistic discussions with seventh grade proficient and non-proficient readers. The procedure involved the reader being recorded reading a passage; this passage was then analyzed using miscue analysis with miscues being selected for discussion. Sometime later, the researcher would interview the reader by discussing the selected miscues.

I noticed the interplay between the types of miscues and the type of text being read. One story that was used, "The Death of a Western Gladiator" (C. Finn, 1958), was a gripping story, which provided an aesthetic experience in that it was narrated from the point of view of the snake, as well as being loaded with scientific information concerning
reptiles and the desert environment. The miscues of one reader in particular seemed to show some ambivalence between her emotional response to the story and its scientific nature. Her miscues and our later discussion of them showed that as she read, she was constructing a story that connected experiential, emotional and informational meaning constructions.

These experiences and speculations had a direct influence on my eventual study. The blending of narrative experience and science conceptualizations and the meaning-making strategies of readers as they engaged with those narratives form the core of this study. Literature as metaphor for concept development and a view of learning as a complex of connection making, collaboration and reflection within a community of learners informed the context for this exploration.

**Purpose of the Study**

This study represents an attempt to explore the process of science conceptualization as it evolves through the reflection, literature group discourse and narrative writing of fifth grade students. Scientific discovery has historically been a circular process that operates on the tension between theory and experimentation (Hanson, 1966; Holton, 1973; Reichenbach, 1951) and operates within a sociocultural context. Therefore the evolution of scientific meanings is embedded in the experiences of individuals, participating in a discourse community. The evolution and expression of new conceptualizations is thought to rest on the dynamics of experience and the symbolic processes such as analogy, metaphor and model (Leatherdale, 1974; Gerhard & Russell,
Moreover, it could be suggested that these symbolic processes are the essence of cognition (Peirce, 1955; Deely, 1982; Langer, 1942) and that scientific knowledge, as is all knowledge, is constantly in process.

However, science has predominantly been taught as a static body of knowledge, rather than the live process of inquiry that it is (Kuhn, 1962; Goodlad, 1984). Pedagogy and research have been primarily focused on the processing of information, rather than the discovery of meaning. A semiotic/transactional perspective of knowledge offers a framework for understanding the process of coming to know as a generative, symbolic and connective process (Rosenblatt, 1981; Siegel, 1984; Short, 1986), that is not restricted to a particular sign system or a particular type of written text within the linguistic sign system. A semiotic/transactional view of conceptualization highlights the potential for the engagement of alternate avenues of knowing such as narrative in generating scientific meanings.

Despite the potential for narrative in science knowing, and while studies in literature have extended our understandings of thinking processes around narrative, for the most part, studies to explore the relationship between science concepts and narrative have been absent (Short, 1995). Therefore, the purpose of this study is to further understanding of these processes by attempting to create a learning environment that offers the possibility for the exploration of science concepts grounded in individual experiences which include past and present narrative engagements.

The study focuses around the following questions:
1. What is the role of experience in conceptualization?

2. What is the relationship between narrative and conceptualization?

3. How do learners use analogy as a process of reasoning in conceptualization?

4. What is the role of metaphor in conceptualization?

5. What is the role of student constructed narrative in conceptualization?

These questions and the data analysis chapters, called theoretical memos, which address them, evolved from a classroom-based study with fifth graders at a Catalina school, north of Tucson. The foundation of the study design involved the development of an integrated theme study focused on the concept of interdependence in relationship to water. The curriculum evolved through an ongoing cooperative effort between myself and the participating teacher. The data collection was qualitative, having been collected through a process of participant observation (Spradley, 1980; Spindler, 1982) using ethnographic techniques that were also, in part, an aspect of the evolving curriculum. This meant that the primary data sources were also components of the curriculum and included:

1. Video and audiotaped literature discussion group sessions.

2. Video and audiotaped study group interviews and curricular sessions.

3. Individual interviews.

4. Learning log entries and reflections.

5. Narratives generated by the students.

The data presented here is embedded in a theoretical framework drawn from
semiotics and the scholarship generated from explorations of the process of scientific discovery. The first chapter is a discussion of broad theoretical issues concerning thought and concludes with a summary of parallel educational paradigms. The second chapter provides an in-depth discussion of concept development and establishes a semiotic theoretical framework of conceptualization.

The data is presented in three chapters which are organized as "theoretical memos," a strategy developed by Siegel (1984) in her dissertation study, a study of the reading process based on a semiotic view of language and learning. The use of theoretical memos is representative of how my thinking evolved throughout the writing process during which I engaged in a reasoning process that moved between forays into theory and analysis of data. The data analysis thus involved a process known as retrogression (Peirce, 1955; Siegel, 1984). In brief, retrogression entails a dialectic between theoretical considerations and data incidences, where explanations for a particular data incidence are generated based on a particular theoretical framework. These possible explanations or abductions, provide direction for further forays into the data. The process of retrogression lends itself to the creation of data analysis chapters that highlight theoretical issues in relationship to the data as they pertain to the study questions.

This process resulted in three theoretical memos. Theoretical memo one explores the role of experience in conceptualization and addresses question one. Theoretical memo two focuses on the role of analogy and narrative experiences in relationship to intertextuality in conceptualization and examines questions two and three. Theoretical
Memo three highlights metaphor in relationship to the intertextual process of transmediation, whereby conceptualization is symbolized through student generated narratives, and investigates questions four and five. Together, these memos provide some insights into aspects of the process of conceptualization that are often ignored both in "real" science as well as science instruction. Finally, the implications of the findings are summarized in light of what is known about the discovery process as compared to what happens in science instruction.
CHAPTER ONE
THEORIES OF COMING TO KNOW

A Brief History of Thought

The history of humankind's search for knowledge can be seen as a constantly changing transaction between philosophy, science and metaphysics. The character of that transaction, formed by the social, political and technological events that define the various historical intellectual epochs, tells the story of humankind's search for truth. The core concepts of that search can be found in the thought of the earliest Greeks, whose "...vision reflected an intrinsic unity of immediate sense perception and timeless meaning, of particular circumstance and universal drama, of human activity and divine motivation" (Tarnas, 1991, p. 17). It is the tension between these two aspects of reality that has driven scientific, philosophical and metaphysical debate throughout the centuries.

Moreover, these two stances emerge from the Greek period through the respective philosophies of Aristotle and Plato. Rationalism became the legacy from Plato, who viewed knowledge as the recollection of ideal forms; and empiricism became the legacy from Aristotle for whom "...knowledge of the natural world derives first from the perception of concrete particulars in which regular patterns can be recognized and general principles formulated" (Tarnas, 1991, p. 59).

Ideas, scientific or otherwise, are not established in isolation, but result from the endeavors of individuals seeking truth about the world within a particular sociocultural context and are built on the conceptions of those that have gone before. Therefore the
conceptualizations of the early Greeks, such as Aristotle, held sway until just before the 
Scientific Revolution, when natural science began an evolution away from theological 
orientation to the logical positivism that is the foundation for contemporary science 
(Renner, 1951; Tarnas, 1991).

This was a time of both philosophical and scientific revolution: in this "post-
Christian era," the search for truth and knowledge moved away from the metaphysical 
realm and into the domain of science and philosophy (Langer, 1942; Tarnas, 1991). The 
thought revolution that was generated provided the philosophical (psychology and 
education) and scientific paradigms that form the foundation of twentieth century 
thought. However, while science, in seeking to understand the natural world has 
surpassed the attempts made by philosophers to develop a science of the mind, the 
parallels between the two are telling (Rosenblatt, 1987; Weaver, 1984).

Francis Bacon formed the empiricist credo that is at the center of experimental 
science when he claimed that truth could be discovered, "...through the careful 
observation of nature and the skillful devising of many and varied experiments" (Tarnas, 
1991, p.272), establishing the simplistic model of induction that was later challenged by 
Charles Peirce (Deely, 1982; Hanson, 1966), among others. A few decades later, 
Descartes established the rationalist approach which contributed two important factors to 
the search for truth: (a) The uncertainties of the sensate world could be overcome through 
the meticulous use of methods of reasoning based on skepticism of all sense perceptions 
and mathematical principles; (b) Reality is characterized in terms of a dualism between
human cognition (subject) and the material world (object). Langer (1942) describes this revolution with the following:

After several centuries of sterile tradition, logic-chopping, and partisanship in philosophy, the wealth of nameless, heretical, often inconsistent notions born of the Renaissance crystallized into general and ultimate problems. A new outlook on life challenged the human mind to make sense out of its bewildering world; and the Cartesian age of natural and mental philosophy succeeded to the realm.

This new epoch had a mighty and revolutionary generative idea: the dichotomy of all reality into inner experience and outer world, subject and object, private reality and public truth. (p. 12)

The tension between rationalism and empiricism seemed to serve the scientific revolution well; by unifying empirical observations with rational mathematical theory, Newton was able to establish a theory of motion that is still the theoretical foundation for contemporary applied science. This borrowed machine metaphor based on the scientific philosophical legacy of subject/object dualism, while serving physical science well, set philosophy on a confusing course that seemed to swing between empirical and rational extremes (Reichenbach, 1951; Randal, 1940). However, neither of these extremes, even in tandem, reflect the dynamics of scientific discovery. Moreover, the machine metaphor, having been proven inadequate in light of the discoveries made in the twentieth century brought about by quantum mechanics and Einstein’s theory of relativity, has been replaced by a non-linear dynamic web of relationships, that are in a constant state of flux.
Newton’s Machine Metaphor

Newton’s theories were based on the notion that the universe was a "great machine" that was ultimately knowable through the pursuit of unchanging laws that governed the motion of the universe (Ferris, 1988; Zukav, 1979). Moreover, these laws made accurate prediction a reality. The main assumptions that followed from this can be summarized as:

1. An objective reality, separate from our own reality exists.
2. Reality is absolute and knowable.
3. Reality is unchanged by our observation of it.

However, the far reaching “intellectual horizon” (Langer, 1942) provided by Newton has begun to change from a metaphor of the universe as a stable machine to that of a constantly changing, organismic web. As we gained access to previously unobservable phenomenon, and more and more significant anomalies began to arise, new metaphors emerged in explanation. Ferris (1988) observes that:

Exploration of the realm of the galaxies extended the reach of human vision by a factor of some 10 (26) larger than the human scale, and brought about the revolution we identify with relativity, which revealed that the Newtonian world view was but a parochialism in a wider universe where space is curved and time becomes pliant. Exploration of the subatomic realm carried us far into the realm of the small, to some 10 (-15) of the human scale, and it, too, wrought a revolution. This was quantum physics, and all that it touched it transformed. (p.286)
Einstein’s theory of relativity made it possible for scientists to expand their vision of the universe with three key notions:

1. All matter and energy is interdependent by nature \( (e=mc^2) \).

2. Time and space are relative concepts.

3. The ever-changing nature of the cosmos makes it necessary to abandon the Newtonian notions of space and time as inflexible, inalterable and ultimately measurable.

Moreover, quantum mechanics, which emerged as a way of explaining subatomic phenomenon, also challenged the assumptions about the universe derived from Newtonian physics. Previously held assumptions about the behavior of matter, such as cause and effect relationships that led scientists to believe that it was possible to, “measure the precise locations and trajectories of billions of particles—protons, say—and from the resulting data make exact predictions about where the protons would be at some time in the future” (Ferris, 1988, p. 288), proved to be false in the realm of quantum mechanics where, “...we can never know everything about the behavior of even one particle....” (Ferris, 1988, p. 288).

These dramatic changes, which “...marked a fundamental change in the world view of physics” (Ferris, 1988, p. 288), have changed forever the previously mentioned Newtonian assumptions about knowledge. Almost harking back to Plato’s notion of the illusory nature of sense perception, quantum mechanics made it necessary to acknowledge that we can only know aspects of material reality; an objective entirely knowable reality does not really exist.
...the mind is such that it deals only with ideas. Therefore, it is not correct to think that the mind actually can ponder reality. All that the mind can ponder is its ideas about reality. Therefore, whether or not something is true is not a matter of how closely it corresponds to the absolute truth, but of how consistent it is with our experience. (Zukav, 1979, p.38)

These ideas are reflected in advances in instrumentation that have made experiences of phenomenon increasingly mediated (Gerhart & Russell, 1984). Ferris (1988) suggests this when he states that:

What we see in an electron path in a bubble chamber is not an electron, and what we see in the sky are not stars, any more than a recording of Caruso's voice is Caruso. By revealing that the observer plays a role in the observed, quantum physics did for physics what Darwin had done in the life sciences: It tore down walls, reuniting mind with the wider universe. (p. 289)

The dualistic notion that separated the observer from objectifiable reality was called into question through the exploration of subatomic phenomena, placing the observer and the observed or the knower and the known in an interdependent, inseparable relationship. Therefore, in the study of subatomic phenomena, scientists began to actually see their impact on the character of the experiment (Ferris, 1988).

The Machine and the Human Mind

Attempts by philosophers to form a science of the mind did not generate the same stunning discoveries enjoyed by the natural sciences. Where science profited from the
tensions between rationalism and empiricism (the use of mathematical theory and experimentation for example), attempts in the field of philosophy to discover the nature of the mind were limited by the notion that knowledge had to either be generated from sense experience or from within the mind, which proved a false and limiting dichotomy. On examining the nature of scientific discovery, especially in this century, the usefulness of a subject/object dichotomy has to be questioned. A philosophical dilemma was created by Hume’s extreme empirical position that, “Man knows only phenomena, chaotic impressions...” (Tarnas, 1991, p.340), and Descarte’s construct that knowledge exists in the mind. In light of Newtonian theory whose power was derived through the unification of these realms, Kant sought a synthesis between them. Summarized by Tarnas (1991):

Kant’s extraordinary solution was to propose that the mind-world correspondence was indeed vindicated in natural science, yet not in the naive sense previously assumed, but in the critical sense that the “world” science explicated was a world already ordered by the mind’s own cognitive apparatus. For in Kant’s view, the nature of the human mind is such that it does not passively receive sense data. Rather, is actively digests and structures them, and man therefore knows objective reality precisely to the extent that reality conforms to the fundamental structures of the mind. (p.343)

Kant’s attempts at synthesis set into motion a legacy of idealistic thought. However, that tradition was ultimately challenged around the beginning of the twentieth century with the adoption of the logical positivistic paradigm by behaviorists seeking to
formalize a science of the mind based solely on observable phenomena. Cognitive science responded from a rational position which held that the effectiveness of a paradigm that ignored the very phenomenon (thinking) that it sought to investigate had serious limitations. However, both approaches held a Newtonian mechanistic metaphor where the mind interacted with the sense environment "...like billiard balls..." (Rosenblatt, 1985). However, the intellectual legacy of Kantian idealism can be found in semiotics (Deely, 1982), where knowledge is seen as neither mind-dependent or mind-independent, but inextricably both. These three paradigms of knowing will be discussed in light of three educational paradigms.

Parallel Educational Paradigms

Because of the historical contrapuntal relationship between science and philosophy, it is not surprising to find striking parallels between advancements in the physical sciences and educational theory (Rosenblatt, 1985; Weaver, 1984). Three paradigms, transfer (behaviorist), interactional and transactional, have been identified (Harste, 1984; Short, 1990) and can be historically derived from educational research (Neisser, 1976). The transfer paradigm represents a strictly empirical approach where the constructive nature of the mind is disregarded. The interactional paradigm, most closely associated with cognitive science, posits the constructive nature of cognition, but as a separate entity. These two paradigms are connected by a twentieth century machine metaphor, the computer, making information processing rather than meaning the focus of human cognition. The transactional paradigm is a view of cognition that extends beyond
the machine metaphor, with a view that highlights all aspects of learning in concert as they occur naturally.

**Transfer, Interaction and Information Processing**

The transfer paradigm, based on behaviorist psychology, dominated the first half of this century. The behaviorists focused on observable behavior (Neisser, 1976; Gardner, 1985) and ignored the thought processes of the individual, an integral part of those behaviors. Learning was thought to take place through a process of conditioning comprised of a series of stimulus response chains (Skinner, 1953). While knowledge was viewed as tangible information that is moved from the outside to the inside (Harste, 1985) and the learner was considered to be, "...almost infinitely malleable...and that the consequences of human behavior are crucially important while mental activity that accompanies the behavior as not" (p. 4). While information was being processed, that information could only be generated from the stimulus environment.

The interactional paradigm developed as investigations into learning focused on the processing of information in relationship to the stimulus environment. As the first half of the century drew to a close, the formalization of the field of cognitive science began by challenging behaviorist notions of learning (Gardner, 1985). This multidisciplinary field, including psychology, linguistics, anthropology, and artificial intelligence, set a new research agenda and sought to investigate the non-public aspects of learning: the mental processes that take place in learning. The computer with its potential as a model for human cognition was added to earlier notions of schema developed by Bartlett and Piaget.
(Dochy & Bouwins, 1990) and the core assumptions of Newtonian physics (knowledge is absolute and exists separately from us). Scholars in the area of cognitive science began to investigate the mental processes of the individual as a separate kind of information processing mechanism (Neisser, 1976). As noted by Bruner (1990) this limited metaphor became the focus for cognitive science:

Very early on, for example, emphasis began shifting from “meaning” to “information”, from the construction of meaning to the processing of information. These are profoundly different matters. The key factor in the shift was the introduction of computation as the ruling metaphor and of computability as a necessary criterion of a good theoretical model. (p. 4)

Based on the organizational protocols of computer processing, schema theory emerged as a predominant model for how humans process information, providing a view of learning by which stored knowledge structures are activated to process information (Rumelhardt, 1977; van Dijk, 1977; Spiro, 1980). Initially, schemata existing hierarchical protocols for processing information, were thought to be rigid structures. These structures would form into appropriate hierarchies in order for the processing of information to take place. But this model of schema theory was an oversimplication of a complex and individualized process and lacked explanatory usefulness in actual learning situations. Therefore, even as schema theory was being developed, scholars had begun to think of schemata more as flexible ever-changing cognitive organizations rather than rigid structures (Neisser, 1976).
The main focus of schema theory investigations into human cognition remains on the systems or networks employed in the storage and retrieval of information. This is clearly demonstrated in a review of schema theory by Bigenho (1992) where various approaches to schema were summarized as:

...concept and slots of supporting information (Anderson, 1985)... relations among networks of propositions (Ellis & Hunt, 1989)...superordinate concept supported by slots of subordinate information (Just & Carpenter, 1987)... rules that produce or describe a prototype (Klastsky, 1980)...clusters of information (Rumelhart, 1980). (p. 19)

As can be seen from this sample, the focus is not on meaning, but the representational structures involved in meaning-making. Moreover, in keeping with a positivistic research paradigm, validity and generalizability can only be established through the abstraction of target information structures (Dochy & Bouwens, 1990; Bigenho, 1992).

Within this paradigm, cognition is investigated as the interaction between discreet elements such as domain specific schematic structures within the mind, as well as points of interaction between those structures and the form and presentation of the material to be learned. This separation makes it necessary to fragment cognition and categorize those fragments as relative to content types. Moreover, schema theoretical explanations of human knowing have generally not addressed the problem of intention and contextual factors (Bierschank, 1991). These fragmentary glimpses into perceptual protocols have added little to our understanding of cognition.
The reunification of all elements of cognition can be found in transactional theory, a third paradigm that is semiotic in orientation, and encompasses both transfer and interactional paradigms by including what behaviorists have ignored and re-unifying what cognitivists have separated.

**Semiotics: Knowing in Transaction**

Semiotics is a theory of knowing from which the transactional paradigm can be derived and will therefore be discussed as a preamble to transactional theory. From a semiotic perspective, knowing is characterized as the construction of meaning through sign action or semiosis. Semiosis will be discussed at length later.

Deely (1982), in his history of semiotic thought, rather than focusing on the history of signs, explores the development of a semiotic logic beginning with the organizational schemes of the Latin and Greek scholars. Two key points of Deely's treatment of semiotics are: (a) A description of cognition as a process of reasoning rather than relative to a specific subject; and (b) the unification in cognition of the mind-independent and mind-dependent aspects of knowing.

As to the first point, Deely (1982) traces the development of logic as it originated from Latin and Greek organizational schemes of knowledge, where logic was associated primarily with scientific knowledge or in other words was content specific. However, in examining the conceptualizations of cognition offered by such scholars as Poinsot and Locke, Deely suggests that a semiotic logic or reasoning process is a dynamic that is involved in all kinds of thinking, regardless of content. This process is suggested in the
following organizational scheme.

Figure 1. A semiotic view of knowledge. Note: From *Introducing Semiotics* (p 65) by J. Deely, 1982, Bloomington IN: Indiana University Press. Copyright 1982 by John Deely. Reprinted by permission.

This chart also addresses the second point, which is that knowledge is considered as the synthesis of mind-independent (ENS REALE) and mind-dependent (ENS RATIONIS). Signs or concepts develop through the indivisible dynamic that obtains through these two aspects of cognition. Semiotics, in that it primarily deals with the logic of conceptualization, is a philosophy that cuts across disciplinary fields. It reconfigures knowing as centered in the convergence of signs unique to the experiences of the individual in relation to the broader context, rather than the artificial division created by the rational/empirical philosophical traditions.

Moreover, according to Deely (1982), the difficulties caused by this artificial
division can be further explicated through an examination of traditional definitions of deductive and inductive logic. Joseph (1916), cited in Deely (1982), summarizes this definition: "We incline to think of Deduction and Induction as processes moving between the same points, but in opposite directions; Deduction, we think argues from the general principles to particular facts, Induction from particular facts to general principles" (p. 71). Joseph goes on to point out that this definition does little to distinguish these two aspects of reasoning and "...leaves out some of the operations of reasoning that best deserve to be called scientific" (p. 71).

Semiotically considered, this definition:

...is replaced rather by the phenomenological contrast between thought in its interaction with the realm of material things outside itself, on the one hand, which interaction moreover is of a twofold character, and thought considered in its internal development according to the relations which are proper to its own realm.

(Deely, 1982, p. 73)

By understanding logic as a function of the phenomenological dynamics associated with material and internal realms, Peirce posited that reasoning could be defined as a process of inference including the elements of abduction, deduction and induction (Deely, 1982). With this definition of reasoning (see Figure 2), abduction takes the place of the traditional definition of induction (the summation of particulars as generated by Bacon). Semiotically considered, "...the mind unifies experiences through the formation of representative notions" (Deely, 1982, p. 73) and induction is more a process of inference than
summation. Therefore, the logical consequences or deductions, established in reference to a specific hypothesis generated through abduction, are observed and synthesized, as they reflect on the hypothesis. Thus, reasoning is understood in terms of the explication and synthesis of experience or semiosis (Peirce, 1955).

According to Peirce's (1955) theory of semiotics, thinking is synonymous with semiosis, a process by which humans make sense of the events of the material world; the meanings that are generated are called signs, "... every thought is a sign" (p. 274). Unlike the Saussuerian model, in which signs have been considered as dyadic relationships between sign and signified (Rosenblatt, 1988), Peirce designated a sign as being a triadic formation (see Figure 3) which also includes an interpretant as well as, a representamen (a material
object or sign vehicle) and an object (a perceptual construct).

\[ \text{INTERPRETANT} \]

\[ \text{REPRESENTAMEN} \quad \text{OBJECT} \]

Figure 3. Peirce's sign triad.

More explication of Peirce's theory of signs will follow in chapter two. However for the present, it can be seen from the figure above that a sign is a triadic formation with the interpretant considered as another sign by which the relationship between the representamen and the object becomes an object of thought. Cognition is semiotically considered in terms of the unity of the triads through which signs are formed and as such is a mediated process where the realm of material objects is unified with perception through interpretation (Peirce, 1955; Siegel, 1984).

Transactional theory as semiotic. A semiotic perspective of knowing can be found in transactional theory. At about the same time that cognitive psychology was becoming formalized, John Dewey and Arthur Bentley presented their transactional theory of learning with the publication of *Knowing and the Known* (1949). The influence of the semiotic theory of C.S. Peirce and the contemporary scientific debates around quantum mechanics can be seen in Dewey and Bentley's description of meaning as grounded in how
individuals with their own unique experiences make sense of their world within a particular social context. The transactional paradigm was a view of coming to know that took into consideration all elements of a total situation (Dewey & Bentley, 1949).

There is a further connection between Peirce's theory of semiotics and Dewey and Bentley's (1949) transactional theory in the conceptualization of coming to know as a cycle of inquiry centered around the experiences of the individual. Dewey and Bentley proposed that the learner and the context were inseparable and part of a holistic and cyclical process that resembled a scientific method of inquiry. Dewey (1933) suggested that this cycle of inquiry reflects what learners do naturally when attempting to make sense of a particular experience or event and what scientists do when exploring the natural world. "Scientific method is not just a method which it has been found profitable to pursue in this or that abstruse subject for purely technical reasons. It represents the only method of thinking that has proved fruitful in any subject..." (p. 191).

Dewey (1958) seemed to see beyond the positivistic methodology ascribed to the physical sciences to the triumph of Newtonian physics, which grew out of the unity between Galileo's empirical endeavors and Descartes' mathematical (rational) methods, and noted that philosophy has not fared so well, "...we are nearer in philosophic theory to the time of Roger Bacon than to that of Newton" (p. 3).

There is a bit of a paradox here in that the reasoning process employed by Newton was semiotic in its unification of realms of knowing, however, the metaphor created by that reasoning began a whole tradition of inquiry based on an artificial separation between
internal and external domains. The kind of scientific inquiry referred to by Dewey and Bentley (1949) was not a dualistic one with the inquirer as a separate interacting entity, but a kind of inquiry that is grounded in the experiences of the inquirer.

Parallels can be found between transactional theory and the shift in the natural sciences from the Newtonian to Einsteinian physics (Rosenblatt, 1985. Weaver, 1984). Moreover, as pointed out by Kuhn (1962) shifts in paradigms necessitates a change in what questions are asked, as well as how they are asked, or in questioning the questions (Gerhard & Russell, 1984).

The questions explored within a transactional paradigm are formed from a perspective of “knowledge-in-process” and center on how individuals construct meaning, rather than how information is processed. Knowledge is seen not as absolute, but always in the process of formation and as centered on the experiences and meanings of the individual. This is reflected in research conducted from a semiotic perspective and within the transactional paradigm. Research based on a transactional paradigm, rather than isolating variables, is based on inquiry as a whole “organic process” (Weaver, 1984) where,

We still can distinguish the elements, but we have to think of them, not as separate entities, but as aspects or phases of a dynamic process, in which all elements take on their character as part of the organically-interrelated situation (Rosenblatt, 1985 p.100)

Studies within the transactional paradigm are often ethnographic, descriptive and
take place as part of a functioning educational context (Dewey & Bentley, 1949; Weaver, 1984; Rosenblatt, 1985; Harste, Woodward & Burke, 1984; Short, 1986). These studies are often concerned with: (a) exploring cognition through the generative processes of individuals (Siegel, 1984; Reimer, 1991, Harste, Woodward & Burke, 1984; Harste, Short & Burke, 1988), and (b) as occurring through the dynamics of the socio-psychological context (Bloome, 1993; Short, 1984; Woolsey & Burton, 1986). Therefore, the intentions of the learner, as well as the context, typically excluded from information processing paradigms, are generic to a transactional stance of knowing.

In conclusion, the parallels between semiotics and transactional theory can be summarized in terms of inclusion. Just as semiotics considers all aspects of cognition in coming to know, transactional theory provides a wider scope for the investigation of how we come know. As Weaver (1984) suggests, this scope includes elements from both the transfer and interactional paradigms:

...the organic paradigm toward which we are moving must include mechanism, but must somehow transcend the simplistic dichotomy I have been describing and demonstrate the ways in which both mechanism and organicism are simultaneously true. (p. 28)

Through a semiotic/transactional perspective it can be posited that the essence of organicism must lie in the intentions of the learner in transaction with the sociocultural context. Those transactions are considered the meaning making activities that are centered on what Rosenblatt (1985) calls a reservoir of potential triadic symbolizations and what
Peirce calls signs or concepts. It is these triadic formations that will be the focus of the next section, which examines the process of concept development.
CHAPTER TWO

THEORETICAL FOUNDATIONS FOR A SEMIOTIC VIEW OF CONCEPT DEVELOPMENT

Introduction

The following chapter explicates the investigations into concept development by Piaget and Vygotsky as an introduction to a semiotic consideration of concept development. There are two reasons why these investigators are significant to this study. The first one is that through their extensive investigations both Piaget and Vygotsky have provided a great deal of information concerning concept development. The second reason has to do with the respective orientations of those investigations as placed within the realm of possible orientations summarized by Gardner (1985),

...the tension between rationalists and empiricists. Those of a rationalist persuasion believe that the mind exhibits powers of reasoning which it imposes upon the world of sensory experience, empiricists believe that mental processes either reflect, or are constructed on the basis of, external sensory impressions. Both Plato and Descartes embraced the rationalist pole, while many succeeding empiricists reacted to it. In our own era, behaviorists have clung to empiricism, while cognitivists are likely to embrace some form of rationalism or a rationalist-empiricist mix. (p. 53)

While both Piaget and Vygotsky can be considered within the "rationalist-empiricist mix" (a category that suggests the limitations of the traditional
empiricist/rationalist dialectic), their orientations differ within that category. These orientations can be seen through Gardner's (1983) summary analysis of the continuum of possibilities for the study of human intelligence:

Findings from biology and from anthropology stand at opposite extremes in any theory of human cognition. From study of the structures and functions of the nervous system, we should ultimately be able to specify certain limits on all human cognitive activities. From study of all known human cultures, we should eventually gain the fullest possible notion of the range of abilities, including thought processes, that have evolved over human history. (p.299)

While the work of Piaget and Vygotsky can be characterized as a rationalist-empiricist mix, their respective orientations, Piaget as biological and Vygotsky as sociocultural, put them at opposite ends of the continuum suggested by Gardner. However, I would argue that a semiotic explication of cognition unifies and expands these two perspectives. Taken together, the work of these two scholars provides useful insights into cognition and concept development. Therefore, a comparison of some of the key features of the theories of these two scholars will provide a bridge to a semiotic explication of cognitive development.

**Piaget and Vygotsky**

The respective theories and investigations of Piaget and Vygotsky, while complementary, have developed from very different orientations. Piaget, whose theory rests on biological notions of development, de-emphasized the role of the social context
and therefore language (communication within the social context) in concept development. Vygotsky approached cognition and concept development from a socio-historical perspective. He emphasized the role of the sociocultural context, as well as language, as a socially mediated sign system through which concept development takes place.

Piaget's theory of cognition is mainly based on biological notions of cognitive development. The core organizing concepts are based on adaptive behaviors observed in animals (Piaget, 1971; Piaget, 1984; Donaldson, 1978) and include self-regulation and equilibrium which is attained through the adaptive processes of assimilation and accommodation. Cognitive development is understood as adaptation through the continuous interaction of assimilation and accommodation. Through these two processes the organism takes in parts of the world necessary to function and accommodates its own structure to fit what cannot be assimilated (Piaget, 1970, 1971; Duckworth, 1987).

Knowledge is considered by Piaget to be primarily biological in nature.

Vygotsky's (1978, 1986) sociocultural orientation led him to describe cognitive development as a progression from elementary or natural forms of intelligence, which evolve to higher forms through social interactions between the individual and the sociocultural context (Wertsch, 1985). Vygotsky considered knowledge to be a social construct that proceeded from externalized less mediated forms that are tied to the immediate context to internalized decontextualized forms that are increasingly mediated by signs, especially linguistic signs. For Vygotsky (1986), "Thought development is determined by language, i.e. by the linguistic tools of thought and by the sociocultural experience of the
Despite these differences in orientation the stages of development described by both Piaget and Vygotsky are markedly similar. Piaget's (1970) sensorimotor stage (birth-24 months) is characterized by the structuring of action schema, practical intelligence (tool use) and the development of the substructures of future cognition, such as object concept. These notions of spatial and causal relationships are necessary for the next stage. This stage corresponds to the first two stages described by Vygotsky (1986) which are the primitive or natural and the "naive psychology" stages. His stages are characterized by pre-intellectual speech and pre-verbal thought, explorations of the body and objects in the environment, tool use and the beginnings of the development of speech.

Concrete operational, the second stage described by Piaget (1970) is characterized by the emergence of the semiotic function (language, game symbols and picture making) and pre-operative representation and ends with the emergence of concrete operations, such as classifying, putting objects in series, connections and understanding numbers. This corresponds to the third stage of development described by Vygotsky (1986) where the use of external signs and external operations to solve internal problems and the use of egocentric speech dominate.

In Piaget's third stage, called formal operational, the individual begins to reason logically, working from propositions or hypotheses and such notions as reversibility (inversion or negation and reciprocity). Again this can be said to correspond with a fourth
stage characterized by Vygotsky (1986) as the internalization of external operations which in the process undergo profound changes. These include the emergence of logical memory, operations that exhibit inherent relations and the use of inner signs.

More similarities exist between the theories of Piaget and Vygotsky which may originate in the limitations of their clinical investigations and shared assumptions about the nature of concepts. While differing in orientation, both Piaget and Vygotsky (although Vygotsky reflected on the limitations of this) carried out studies within artificially constructed contexts using contrived tasks. This can be seen in how Vygotsky (1984) investigated and described the development of concepts, which compares with Piaget's concrete operational stage and his notion of "reflective abstraction" (coordinated actions resulting in schemes that are additive, temporal, corresponding and intersecting).

Using a task that focused on the sorting of blocks of various size, shape and color to discover a target rule, Vygotsky (1986) developed a series of stages for concept development. In Vygotsky's first phase, the child moves from seemingly incoherent and unarticulated actions where "...word meaning denotes nothing more to the child than a vague syncretic conglomeration of individual objects that have somehow or other coalesced into an image in his mind" (Vygotsky, 1986, p. 110). This phase is characterized by random groupings arrived at through "trial and error" thinking.

In the next stage, objects are related "...by a purely syncretic organization of the child's visual field" (Vygotsky, 1986, p. 111) with space, time or other perceptions influencing the groupings. Concept development then proceeds through a series of stages
termed thinking in complexes, pseudo-concepts and finally true concepts, which emerge in adolescence.

The higher levels of intelligence reached at this stage are considered logical-mathematical by Piaget (1971) and primarily linguistic by Vygotsky (1986). Logical-mathematical structures emerge through a succession of stages with "...the integration of lower structures into the structures of the subsequent stage to form a hierarchy whose levels correspond to the successive phases of growth" (p. 321). Moreover, Piaget (1971) considers logical-mathematical structures to be an "extension of organic forms" (p. 339) and an outgrowth of the biological processes involved in adaptation.

However, Vygotsky (1986) considered higher intelligence, because it is socially constructed, to be primarily linguistic. Moreover, where Vygotsky considered biological development to be a factor, he characterized stages of development as ultimately dependent on the sociocultural context.

Both these orientations provide insights into some of the elements involved in cognitive development, but are limited by dualistic notions of knowledge. In Piaget's case it is a dialectic between the organism and the adaptive environment, where for Vygotsky the dialectic is between the individual and sociocultural context. This can be seen in the previously described stage theories posited by both scholars.

In arguing for a semiotic perspective, I would suggest that there are dialectical or dualistic factors involved, but that cognition and concept development are much more than those factors. Dialectics is certainly involved, but knowledge is the something
beyond, obtained through dialectical processes and in this way is simultaneously individual and social. Both Piaget and Vygotsky, even while operating within a dualistic framework allude to that something more. Piaget (1971) suggests this when he states that, "...every logical connection is simultaneously ----and indissociably----individual and social" (p. 307).

Vygotsky (1978) describes concept development as a spiral, "...passing through the same point at each new revolution while advancing to a higher level" (p. 56), with concepts beginning as "functional equivalents" which "...stand in the same relation to true concepts as the embryo to the fully formed organism" (1986, p. 106). Vygotsky (1978) believed that, "The potential for complex sign operations is embedded in the earliest stages of individual development" (p. 46), and that cognitive development takes place through the psychological transitions where, "In the history of behavior these transitional systems lie between the biologically given and the culturally acquired. We refer to this process as the natural history of the sign" (p. 46).

These reflections on concept development seem to be inconsistent with Vygotsky's insistence that "true concepts" do not exist in earlier stages, but that a series of stages culminate with the real thing in adolescence. Despite these inconsistencies, Vygotsky who was greatly influenced by semiotics (Wertsch, 1985), believed cognitive development to be a generative process that proceeds through the use of more complex and mediated signs as individuals make meaning within a sociocultural context.

While both Vygotsky's and Piaget's concern with the dialectical forces at work are
well founded, they do not provide the full picture. The weakness of Piaget's use of biological adaptation as a construct to understand human cognition does not arise so much from its inapplicability, but in the fact that theoretical anomalies that have arisen in the physical sciences and inspired the development of new constructs such as chaos theory (Gleick, 1987), indicate something more than the mechanistic interaction of organism and environment. Even Piaget's seemingly straight forward analogy between adaptation in the animal kingdom and cognitive development in humans indicates a complex, unpredictable process that is web-like and dynamic.

**Concept Development as Semiosis**

It is these web-like relationships that create unexpected occurrences, the something more, that is at the core of a transactional/semiotic theory of knowledge. Cognition is semiotically considered by Peirce (1955) as mediated and generative with concept development being a process that is constantly building on itself through a succession of interlocking representations which Peirce called signs and defined as:

...something which stands to somebody for something in some respect or capacity.

It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the interpretant of the first sign. The sign stands for something, its object. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the ground of the representamen (sign). (p.99)
Cognition stands on this triadic relationship by which we orient to and make sense of our world through the interpretation of signs through other signs. Therefore, a representamen or sign vehicle, represents or points to an object (a hypothesis or cultural construct) which is connected through the interpretant, which is another sign (see: Figure 4). Peirce associated these elements with what he called “modalities of being”. These were described through the categories of Firstness, Secondness and Thirdness, as a way to distinguish experience by modalities of being which are "...the universe of ideas or possibilities, the universe of brute objects and events, and the universe of habits or laws." (Siegel, 1984, p. 43).

**INTERPRETANT**

**REPRESENTAMEN**

**OBJECT**

*Figure 4.* Peirce’s sign triad.

Firstness, then is simply the existence of a quality, sensation, feeling or an essence without any reference to anything else, but is possibility or potential; Secondness is dyadic and brings two objects or events into relationship (a fact); Thirdness has to do with established relationship that can be a law or general conception (Sheriff, 1994) and involves an interpretant where, "...a possibility (Firstness) is brought into relation to a brute object or action (Secondness) by a habit which is a well-developed interpretant..."
These modalities of being were associated with the elements of a sign in that:

A Sign, or Representamen [which] is a First which stands in such a genuine triadic relation to a Second, called its Object [cultural construct], as to be capable of determining a Third, called its Interpretant, to assume the same triadic relation to its Object in which it stands itself to the same Object. (Peirce, 1955, p. 99)

Cognition is also semiotically considered to exist on three levels: sensation, perception/representation, and understanding/signification (Deely, 1982; Siegel, 1984), which can be associated with firstness, secondness and thirdness, respectively. Where sensation is associated with the modality of firstness, perception/representation can be associated with secondness, in that perception/representation arises from the relationship between the physical environment and sensation. Thirdness is associated with understanding/signification in that it involves the consideration of ideas that are not tied to the immediate perceptual context.

While sensation, perception and understanding can be correlated with the modes of existence of firstness, secondness and thirdness, respectively, they are all considered to be triadic in nature, just as they exist as an indivisible whole. More discussion of these will follow, however, for the present, it can be suggested all levels of cognition exist throughout development; it would be impossible for development to take place otherwise. Moreover, while the following discussion divides cognition into three levels, cognition in reality only exists as an interconnected whole and can be really only understood as such.
Sensation

This level of cognition, most closely associated with the semiotic category of firstness is in essence "...the immediate nonconceptual given of sense experience" (Sheriff, 199, p. 42). It is how the newborn child first comes to know the world and is inscrutable at the same time that it characterizes the beginnings of human cognition. Sensation results from physical stimuli. It is a basic level of cognition, yet at the same time, sensation rests in the coordination of several highly complex systems.

Piaget, through his observation of infant behavior, considered the coordination of sensory data, the first task for the infant, to be the beginning stage of intelligence to come. According to Piaget (1954) the newborn and young infant assimilate sensory data into schemata which he considers to be the reflexes that constitute the "earliest habits" of the organism. Moreover, "...the infantile universe is formed of pictures that can be recognized but have no substantial permanence or spatial organization" (p. 4). Piaget further suggests that the infant, who has no concept of objects separate from itself, has the task of the "intercoordination of schemata" such as sight and hearing.

However, if sensation is considered multi-modal, when the infant responds to physical stimuli, sensory "schemata" are intercoordinated from the onset, with the infant already engaging in a basic kind of semiosis. The neuro-sciences have provided increasingly more specific information concerning how sensation functions in the brain. Throughout this century the debate in neuro-science has been between those who ascribe to a localized theory of brain functioning and those ascribing to a molar theory of brain
functioning (Nadel, Willner, & Kurz, 1986; Gardner, 1986). As more about neurological functioning is discovered, a picture that includes both these stances is developing. In their review of neurobiology, Nadel, Willner & Kurz describe sensorimotor orientation as it takes place in the optic tectum in frogs and the superior colliculus in mammals.

Most of the neurons in the deeper layers of this system are responsive to inputs from any of several modalities --- a property seen in even quite primitive species. The critically important feature of these neurons is that they are activated by stimuli from different modalities but occurring in the same part of egocentric space. Intercalated with these neurons responding to inputs from particular spatial locations are others, sources of efferent fibers to as many as fifteen motor areas, in each case eliciting an orientation toward the part of egocentric space "mapped" by neurons responding to afferent input. (p. 229)

It would seem from this evidence that orientation, a complex function involving sensorial coordination at a particular site in the brain, begins developing within a few days of birth. It can be suggested that "...the tectum/colliculus is a kind of "production system" which contains the rules governing a wide variety of orienting behaviors in local egocentric space" (Nadel, Willner & Kurz, 1986, p. 230). Because this production system is also the site of sensory modalities as they develop, it points to the early multi-modal nature of sensation.

These discoveries in neuro-science suggest that sensation is both integrated and multi-modal and concurrent with semiotic notions of sensation. Semiotically considered,
the nature of sensation is mediated; the infant doesn't simply take in the world through one sensory channel or the other but,

...becomes aware of this stimuli on the basis of the fact that sensation is multi-modal. Although it is possible to speak of a single sensory channel in the abstract, other channels operate simultaneously such that sensations from one channel are brought into awareness through the functioning of others. (Siegel, p. 64)

Rather than viewing sensation as the assimilation and coordination of pieces of the outside world by individual sense organs, sensation can be characterized as early sign action. The propensity of humans to make sense of the world through the construction of symbols exists from early cognition, rather than developing at a later stage when the intercoordination of sensory schemata leads to the concept of object, as suggested by Piaget (1954).

Related to Piaget's notion of object concept is the idea that early cognition is autistic in nature and characterized by a kind of pleasure principle where cognition consists of a series of unstable, drifting and partially formed images. This is challenged by Vygotsky (1986), who considered social interaction to be the primary force of early cognition.

And actually, as soon as one turns from the general thesis of the superiority of the pleasure principle over realistic thinking to the actual process of phylogenetic development, one sees that the primacy of autism is biological nonsense. To let the pleasure principle become a starting point of development is to make the origin
of thinking and intelligence absolutely obscure. (p. 22)

In sum, semiotically considered, the sensorial level of cognition is mediated and therefore triadic:

...the features of the interaction environment made known uniquely through any specific sensory channel bring along with themselves into awareness other features which are not uniquely attained by any one channel but overlap with and are attained in common by several channels -- simultaneously with the unique features, although dependently upon them. Here therefore, we have already the type of relationship constitutive of signification, at the very first moments of cognitive awakening. (Deely, 1982, p. 97)

And grounded within the social context:

The initial contact between cognizing organism as such under the heading of "subjective" or "objective", since it is indistinctly both and prior to the applicability of any such dichotomy. In sensation, that is to say, in the origin of cognitive life, the cognition that arises within the organism is coordinated and continuous with the physical impingements of surroundings on the organism. (Deely, 1982, p. 96)

This basic level of sign action through which organisms initially make contact with the physical environment forms a "...a network or web or semiotic relations centered on the cognitive organism..." (Deely, 1982, p. 98), which can be termed perception/representation.

Perception/Representation
Perception/representation is primarily associated with secondness and is the level of cognition, whereby, "Impressions of sense, precisely as constituting a network or web of semiotic relations centered on the cognitive organism, are passed through the channels of external sense to the higher levels of cognitive activity..." (Deely, 1982, p. 98). These "higher levels of cognitive activity" are representational functions that form "...the basis for the organism's apprehending and responding to its surroundings at a higher level than merely as affecting it here and now" (Deely, 1982, p. 96). It is these representational functions, which establish "...a proportion between what is given in sense versus what is perceived in experience..." (Deely, 1982, p. 100) and gives perception its triadic nature.

Investigations into perceptual/representational functions have highlighted ontological sequences as can be seen in both Piaget's and Vygotsky's stages and particular forms of representation (Piaget/spatial-mathematical; Vygotsky/verbal). These investigations perhaps misrepresent the actual nature of the process involved in this level of cognition. Perception is associated with the notion of schema, which provides some common ground for various understandings of perception/representation.

**Actions, pictures, words.** A philosophical thread can be traced back to Kant who proposed that, "A schema serves as a mediating representation which is intellectual in one sense, sensible in another. Thus, a schema is directly activated in terms of sensory experiences and yet can be plausibly thought to provide an interpretation of that experience" (Gardner, 1986, p. 116). The role of schema in memory was explored by F. Bartlett who "...claimed that the typical memory system used by humans involves the
formation of abstract cognitive structures, or schemas" (Gardner, 1986, p. 116).

Piaget (1971) defined perception as the "proximate structure given to sensorial evidence" (p. 3). He used the term schemata to describe the organizational structures generated from various actions through the adaptive processes of assimilation and accommodation. Furthermore, Piaget (1971) suggests that "...any type of knowledge inevitably contains a fundamental factor of assimilation which alone gives significance to what is perceived or conceived" (p. 5).

Duckworth (1987) states that schemata can be categorized in three basic forms. In her discussion of concept development, she cites Piaget who hypothesized:

"...that our knowledge has three lines of access. One is perceptual: something about the way things look connects to something about how things looked before. Another is action: Something about what we do calls up what we have done before. The third is conceptual: An idea, a word, or a formula is the link." (p. 45) In other words, representations can be visual images, actions or represented in some sign, either linguistic or otherwise.

Bruner (1973) expands on this when he states that:

"In effect, representation or a system of representation is a set of rules in terms of which one conserves one's encounters with events. A representation of the world of some segment of one's experience has several interesting features. For one thing, it is in some medium. We may represent some events by the actions they require, by some form of picture, or in words or other symbols. There are many
subvarieties within each of these three media—the enactive, the iconic, or the symbolic. (p. 316)

Enactive, iconic and symbolic have been suggested as a general ontological sequence with representations becoming increasingly mediated.

Piaget (1970) suggests this sequence when describing his stages of development, where all intelligence is enactively derived with learning taking place when individuals "... assimilate reality into systems of transformations. To know is to transform reality in order to understand how a certain state is brought about" (p. 15). Piaget called this process of transformations reflective abstraction and described it as the coordination of actions within various frameworks such as additive (joining of objects), temporal (ordinal or sequential), correspondence (between one action and another) and intersections (among actions). The sensorimotor stage is identified by Piaget as a series of substages that lead to more complex coordinations of actions that are the external forms of representational organization.

This ontology is further explicated when Piaget posits that symbolic representation emerges between two and a half and three years old, as action schemes begin a process of internalization. Piaget (1972) calls this the symbolical function and states, "The appearance or the symbolical function in its various forms: language, symbolic play (or imagination) in contrast to the simple play of exercise, postponed imitation, and probably beginnings of the mental image conceived as internal imitation" (p. 57).

However, this sequential progression can be called into question on a couple of
accounts. While infants may be focused in on the physical, and are initially without verbal signs for communication, this does not preclude the occurrence of symbolizing or sign function. Moreover, it is hard to conceive of the notion that when a child reaches the age of two or three, that there is a sudden onset of a symbolic function. What Piaget describes as the beginning of symbolic function is simply symbolic thinking that has become more evident to observers through the ability of the child to communicate meanings through the use of various sign systems. Furthermore, perceptual organization is dependent on factors unique to the individual (manifested later through facility with various sign systems (Gardner, 1983) in relation to a specific context.

Piaget's view of the nature of early thinking is in contrast with Vygotsky's (1986), who observes that a primary activity of the infant is to make contact and communicate with the social environment. Therefore, rather than representational structures developing at a later stage that "...results from a differentiation between the signifcants and the signified (until now undifferentiated, as in the case of the perceptive signs or signals of conditioning)" (Piaget, 1972, p. 73), it could be suggested that infants have an early awareness of their environment and the capability to symbolize, if not communicate their experiences.

The early social nature of infants has been further substantiated by Bruner (1975) through observations of infant-mother interactions that indicate the early generation of a kind of "mutualness" of meanings. Further evidence is suggested by Donaldson (1978) citing:
...Colwyn Trevarthen, who claims that evidence from films of more than 100 exchanges between mothers and their infants of two or three months of age forces us to conclude that a complex form of mutual understanding develops even at this age. (p. 23).

Moreover, Donaldson (1978) observes that:

By the time they come to school, all normal children can show skill as thinkers and language users to a degree which must compel our respect, so long as they are dealing with 'real-life' meaningful situations in which they have purposes and intentions and in which they can recognize and respond to similar purposes and intentions of others. (p. 127)

Despite the questions raised by his theories, Piaget gave rise to the notion of nonverbal thought, and posited that concept development is not necessarily a function of language development as much as the development of representational structures, which he characterized in terms of mathematical and spatial relationships. Piaget divided representational thought into two forms which he called figurative (perceptually generated mental pictures) and operative (based on acquired laws), with operative being generated from sensorimotor schematization and internalized and expressed through the symbolical function and figurative representation.

Of primary importance for Piaget was the internalized operations in which thinking is not tied to perceptually generated notions and is therefore disconnected from the immediate context. Studies of pre-linguistic sensorimotor intelligence led Piaget
(1972) to believe "...that there exists a logic of coordinations of actions far deeper than the logic related to language" (p. 110). However, Piaget's desire to discover this logic led him to investigate cognition by using decontextualized tasks and minimalizing verbal interactions. Despite the potential for understanding thought in all its representational manifestations, the elimination of context and the use of tasks that made little or no sense to children, limited this potential in Piaget's studies (Donaldson, 1978).

Where Piaget attempted to study concepts "...by freeing it from all ties to a system" (Vygotsky, 1986, p. 171), and therefore, limiting contextual and verbal elements. Vygotsky (1986) placed them at the center of his investigations. While Vygotsky (1978), just as Piaget, believed that higher forms of intelligence emerge as mental structures become more mediated, de-contextualized and internalized, Vygotsky posited that perceptual organization evolves as a function of the onset of speech, therefore leading him to investigate the relationship between these two functions.

Vygotsky's sense of the "deeper logic" alluded to by Piaget can be seen in a study Vygotsky (1978) conducted in response to a study done by Binet and analyzed by Stern. In this study, children of various ages were asked to describe pictures. Based on a comparison of verbal descriptions, it was found that younger children tend to describe separate objects, whereas older children described actions and relationships, leading Stern to conclude that children undergo a stage where they perceive separate objects before perceiving the picture as a whole.

But when children were asked, in a study by Vygotsky, to act out the picture,
young children were capable of rendering the picture complete with dynamic and relational features. This led Vygotsky (1978) to the conclusion that, "What Stern regards as a characteristic of the child's perceptual skills proved to be a product of the limitations of her language development or, in other words, a feature of her verbalized perception" (p. 32).

Vygotsky focused on cognitive development as embedded in verbalized perception and suggested a progression from perception of a situation as a whole dynamic, to distinguishing separate objects through labeling and expressive gestures, to one where, "By means of words children single out separate elements, thereby overcoming the natural structure of the sensory field and forming new (artificially introduced and dynamic) structural centers" (p. 32). Through this progression, representational structures become increasingly more mediated.

Vygotsky (1978), rather than attempting to isolate his investigations from the effects of the sociocultural context, suggested the notion of the zone of proximal development as a way to explain cognitive development in terms of the interplay between the individual and the social context. Defined by Vygotsky as "...the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult [or peer] guidance" (p. 86), this zone suggests that cognitive development is not a sequence of immutable universal stages, but a formative process that reflects the unique experiences of the individual.
This interplay is explicated further with Vygotsky’s (1986) characterization of concept development as a process of individuals becoming aware of their own thinking or spontaneous concepts through interaction with what he called scientific or formal concepts. “Scientific concepts, with their hierarchical system of interrelation, seem to be the medium within which awareness and mastery first develop…” (p. 171).

However, Vygotsky’s (1986) description of the relationship between spontaneous and scientific concepts is confusing. While Vygotsky suggests that “…systematicity and consciousness do not come from outside, displacing the child’s spontaneous concepts” he states that the “Systematic reasoning, being initially acquired in the sphere of scientific concepts, later transfers its structural organization into spontaneous concepts, remodeling them ‘from above’” (p. 172). Moreover, Vygotsky (1986) states that:

The interdependence between spontaneous and scientific concepts stems from the special relations existing between the scientific concept and the object. In the scientific concepts that the child acquires in school, the relation to an object is mediated from the start by some other concept. Thus the very notion of scientific concepts implies a certain position in relation to other concepts, i.e., a place within a system of concepts. (p. 172)

If Vygotsky’s (1986) terms are replaced by semiotic terms, what he is saying is that scientific concepts (object or cultural construct) and the object of study (representaman or sign vehicle) are mediated by another concept (interpretant) which I take to mean another object. What he seems to be describing here is sign action, however.
it is sign action which assumes that only the formalized hierarchical scientific concepts are mediated and that spontaneous concepts are simply non-mediated perceptions. This becomes clear when Vygotsky draws a distinction between empirical concepts "reflecting mere appearances of objects" and scientific concepts which stand "in a different relation to the object, in a relation achievable only in conceptual form". Vygotsky then states that, "It becomes clear that logically the distinction between spontaneous and nonspontaneous concepts coincides with the distinction between empirical and scientific concepts" (p. 173).

What it seems that Vygotsky is saying here is that the child enters school with a system of spontaneous representations derived from experience thus far and is then confronted with a system of mediated relationships which he calls scientific concepts; and it is at this point that individuals begin to engage in mediated sign relations changing the psychological structure of spontaneous concepts from the top down.

This seems like a fair description of learning as described within the interactional paradigm. While Vygotsky acknowledges the mediated nature of knowledge, his intent here is to describe concept development in terms of understandings gained from taking on already established meaning structures. In other words, it is through the manipulation and re-systemization of spontaneous concepts, or schema activation and preparation, that concept development takes place.

Despite their different orientations, both Piaget and Vygotsky's theories are limited by four factors:
1. Cognitive development is characterized in terms of set stages of development.

2. A focus on singular aspects of cognition (Piaget/ mathematical-spatial; Vygotsky/ linguistic).

3. Cognition is not considered much beyond perception/representation.

4. Symbolizing is a defining aspect of particular stages of cognition, where symbolizing was not considered as an inherent part of all aspects of concept development, but only considered in relation to the external evidence of it.

**Perception/representation considered semiotically.** Semiotically considered, perception/representation is characterized as signs which exist from earliest life. Langer (1942) suggests this when she states that, “The use of signs is the very first manifestation of mind. It arises as early in biological history as the famous ‘conditioned reflex’ by which a concomitant of a stimulus takes over the stimulus-function”(p. 29). Therefore,

From the moment that there is thought everything is a sign. And these signs are capable of forming new ideas and new habits of relating in the mind in a manner analogous to the way elements of Firstness, Secondness, and Thirdness form ideas and regularities in the cosmos. (Sheriff, 1994, p. 33)

While symbolizing becomes more evident as the individual is better able to communicate using conventional representational structures, it does not preclude the existence of mediated mental activity. Langer (1942) suggests that what separates humans from other creatures on earth is their propensity for symbolizing. In other words, humans are born with this powerful potential for symbolizing, rather than it appearing as an aspect
of a stage of development.

This potential for symbolizing is at the core of a semiotic theory of cognition and is characterized in terms of a theory of signs. According to Peirce (1955) signs can be categorized within three trichotomies from which ten levels of signs can be established. The first trichotomy: Qualisign (a quality), Sinsign (a thing or event), and Legisign (law or convention) which are three kinds of signs or representamen, the second trichotomy: Icon (image, diagram), Index (refers to or indicates an object), and Symbol (refers to as a law or association of general ideas) refer to the relation of a sign to its object; the third trichotomy: Rheme ("...a sign of qualitative possibility"(Peirce, 1955)), Dicent Sign (a proposition), and Argument ("a sign of law") which refers to the relationship between interpretant and representamen as a "...possibility, fact, or reason" (Sheriff, 1994, p. 42).

These three trichotomies provide the elements which make up Peirce's ten classes of signs (see Figure 5). These classes of signs, however, rather than necessarily indicating an ontology for cognitive development, suggest a range of ways in which it is possible for the human intellect to construct meanings. Deely (1982) describes this when he states that, "Together, these two levels of cognitive activity (sensation and perception) enable the spinning of a semiotic web, that is to say, a structure of experience built up through sign relations" (p. 101). Signs can be considered concepts which construct a semiotic web comprising a conceptual ontology that is unique to each individual. It is a process where signs build on each other and "...the thought in any one moment determines the next thought is of the nature of reproduction, and therefore a part of every thought continues in
the succeeding thoughts. Every thing is interpreted by a subsequent sign or thought in
which the relation-of-the-sign-to-its-object becomes the object of the new sign” (Sheriff,
1994, p. 37) A view of concept development based on semiosis makes it impossible to
characterize one type of perceptual structure as being necessarily dominant, as well as
making it untenable to posit a universal conceptual ontology.

<table>
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<tr>
<th>Phenomenological or formal categories</th>
<th>Ontological or material categories</th>
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<td></td>
<td>Firstness</td>
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<tr>
<td>Firstness</td>
<td>A sign is:</td>
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<tr>
<td></td>
<td>QUALISIGN</td>
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<tr>
<td>Secondness</td>
<td>A sign refers to its object in having:</td>
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<td></td>
<td>ICON</td>
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<tr>
<td>Thirdness</td>
<td>A sign’s interpretant represents it (sign) as a sign of:</td>
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<td></td>
<td>RHEME</td>
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Figure 5. Sheriff’s version of Peirce’s taxonomy of signs. Note: From Charles Peirce’s
Guess as the Riddle (p. 43) by J.K. Sheriff, 1994. Bloomington IN: Indiana University

This brings us to the third level of cognition, understanding/signification which
arises when, “...the relation between the representamen and object become an independent
consideration, available for further evaluation and development” (Siegel, 1984,p.45)

Understanding/Signification
While perception/representation involves sign-action, in order for signification to occur, interpretation is necessary. Put in terms of a theory of signs,

A sign vehicle (or representamen) can represent an object such that it will be perceived but it can only be said to signify when that relation is detached from the given moment of perception. Signification requires the relation between representamen and object become an independent consideration available for further evaluation and development. (Siegel, 1984, p. 45)

The distinction between these two modes of cognition is further clarified by Deely (1982) when he states, “Perception reveals objects as they are only relative to the interests (dispositions, needs, and desires) of the organism perceiving”, whereas understanding is the “…further realization that these objects of experience don’t entirely reduce to that experience of them” (p. 103). Deely (1982) states that:

...the field of awareness is something unified (Umwelt), in the sense that the significant elements making it up, whether their signification is genetically determined [as Piaget might suggest], purely a product of social interaction [as Vygotsky might suggest] or also reflective of environmental connections that obtain apart from the cognitive process, function in common to reveal to the organism its own interests in the environment. (p. 103)

Vygotsky's concept called "decontextualization of mediational means" by Wertsch (1985) and Piaget's notions concerning the processes involved in the transition to the "reflective" level of development can be considered next.
Vygotsky posited that concepts develop through, "The decontextualization of mediational means [which] is the process whereby the meaning of signs become less and less dependent on the unique spatiotemporal context in which they are used" (Wertsch, 1985, p. 33). Vygotsky considered decontextualization as the defining characteristic for conceptual development and the process through which higher mental functions develop. The concept of decontextualization was also extrapolated from the block sorting task described earlier. To do this, the blocks of differing size, shape and color, were also marked with nonsense verbal symbols, which, if used to sort the blocks would reveal the organizational rule. In this way, Vygotsky identified stages of concept development based on the progression from sorting based on spatial proximity to colors or shapes to the use of the decontextualized verbal symbols.

This work has similarities with Piaget's (1981) theory of concept development, where concept development is a function of the increase in distance between mental operations and the perceptual context. "...an increase in distances, enabling actions affecting real entities to be extended by symbolic actions affecting symbolic representations and thus going beyond the limits of near space and time" (p.121).

While these two theories define the highest level of cognition in terms that have commonalities with the semiotic notion of signification, both posit a limited potential for signification to occur throughout the development process. This is contrary to a semiotic perspective of knowing, which suggests that signification is an aspect of cognition that occurs from the onset of thought.
The conclusions reached by Vygotsky and Piaget can also be considered a function of their study designs. Evidence for the human capacity for symbol construction can be found in studies of re-designed Piagetian tasks, where infants were able to think beyond the immediate sensate environment to find objects that after their removal existed in perception (Donaldson, 1978). The tasks devised by both Piaget and Vygotsky, rather than investigating the child's meaning constructions, were tests based on their own conceptualizations about concept development. There are important pedagogical considerations that follow from this realization.

While in reality it is impossible to separate perception/representation and signification/understanding, the distinction between these aspects of cognition is significant. The nature and form of perceptual/representational aspects of cognition have been the primary focus for cognitive science investigations, rather than the unique understandings of individuals which have meaning in transaction with the sociocultural context. Because perception/representation is necessary for knowledge (signification/understanding) to exist, it has been confused with signification/understanding (the next level of cognition) within the interactional paradigm and considered the terminus of cognition (Siegel, 1984). The pedagogy that results from this confusion is focused on the teaching of representational structures, rather than engaging perception/representation in the process of understanding or signification.

Investigations have been based on the assumption that human intelligence can be described in terms of “...all-purpose information-processing mechanisms...” (Gardner,
1983, p. 32) or micro-protocols of specific intellectual operations. A notable exception to the predominance of cognitive scientific research which is connected to a semiotic/transactional paradigm of cognition, is the work of Howard Gardner (1983) and his theory of multiple intelligences. Drawing from diverse areas of cognitive research, Gardner posits that human intelligence can be understood as a synthesis of a range of disciplines as diverse as biology and anthropology through a taxonomy of symbols and symbol systems:

In dealing with symbols like words or picture, with symbolic systems like mathematics or language, with symbolic products like scientific theories or literary narratives, we have commerce with entities and levels of analysis, that can ‘address’ both biology and anthropology. (p. 300)

Rather than focusing on intellectual growth as resulting from the grasping of spacial-mathematical concepts as with Piaget or in terms of verbalized conceptions as with Vygotsky, Gardner (1983) identifies seven intelligences (linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, intrapersonal and interpersonal) and suggests that human intelligence operates as a cross-modality of sign systems associated with these intelligences. He also suggests that the “raw intelligences” of infancy are “…almost immediately enwrapped in meaningful activites…” (p. 311), allowing for a myriad of possibilities for meaning construction, and acknowledging the vast potential of the as yet unseen evidence of symbolizing that begins with the first spark of mentality.

Based on a semiotic/transactional paradigm, then, cognitive development can be
seen as the construction of symbol systems that are both biologically and socially derived. These systems grow out of the unique meaning constructions and connections of the individual, which are triadic in nature and mediate our knowledge of the world. (Siegel, 1984; Deely, 1982, Peirce, 1955). Cognitive development can be characterized therefore, as a spiralling, reproductive and uniquely connective process.

...that permits humans to experience their world and act on it. The modifications of experience it brings about are not unidirectional, though, for at the same time that semiosis provides an interface between humans and their surroundings, the very fact of that interface brings about changes in the codes that are used. What this means is that semiosis is a living thing changing and changed by action.

(Siegel, 1984, p. 57)

In this way, concept development cannot be considered in terms of stages, but discovered in the unique systems of signs that obtain through the transactions of individuals within a particular sociocultural context.

The sign systems through which we construct meaning are not strictly linguistic in nature. As noted by Vygotsky (1978,1986), it is often through language oriented interactions that concepts develop. Pedagogically speaking, knowledge is predominantly preserved and disseminated verbally, therefore creating a special relationship between language and learning. Since this study explores the connections between narrative and science conceptualization, the relationship between language and learning is a key consideration and will provide the concluding section of this chapter.
**Language and Learning**

Connections between language and learning can be seen through the rubric of critical thinking as developed by Short and based on Peirce's cycle of reasoning.

In an article titled "A critical thinking perspective on reading comprehension research", Short (1985) makes a comparison between a semiotic view of conceptualization as represented by Peirce's cycle of reasoning and the cycle of reasoning that occurs during reading (see Figure 6). In this way, reading can be considered as a process of critical thinking where learners engage in a cycle of reasoning in order to make sense of textual experiences. In order to make meaning from texts, learners engage in inquiry through a process of abduction, generated from an anomaly that exists as the observation of something that is aberrant to our own unique experience. A hypothesis is generated from which deductions are derived, which are explored through the process of induction, where observations are synthesized into new understandings.

This parallels the reasoning process involved in conceptualization and in this way, science conceptualization and textual engagements connect through underlying dynamics of reasoning rather than through surface characteristics. The strength of that connection and therefore the potential for conceptualization depends on the perspective on language and learning held by the participants in the reading event.

How language is viewed in relationship to learning either limits or extends the potential for conceptualization. Science education and reading have formed an uneasy relationship based on the need for written discourse in science learning (Holliday, 1984).
In a comprehensive study of the state of schooling in America, Goodlad (1983) observed that, "Since textbooks appear to be by far the major vehicle for teaching science, clearly proficiency in reading becomes a requisite for comprehending science information and concepts" (p. 215). His statement characterizes the relationship between reading and science conceptualization as focusing on the efficient processing of information from textbook materials.
The response from the field of reading has been the development of content area reading, which is largely focused on teaching students to read and comprehend textbooks. According to a NAEP (National Assessment of Educational Progress) report cited by Armbruster (1989), students are leaving school without the necessary "skills" in science. Armbruster (1989) states that these skills included finding, understanding, summarizing and explaining complicated science information, and suggests that one cause of this problem stems from lack of experience with informational texts. It could be argued though, that how the reading process itself is conceptualized lies at the heart of the problem. this can be summarized in terms of the educational paradigms discussed in chapter one.

In the transfer paradigm, knowledge is considered to reside in words, which are considered as verbal components of the stimulus field. These components are considered in terms of surface perceptual characteristics, rather than as part of a system of meanings. Because task analysis is a central technique for stimulus response research, text is considered as a building block structure with letters, words, and sentences forming a bottom up hierarchy.

Reading is conceptualized as a situation where the stimulus (text) causes an appropriate response in the receiver of that stimulus. This perspective is manifested in the plethora of phonics approaches to reading, where the graphophonic structure is highly controlled and introduced in a sequence based on a hierarchy of components.

The interactional paradigm also considers knowledge to reside in the text but with
a focus on the role of the reader's schema in the processing of that text. Therefore the form and delivery of textual information must match up with an appropriately activated schema (Schallert, 1982). Reading research, from an interactional paradigm tends to focus on the interplay between reader and text with questions revolving around the influence of various instructional treatments on the reader (Siegel, 1984; Short, 1986). While the design of these studies reflect the constructive role of the reader, it is considered an isolated variable and used as a point of comparison for comprehension strategies. The language/learning relationship is predominantly researched through questions concerned with the influence of various instructional treatments on the reader (Siegel, 1984).

The transactional theory stands in contrast to the transfer and interactional paradigms, summarized here by Rosenblatt (1985):

Instead of trying to plaster over the distinction between the dualistic mechanistic, linear, interactional view, in which the text, on the one hand, and the personality of the reader, on the other, can be separately analyzed, with the impact of one on the other studied in a vacuum, we need to see the reading act as an event involving a particular individual and a particular text, happening at a particular time, under particular circumstances, in a particular social and cultural setting, and as part of the ongoing life of the individual and the group. (p. 100)

Within the transactional paradigm, text is considered as a potential for meaning construction (Harste, 1984; Siegel, 1984; Short, 1986) where the emphasis is not on the text itself as much as it is on how it is engaged to solve problems and reach new
understandings. This can be seen in terms of critical thinking (McPeck, 1983; Short, 1990).

As suggested previously, the relationship between reading and conceptualization converges in the process of critical thinking where a hypothesis is generated, explicated and tested in explanation of an observed anomaly. Goodman (1984) posits this process with a model of reading as a "psycholinguistic guessing game" where the reader engages in sampling, predicting and using various cuing systems. These cuing systems are not exterior systems, but are embedded within the reader's unique schematic processes. Moreover, Goodman observes that readers read for a purpose and therefore the whole process of reading is centered on the construction of meaning, rather than the processing of text.

Therefore, the critical thinking process of anomaly/question, hypothesis generation and explication, testing and regeneration, highlights the logical connections between science learning and reading.

**Conclusion**

The previous theoretical considerations provide the framework for the exploration of science conceptualization as semiosis. Semiotically considered, concepts are signs that are constructed through human transaction and are unique to the experiences of individual actors. However, there are universal aspects of cognition that can be discovered not in relationship to a particular sign system, but in the reasoning process underlying semiosis. With this perspective in mind, the curricular indications of a semiotic/transactional
perspective of cognition will be taken up in the next chapter, which is a description of my attempt to engage the intellectual potential of learners while peering into the window of their consciousness.
CHAPTER THREE
A RESEARCH STORY

The main goal of this chapter is to tell a research story. Embedded in that story are decisions about study design and data collection that reflect a particular theoretical perspective. Therefore, this chapter will begin by locating that perspective within a broader investigative context, followed by sections concerning the research setting, curriculum, and data collection. The inclusion of curriculum as a component of the research methodology is indicative of the participant observation approach that is employed in this study. The following section will be a discussion of this type of research as it relates to the broader context of social sciences research, followed by sections describing the research setting, curriculum and data collection.

In an attempt to develop a rigorous methodology for the study of human intelligence, positivistic experimental logic was adopted from the physical sciences as applicable to the study of the mind, based on "...the belief that the model of explanation employed in the natural sciences provides the logical standards by which the explanations of the social sciences can be assessed" (Carr & Kemmis, 1986, p. 62). Aside from the evident difference between things or animals as research objects and humans as subjects, the inadequacy of a positivistic model for research stems from two areas of difficulty: (a) Assumptions that are no longer viable even in the physical sciences, and (b) the
misunderstanding of aspects of the model itself.

The assumptions that follow from a positivistic paradigm are based on mechanistic notions that are not only unworkable for the social sciences, but have become almost obsolete in the physical sciences as well. Guba and Lincoln (1982) summarize these assumptions in terms of social science research as:

1. A single tangible reality that can be divided into variables and segments.

2. It is possible and desirable to maintain a separation between observer and observed.

3. It is possible to attain a "monolithic body of knowledge" which is "encapsulated" in context-free generalizations.

4. Every event is explainable by cause and effect.

5. If done using objective methodology, research is value free.

It has been pointed out by Guba and Lincoln (1982) the key to the inadequacies of scientific rationalism for social science research is that the phenomena being studied are so completely different:

In the hard or life sciences there can be little doubt that there exists a tangible reality which is the focus of inquiry....In the social/behavioral sciences, however, the class of phenomena typically addressed in inquiry had no reality in the physical sense. (p. 10)
These assumptions have also proved inadequate even in the physical sciences. The machine metaphor proved useful for the physical sciences for an extended period from the scientific revolution until the beginning of this century when, with the discovery of quantum mechanics and Einstein's theory of relativity, it was realized that the machine metaphor was no longer tenable. What these discoveries pointed out was that although there is certainly a physical reality, it is not directly knowable and that how that reality is understood is dependent on the knower.

Not only did the social sciences adopt an inappropriate metaphor, but it turns out to be one, which does not necessarily work even in the physical sciences. These assumptions have not only proved to be unproductive for the social sciences, but somewhat destructive (Britton, 1983; Martin, 1983; Langer, 1942). The social sciences needed a constructive metaphor for human cognition that moved the focus from the "tangible objects, events, and processes" (Guba & Lincoln, 1982) that certainly impact people, to a focus on the meanings that are constructed around such events which "...exist only in the minds of people" (Guba & Lincoln, 1982, p. 10).

It follows that none of the remaining assumptions can have relevance to inquiry into human behavior. Objectivity is not only unattainable in human inquiry but does not serve any explanatory usefulness. Bruner (1990) notes that: by eliminating 

...those intentional states—beliefs, desires, intentions, commitments—that most
scientific psychology dismisses in its effort to explain human action from a point of view that is outside human subjectivity, formulated in Thomas Nagel's deft phrase as a 'view from nowhere' (p. 14).

To reduce something as complex as human intelligence to generalized laws, based on cause and effect relationships is not only a "view from nowhere" but a view of nothing very recognizable as human thinking.

The logical standards of the positivistic model have also proved troublesome. On the surface, quantitative social science studies follow the logical model of experimentation in the physical sciences. Deductions are developed from hypothesis, which are then tested inductively through the computation of numerical values, and in turn used to confirm or disconfirm the hypothesis. There are two apparent weaknesses in this process that stem from historic misunderstandings of logical models. The first one has to do with the generation of the hypothesis or hypotheses in the first place. Little attention has been given in either the physical or social sciences to this aspect of experimentation (Hanson, 1966; Holton, 1973).

The second weakness is related to hypothesis generation in that it has to do with induction. Induction has been misunderstood as the summation of particulars from which a law can be reasoned. Induction does not involve the summation of all possible incidences, but the inferential connection of particulars. The inadequacy of the machine metaphor and
the misuse of logical standards has caused such a mismatch between research and the actual phenomenon, that the impact of research on educational practice, as observed by Guba (1982), has been limited. "The impact of research on practice is conspicuous by its absence; for example, evaluation data remain unused and the practice of most social institutions such as schools, hospitals and prisons, is still based on experience" (p. 2).

Alternative methods of research can be found in naturalistic inquiry, what Guba and Lincoln call an emerging research paradigm, which embrace rather than dismiss the human elements that have traditionally been the source of so much consternation for scientific inquiry. Naturalistic counterparts to the above assumptions suggested by Guba & Lincoln (1982) are:

1. There are a multitude of realities that can only be studied "holistically" and are divergent.

2. The nature of the relationship between researcher and the researched is a transactional one and therefore there is mutual influence.

3. Knowledge is expressed in terms of working hypotheses that are descriptive of the individual context.

4. Any event or action is shaped by many interacting factors from which only inferences can be drawn.

5. Values are intrinsic to research as embodied by choice of problem,
It is from these assumptions that the research design of this study evolved. Two central beliefs about research dominated the design and data collection choices that I made: (a) To be useful, educational research needs to be conducted within the "natural" setting of the classroom and therefore be responsive to curricular considerations. (b) Educational research should be done with people, rather than to people. These beliefs corresponded to the transactional paradigm introduced in the first chapter. Dewey and Bentley (1949) describe inquiry within a transactional paradigm as

...men talking and writing, with their word-behaviors and other representational activities connected with their thing-perceiving and manipulations, and which permits a full treatment, descriptive and functional, of the whole process, inclusive of all its "contents", whether called "inners" or "outers", in whatever way the advancing techniques of inquiry require. (p. 123)

Transactionally considered, inquiry or the process of coming to know in the classroom is not a process of imposing from the outside, but a generative one where the meanings of all participants are valued (Dewey & Bentley, 1949; Rosenblatt, 1988). This is reflected in ethnographic techniques, such as participant observation (Spradley, 1980), which make it possible for the researcher to study the relationship between broader social contexts and specific phenomenon.
Spindler (1982) has listed several criterion for school ethnography, some of which are here paraphrased:

1. Observations need to be contextualized.
2. Questions and hypotheses emerge as the study progresses.
3. Observations need to be extended and repeated.
4. The "native view" is inferred through various forms of ethnographic inquiry such as interviews and the collection of artifacts.
5. The discovery of the sociocultural knowledge of the participants needs to be included.
6. Ethnographic techniques for gathering information are developed in the field.
7. Minimize the disturbance caused by inquiry and observation to interactions and communications in the research setting.

With the exception of the last, the process of inquiry for this studied followed these guidelines. Because Cathy and I were involved in a co-teaching situation with each other, there was a greater emphasis on participation, making it sometimes impossible to minimize my impact on the situation.

Research Overview: Setting the Scene

The Coronado School campus is located in Catalina, a small community north of Tucson. While small in population, the community is spread out over considerable area,
and can be characterized as middle class ranging from blue collar to professional; the ethnic mix is primarily Anglo and Hispanic.

The school is a fairly new facility that includes both an elementary building and an adjacent middle school building. Cathy lives in the community and was attracted to the school as the principal is supportive of a literature based approach to teaching, which is something Cathy had done for several years. I began my relationship with Cathy when I wanted an opportunity to explore social issues with students through children's literature. Cathy saw herself as a learner and was well thought of by her colleagues (she was elected teacher of the year for her district for 1991-92), which made it conducive for her to be flexible, willing to take risks and explore. Our relationship from the beginning was a comfortable one.

When Cathy moved to Coronado School in 1988, she had shifted from early primary to middle primary and felt the need to integrate more content area study with her already strong language arts and math programs. Cathy, who had been involved with literature discussion groups and process writing for a number of years, was interested in how language arts and content areas could be integrated. My goals were related to this in that I was interested in exploring the relationship between narrative experience and concept development. I began working with Cathy, who was teaching 5th grade in the fall of 1990, as a way to explore conceptual intersections between content areas.
I began visiting Cathy's classroom once or twice a week to work with a small group of students in a series of literature study groups. For me, the focus of these discussions was how students used literature to develop and explore social issues. After this series of discussion groups had ended, my participation in the classroom increased, eventually evolving into possibilities for exploring ways of developing an integrated curriculum that would pull together literature, writing and content areas around science.

During the winter and the spring of 1991, we began to experiment with ways to integrate science and social studies with literature study and an inquiry oriented approach to learning. The focus for social studies for that year was the Westward Movement. Thinking that various types of rocks and minerals played an important role in the settlers' progress west, we attempted to integrate science, math and social studies by creating a geology unit.

As Cathy and I explored the integration of content areas and the inquiry process, we discussed issues involved in creating an atmosphere for self-directed inquiry. We wanted to find a way for the kids to construct their own knowledge by asking questions, and developing ways to explore those questions. We initiated a series of sessions were students were expected to engage in self-selected research projects within the parameters of the Westward Movement.

These social studies projects were flanked by two series of science experiences.
Students engaged in various open-ended science investigations with rocks, minerals and powders drawn from materials developed by Delta Education (1985) and Elementary Science Study (McGraw-Hill, 1967). These activities asked students to find out as much as they could about various materials based on observations of their defining characteristics and properties. Math concepts were included through measurement, such as when students were required to include density \(d = \frac{v}{w}\) as one of those defining characteristics. The science experiences involved a process where we introduced materials, discussed ways to keep records and gave students some broad directions (in the case of geology, find ways to categorize rocks).

For social studies, (Westward Movement) we did what is known as a multimedia blitz (Robinson, cited in Harste, Short & Burke, 1988), which involved the gathering and display of various materials. Students were then asked to browse and to select an area of study, they were then formed into groups based on their interest. At this time students were also reading various fictional pieces related to the areas they were studying.

There were two areas of concern that developed from this experience. One was how to put a context for inquiry in place, the other concern was finding ways to build connections between science, social studies and literature study. We both knew that a context for inquiry would have to involve large blocks of time for concentrated exploration. At first Cathy was uncomfortable with large blocks of time so we looked at
ways to structure the time without fragmenting it. A process of constant negotiation with each other and with the class ensued. Eventually these large blocks of time for social studies were divided into segments where everyone was doing a specific activity such as webbing, reading quietly or meeting in groups. While this was not entirely satisfactory to me, it was something to build on for the next year.

While Cathy and I both saw the advantage of making connections between content areas, due to limited time and availability of materials, the science experiments remained fairly discreet from the social studies unit. As we proceeded with the Westward Movement projects, we began to see some connections being made. For instance a student who was reading Laura Ingels Wilder, decided to look at the foods of the Westward Movement. This particular project provided a link between social studies content, narrative and science.

Although the potential for connections was there and indeed many connections were made during discussions, the resulting presentations did not reflect those connections. The result of many of these projects, even the ones where learners had made numerous connections during the process, was basically a sharing of information in a report form.

As we continued with the projects, Cathy and I discussed ways to develop a context for inquiry for the following year. We began to seek ways to support learners in
making as many content area and experiential connections as possible. We also continued to think about ways to establish large time blocks with enough structure to support learners while allowing enough flexibility for exploration. Much of what we discussed is reflected in what we eventually developed for the present study.

**Setting the Scene for the Current Study**

Over the summer, Cathy and I began to plan for the upcoming fall when I would take a more active role in planning and implementing curriculum. We were to start with a new group of students (the previous group had been with Cathy for two years) and my attendance in the classroom expanded from one or two days a week to four.

During our first planning session, in order to give Cathy a better sense of what I was thinking, I asked her to read an article by Burton and Woolsey (1986) which described an exploration of aesthetic and efferent stances for learning science. This was done by including literature and other sign systems such as art in the study of the human body. This study made sense to her and placed her own sense about literature and content areas in a theoretical context.

While our goals were very similar, our reference points for implementation differed; Cathy's orientation included the pragmatics of running a classroom and the accountability associated with her position, where I was orientated more towards theory and research. However, Cathy was stretching herself to explore theoretical issues and I
was grounding my research in the pragmatics of the classroom, essentially thrusting the stressful task of maintaining dual roles on both of us. I felt that for the most part it was a good balance and that we communicated fairly well with each other.

The issues that came up for us, while on the surface appeared to be control issues, actually stemmed from a difference in our roles. Accountability was always on Cathy's mind and just as she was to be accountable for her curriculum, she expected the students to be accountable to her by producing artifacts that she saw as valid. The arrival of a new principal was also a catalyst for this situation. Unlike the principal that Cathy had begun with, this principal was much more involved in the daily operation of the classrooms. For example, he demanded full lesson plans for the following week by Friday afternoon, which made the shadow of accountability loom larger for Cathy.

I felt that in order for inquiry to take place, learners needed to have large blocks of time to explore independently. While Cathy agreed with this in theory, she was uncomfortable with the idea in practice. The dynamics of the situation were always that I wanted to really open things up, and Cathy wanted more control. This issue was most apparent with schedule log time, a large block of time during which the students had weekly schedules that they were to fill in each day with whatever activities they needed to be doing. An entry in my field notes reflects this:

We discussed her discomfort with the schedule log time and she observed that she just didn't trust the kids. We talked about this because it was something I was
sensing from her. I shared my philosophy about starting our trusting kids and then if there are problems we deal with it. (9/18/90)

I felt that Cathy's concerns were valid and wanted to make sure she felt comfortable with what we were doing. We discussed an action plan where we would give the students some strategies for conducting project group meetings, and planning their time. This was a constant issue for me as reflected in another field note entry:

My feeling is that I need to provide the kind of support that does not impede the kids but also provides an appropriate comfort level for Cathy. (9/18/91)

It seemed to be a matter of finding a balance. This balance was described by Vygotsky (1978) in terms of the zone of proximal development, a construct that he posited in association with evaluation. Vygotsky felt that it was impossible to get a sense for the development of an individual by testing her in isolation, but that a cognitive level could only be established by observing the individual's ability to solve a problem with the assistance of a more experienced learner. This speaks to the dynamics that often occur in school settings. Students are either completely unsupported as with testing or they are being given too much assistance, as with highly structured settings. I knew that Cathy did not want a highly structured setting, but was seeking some kind of balance.

The accountability issue also often came through in our discourse and the way we conceptualized expectations to the kids. For instance, when we began science experimentation we provided students with materials for experiments with water and
asked them to record their observations. There was no set lab exercise as the students were expected to devise their own experiments. Where my focus was generally with the discovery of a question to be explored, Cathy tended to focus on the details of recording in the logs. At one point Cathy switched everyone’s logs and asks the students to carry out the experiments recorded in them. Rather than highlighting the explorative aspect of the experiments, Cathy was focusing on the explicative.

Another example of this occurred when I had read one of the student stories from the article by Burton and Woolsey (1986) to the students in order to give them some sense about the possibilities for their own inquiries. The reading of the story was followed by a discussion in which the students made comments about their impressions. The following is an entry from my field notes:

I'm ready to let them go, but C. really won't let go until she is sure that the kids understand why we read this article to them. She says that she sees some people doing what she though of as fidgeting behavior and not listening and she wants an answer to why we read that story. I intervene and change the question to how will this effect your writing today. A few responses, many hands go up, but I am ready to let this go and we finally start schedule log time. (10/1/91)

Although at times I was uncomfortable with what appeared to be parallel agendas, I felt that it was a good kind of tension that kept me thinking about classroom dynamics in relationship to learning; in this we were devil’s advocates for each other.

Curriculum Methodology

The broad theoretical and pedagogical framework for the curriculum during this
study is found in the "authoring cycle", (see Figure 7) developed by Harste, Short and Burke (1988). The authoring is not only about writing but about constructing knowledge, therefore, the authoring cycle is also considered an "inquiry cycle" (Short & Harste with Burke, 1996). The inquiry cycle is partially drawn from Peirce's (Short, 1990) theory of reasoning, where an anomaly sets a cycle of critical thinking into motion, which involves the development, exploration and evaluation of hypotheses. The cycle of inquiry, in the broadest sense, begins with the life experiences and questions of the learners, who then engage in various activities through which discoveries can be made. The orderliness of the inquiry cycle is deceptive though, as the actual inquiries of learners do not follow an orderly cycle, but depending on the nature of the exploration, often loop back and move freely between aspects of inquiry. As a curricular framework, the inquiry cycle provided a broad foundation from which to build. With the exception of the science explorations, the classroom engagements were drawn from Creating Classrooms for Authors (Harste & Short with Burke, 1988).

**Phase I** In the first phase, along with establishing some classroom routines and rights and responsibilities, our goal was to introduce various strands, themes and strategies. These engagements were to take place during a time period that we called schedule log (Harste & Short with Burke, 1988). This was to be a large block of time (one and a half to two hours) during which students were given the opportunity to schedule
their own activities. Initially, however, much of this time was used to introduce students to various engagements.

During the first two to three weeks, we engaged the students in journal writing, authoring, strategy sessions and science experimentation. Cathy provided the students with writing journals and introduced them to the routine of business, read aloud and
journal writing that was to begin each day. We began the authoring cycle with "Getting to
Know You" (Harste & Short with Burke, 1988) a strategy in which students interviewed
each other and created their first piece of writing for the year and thereby serving as a way
for students to be introduced to each other, as well as a way to for us to walk the students
through the authoring cycle. As students paired up and began to interview each other, the
cycle of inquiry began with the learner's experience.

We also engaged the students in "Partner Reading", "Say Something", "Paired
Books", "Invitations", and other strategies drawn from Creating Classrooms for Authors
(Harste & Short with Burke, 1988). With partner reading the students were paired up to
read a section of book. The students were asked to decide on how they would proceed
and to notice what was happening as they read. After partner reading the students
reflected that: (a) they could get help with words, (b) they could share their thoughts, (c)
they might select books they wouldn't ordinarily select, (d) you don't get down on yourself
that much. This strategy was extended to "Say Something", a strategy were partners again
decided on how they would share the reading. This time when the person stopped reading
each partner was instructed to say something about what was read, therefore encouraging
learners to build on each other's interpretations.

"Paired Books" and "Invitations" are both experiences where learners think
through concepts using connections between literature. "Paired Books" is a strategy where
students read two books and reflect on how they connect; we asked students to draw a picture, a web or diagram to communicate the connections. "Invitations" is a strategy that engages learners in the exploration of a problem or concept through a set of literature and other materials. The materials are accompanied by an invitation that stated the problem, concept or question and asks students to explore some possible solutions or responses. These included: "Changing Worlds" (human impact on planet); "Thinking Like a Scientist" (why did the dinosaurs die out?); "Journeys" (exploring kinds of journeys); "Explorations" (ways of solving problems); "Interdependence" (exploration of the concept); and "Cycles" (some are based on invitations by K. Short, 1991). The "Invitation" was mounted on a piece of poster board and began with a statement about the concept and directions for possible inquiry (see Figure 8).

Both the paired book and invitation strategies were difficult for the students. Part of this could have been a time factor, as they may have needed several sessions; another issue was the selection of the books. I selected pairs of books that I thought would be close enough for them to be able to make connections, however, judging by the results they may have been too close. The students tended to focus on the surface commonalities and did not go beyond that. For instance in comparing Bringing the Rain to Kapiti Plain (V. Aardema, 1981) with The Rain Door (Hoban, 1986), Tiffany and Betsy T. listed: (a) both had men make it rain, (b) both had men make it rain, (c) they have animals in both
Cycles of Life

There are cycles all around us in our lives.

Cycles are circles that turn over and over again.

Each of these books has a different kind of cycle in it.

To explore these cycles:

1. Browse through the books.
2. Choose one book to focus on.
3. Find a way to make a picture that describes the cycle you have read about.

Figure 8. A sample invitation.

stories, (d) they build something to help people, (e) they both had strangers for who they helped, (e) they both talk about black clouds that are full of rain, (f) they both have one animal trying to make the weather change, (g) they both have rain storms, (h) they both have dried up land, (i) they both have animal that are hungry because the land is dried up, and (j) they both have something happening. These initial connections were mostly based on surface commonalities, but could have been extended with further engagements. The invitations, as they included a variety of books and asked students to reflect on complex questions, and so were even more involved and difficult for the students. Both these strategies initiated students into the kinds of strategies we would be using and encouraged
them to make connections. Also the invitations foreshadowed the upcoming conceptual focus. Therefore, even though they were only able to have limited engagement, the decision was made to push on.

Science exploration was also introduced. The students were given learning logs in which they were to record science observations and experiments, as well as literature discussion reflections and project group information. For the initial science session, students were provided with a variety of materials (wax paper, aluminum foil, plastic wrap, newspaper and jars of water), and asked to discover what they could about water.

Two observations about these initial science sessions are recorded in my field notes:

Some issues of ownership. What I noticed about the last science experience was a lack of collaboration between partners. Discussed this with C. who feels the same. Another issue is the depth of involvement. The kids could be operating on short time periods from last year. I want to explore ways to foster depth of involvement. For now will be repeating strategies in different forms. (8/26/91)

Looking back on these initial experiences, we were asking students to do a number of possibly unfamiliar things all at once, such as work collaboratively, organize their time, and reflect on their thinking. At the time my expectations may have been too high for them and given more time, I would have probably allowed more time for these engagements.

During the next science session I introduced science activity cards (Educational Development Center/Delta Education, 1971) which suggest a range of explorations that focused on the properties of water. These are not experiments where a correct answer is
expected, but suggestions for exploration. Cathy took field notes as I introduced the

lesson.

Intro to activity cards. Jan remarks that the kids have already thought of what
most of the cards say. Jan reads ideas off several cards: speed of drops, speed of
drops on various surfaces, drops of different # put together, drops from different
heights. (8/28/91)

We then asked the students to do some planning before they got started with the materials.

They did this and began the session. However, the session still seemed chaotic and Cathy
was very uncomfortable with what she saw:

We need to do some thinking about this. Some very surface chaotic things
happening, as well as very focused directed experiments. How do we get kids to
focus into the inquiry process? Do they need more time to play? (8/29/91)

This experience led to a session of bubble play where students were given some time to
just play around with bubbles and water. I felt this was a very productive session as the
atmosphere of "play" allowed the students to be more exploratory. This was evident in the
learning logs where many students wrote very descriptive entries drawn from this
experience (see Figure 9).

There were two more class science sessions. In an attempt to get the students to
focus in, the next science session was a little more controlled and involved sinking and
floating. For homework, Cathy asked the students to bring objects from home that they
thought were either sinkers or floaters. The students were asked to predict in their logs
which items were sinkers and which were floaters and asked to give a rationale for those
predictions. They then proceeded to test those predictions. During the next session, I gave each group of four students an activity card for sinking and floating (Educational Development Center/Delta Education, 1971) with the instructions that they were to complete the card collaboratively.

9/3/91 Experiment with bubbles. How tall can the bubbles get? 8 inches and 5 inches wide. How long does it take for all the bubbles to pop? Time starts at 12:05; all the bubbles popped by 12:25. "How am I going to put this experiment together?" By taking a tub and a cup of soap water and blowing as many bubbles as I can and then wait for all the bubbles to pop.

Figure 2. Diane's learning log entry for "bubble play".
This was a demanding process for them. To complete the activity card, students had to work together to weigh (using triple beam balance scales) the objects, place them in order and make predictions about whether they would sink or float. They had never used triple beam balance scales and may not have ever been asked to engage in this kind of thinking. Also, because collaboration may have been unfamiliar to the students, as well as being the beginning of the year with the group still in the process of forming working relationships, this type of engagement was difficult for them. This resulted in arguments that impeded the completion of the activity.

However, one successful group was asked to share what they did with the class. The composition of this group was interesting. It consisted of two boys and two girls who would be considered as representing a mixed range of "ability" and included one Chapter One student.

After this session, the activity cards were placed in the science area and science experimentation became part of the options for schedule log time.

**Phase II**: In this phase we introduced what would be the core of the curriculum for the study. Literature discussion and research project groups were formed simultaneously and with a focus on interdependence in relationship to water, our conceptual theme.

I gave some book talks on the choices for literature discussion books and asked the students to browse, decide on a book and write two choices on a card. The selections:
(a) The Talking Earth (George, 1983); (b) Watersky (George, 1987); (c) Hook a Fish, Catch a Mountain (George, 1975); and (d) The Green Book (Walsh, 1982)) all had a theme of interdependence. With the exception of The Green Book, all were written by Jean Craighead George, who was also our featured author. The choices were fairly well distributed with the exception of The Talking Earth which began as two groups of four and ended up as one group. The Watersky and Green Book groups were Cathy's responsibility, and The Talking Earth and Hook a Fish, Catch a Mountain were mine.

To introduce the research projects, we began with a "multi-media blitz" (Robinson, cited in Harste & Short with Burke, 1988) where a multitude of books, articles, tapes, and games are displayed for a long browsing session. The materials remained out for about a week as the students decided on areas of inquiry and formed groups based on those interests. The groups were focused on rivers, ocean pollution, whales, dolphins, the rainforest, and sharks. The students then began to use parts of their schedule log time to gather information.

The next step, which involved the formation of a question that would focus their inquiry was difficult for most of them. Gathering information for reports was something they were familiar with, but exploring their own questions was not. Cathy and I suggested that students brainstorm by webbing or diagraming to represent their topic in some way. We eventually divided the class into two groups and met to discuss possible questions
with them.

The understandings gained from the research projects were to be presented in the form of a visual representation and a narrative piece that would include information from their research. The visual representation was eventually abandoned, mostly due to time constraints. However, what was interesting was that the students used all kinds of visual representations to explore their topics. We were imposing an assignment on them that, in this case, was inappropriate as it was a strategy they seemed to be using throughout the inquiry process.

The stream table (Delta Education, 1985) was one final science engagement introduced during this phase. This table consisted of a large plastic lined box that was placed on a table. The box contained sand, rocks, water and a pump, making it possible for students to explore water dynamics such as erosion and velocity in a microcosmic stream environment.

During phase II, roughly a seven week time period lasting until the end of the study, participants engaged in inquiry through a variety of means. This was not a well ordered progress, but involved regular reassessment making it a process of continuous negotiation between Cathy, myself and the students as we all engaged in our own explorations. Reflection was an important part of this negotiation process.

Over the course of the study, in addition to oral interviews, the students were
asked to write specific reflections. Three of those reflections occurred on Friday afternoon (a day I was not in the classroom) and two took place as part of the study. The three that were initiated by Cathy on the Friday afternoons asked students to reflect on:

(a) how they saw themselves as readers, writers and in math and if they thought they were giving it their best effort, (b) how they understood collaboration, (c) what they thought learning was, and (d) what they thought of schedule log time. Again, Cathy's choices of questions for reflection seem to manifest her issues concerning accountability.

The two written reflections initiated by me included a series of "What are you doing and why are you doing it?" probes. These reflections involved taking pictures of the students and attaching them to a piece of paper with the question written below the picture. The other reflection was done at the end of the study and asked students to reflect on what they thought they had learned through the various projects, what kinds of connections they made, what kinds of strategies were used and any other thoughts they had.

The previous summary of the curriculum methodology for this study will be expanded in the theoretical memos that comprise chapters four, five and six, where more details related to specific curricular engagements will be discussed.

Student Participants

Cathy's class was originally intended to be a fourth/fifth split and this is how we
began the year. However after the first week, due to unexpected numbers, the fourth graders were replaced by fifth graders. The remaining twenty four students included thirteen girls and eleven boys. Three of the students were Chapter One students and that received special assistance.

I interacted with all the students in my dual role as researcher/teacher, but for the purposes of data collection I planned to focus on eight to ten students. These students were selected based on their willingness to participate in interview sessions and to a lesser extent on gender. Once I had identified eight participants, we negotiated their selection of a literature group. In order to focus on the students, I needed to have them in the same groups. Four of the students (Diane, Holly, Lynn, Tammy) chose The Talking Earth (George, 1983) and another four (Tom, Victor, J.P., Betsy) Hook a Fish, Catch a Mountain (George, 1975).

The following section will provide a brief introduction of these participants through their "Getting to Know You" interviews, (an initial strategy where students interviewed each other and took the interviews through to publication in a class anthology), responses on a Burke Reading Interview (Y.Goodman, Watson & Burke, 1987) or BRI, reading miscues, reflections and their inquiry focus. Where the original artifact is not reproduced, the spellings have been standardized.

Betsy. Betsy was introduced by Calley who wrote:
Betsy was born September 23, 1980. Her favorite sport in P.E. is kickball. She also likes mud surfing. Mud surfing is when you're standing on a board and surfing through the mud. Her favorite book is *Where the Red Fern Grows*. She likes that book because it has adventure and is sad. Betsy likes mystery and adventure books. Her favorite food is vinegar. She likes fluorescent green. Betsy's favorite station is Cool 92.9. Betsy's favorite animal is a tiger because their eyes and stripes. I hope you have enjoyed reading about Betsy.

It is easy to see why Betsy chose *Hook a Fish, Catch a Mountain* for her literature discussion group book, as her interests obviously lie with active outdoor adventures.

Betsy's responses on the BRI profiled her as a proficient reader who enjoys reading and can employ a variety of strategies. Moreover, it is plain that Betsy enjoys reading as she suggests reading to someone everyday as a strategy for helping someone with reading.

The blending of "literary and informational ways of knowing" (Burton & Woolsey, 1986) was a highlight for Betsy as evidenced in a final reflection:

1. I have learned you could get information out of a story book and it's easy to find how to weigh and I learned stuff about why things sink and float.
2. I read *Hook a Fish, Catch a Mountain* and you can get information out of a story book you just have to think how conquer learned not to drink water from the stream. How she also helped a boy going to get yarn but runt yarn.

[Note: The text appears to be a mix of possible coding or special characters, which may not render properly in this context.]
I have learned you could get information out of a story book and it's easy to find how to weigh and I learned stuff about why things sink and float. I read *Hook a Fish* to learn that you can get information out of a storybook you just have to think. How Spinner learned not to drink the water from the stream. How she also helped Al by going to get Gunner without losing him. (10/24/91)

**Figure 10.** Excerpt from Betsy's final reflection.

This blending was evident in Betsy's narrative "The Escape of the Mayor's Lipstick", which incorporated information about whales and knowledge of the sociocultural dynamics involved with environmental issues into a rousing adventure story.

**Diane.** Diane was interviewed by Linda who wrote:

Diane was born in Wyoming on August 5th, 1981. She is 10 years old and is in 5th grade. She had 3 sisters and one dog named Penny. Diane's favorite food is spaghetti. It's her favorite food because she ate it a lot when she was little. Her favorite color is light blue. Diane's favorite sport is volleyball. Her favorite TV show is *Rescue 911*. Diane's favorite holiday is New Years Day because it's beginning of a new year.

Based on her responses on the BRI, Diane seemed to lack confidence as a reader and felt that she was slow and had trouble with long words. However, Diane was a serious and observant thinker with little time for frivolity. She expressed this in a reflection in which she was frustrated with the way that others were functioning:

*If we didn't have to go in groups people would get with it. And it's hard to work with people that don't want to do that. Most of the time they don't get in group and talk.*
If we didn't have to go in groups people would get with it. And it's hard to work with people that don't want to do that. Most of the time they don't get in group and talk. (9/27/91)

Figure 11. Diane's reflection on working collaboratively

This reflection was aimed at the rainforest project group of which she was a member, although later she switched to the periphery of the whale group. Diane was also a loner and valued her independence to pursue her subject without interference from anyone as evidenced in the following reflection:

"I don't like it when people check up on me when I know what to do and when to do it. (9/20/91)

Figure 12. Diane's reflection on independence

This fierce independence comes through in Diane's story "The Polluted Atlantic" where the main character, a whale named Josh, single-handedly cleans up the pollution in the Atlantic ocean.

Holly. Holly was interviewed by Mary who wrote: Holly was named after a flower. Holly likes to do many things in her spare time, such as ride her bike, listen to music and talk about boys. She move here in July.
She likes Coronado School. Her favorite colors are pink, purple, and black. She feels they are nice colors to wear. She plays the flute and the drums. She likes listening to 93.7 KRQ and J14.90. Her favorite singers are Paula Abdul, Wilson Phillips, M.C. Hammer, and Vanilla Ice.

Holly was socially adept as evidenced in her reflection on working collaboratively:

I feel ok in a group because in the group if I don't understand I can ask someone in my group and they can ask me. Sometimes I like working by myself because some people are really slow but I help them out and we go a little faster. I only like to work with people that are interested. Most people in the class are like that so there's no problem with groups.

Figure 13. Holly's reflection on working collaboratively.

Holly was a confident, proficient reader as evidenced through miscue readings and the following reflection about herself as a reader:
Most of the time I free read very well. I try very hard to understand the words in the books that I read. In my literature group I concentrate and focus on the conversation. I also have my home work for literature group done. I feel I'm at 5th grade in reading. (10/8/91)

Figure 14. Holly's reflection on herself as a reader.

Holly was a focused inquirer as she pursued her interests in rainforests and survival through her participation in the rainforest project group and The Talking Earth (George, 1983) literature discussion group. Holly's interest in rainforests was focused around the relationship between encroaching human population and the survival of the rainforest inhabitants. This was developed in her story "Sera Pellada's Fear for the Disappearing Rainforest", in which a young girl living in the rainforest attempts to stop the trees from being chopped down.

J.P. J.P. was introduced by Jim:

J.P. went to Texas this summer and saw all kinds of movies. His favorite movie is
Robin Hood. J P's favorite sport is football. He likes football because Jim Kelly plays football. J P likes Jim Kelly because he is a good athlete. When J P grows up he wants to be a pro baseball player like Cal Ripken, who plays for the Baltimore Orioles.

J P considers himself a good reader as evidenced through his responses to the BRI. Based on his reading miscues he is a proficient reader, although many repetitions and corrections show that he is cautious and meticulous. This is also representative of J P as a learner in that he was careful and serious about his work. In a reflection in which he was asked about working collaboratively and what he thought learning was, he states:

1) Try to get along by not favoring, trying to work out problems and working with people you like.
2) I think learning is when you get smarter by listening and following directions.

Try to get along by not favoring, trying to work out problems and working with people you like. I think learning is when you get smarter by listening and following directions. (9/27/91)

Figure 15. J.P.'s reflection on working collaboratively.

J.P.'s inquiry was focused on sharks, about which he gathered a great deal of information. This was incorporated into his story "J.P.'s Doctor Appointment" where a shark is injured and in the process of being tended to, sets out to learn all about himself by
going to a special school

Lynn. Lynn is introduced by Bonny

Lynn is ten years old. She likes Abraham Lincoln because of what he did for this country; he held the U.S.A together during the Civil War. She wants to be a principal because she likes to work with kids. Her favorite author is Edgar Allan Poe because of the poetry he wrote about the Lady Lynn, she got named after the poem. She likes "Rescue 911" because it shows people helping other people. January is her favorite month because it's her birthday. Her favorite holiday is Christmas because she likes lots of presents. Her favorite pet is a Hybrid Timberwolf because she has three of her own.

Lynn was a self confident reader and learner and liked to take risks. Her responses to the BRJ ("Yes, I enjoy and understand about every book"), as well as reading miscues showed Lynn to be a very proficient and avid reader.

Lynn was such an enthusiastic learner, that in the project group setting she became a kind of a director. This can be seen in her reflection on working in groups:

What strategies do you use when you collaborate? Well, have every body choose their own question. Either all info for everything even if it's not they're? Then share all information. When that's done you need to focus on your quiver and get all the requirements done. Next share with group. Then feedback (questions or comments) then make perfection with group. Present self needed.
What strategies do you use when you collaborate? Well, have everybody choose their own question. Gather all info! For everything even if it's not their's? Then share all information. When that's done you need to focus on your question and get all the requirements done. Next share with group. Then feedback. (9/27/92)

**Figure 16.** Lynn's reflection on working collaboratively.

With Lynn's direction, the whale group created a large chart for the collection of information on a variety of whales. As evidenced by her story "A Whale of an Answer". Lynn focused her inquiry around migration routes, the relationship between whales and humans and the differences between types of whales.

**Tammy.** Tammy is introduced by Tina:

My report is on Tammy H. She was born on August 26, 1981. Her favorite color is green because it's her birthstone. She likes to skate a lot. She wears a size two in skates. When she skates she goes for three or four hours. Her favorite food is chocolate ice cream. She likes ice-cream because it's good and it keeps you cool in the summer. That's my report on Tammy H.

Tammy had a strong sense of herself as a reader and learner. Her BRI ("Yes because sometimes I read a book without having any word to trouble me") as well as her reading miscues portrayed her as a proficient reader who dealt effectively with challenges.

Tammy was an enthusiastic collaborative inquirer, who made her focus the relationship between whales and plants. She also considered her classmates as resources. In response to a "What are you doing and why are you doing it?" prompt where Tammy was pictured sharing with the class she stated:
I'm sharing what I did that day. I was sharing that I asked Chris some whale questions. I was doing it because I had gotten a lot of info and I was excited to make my story!

Figure 17. Tammy's "What are you doing and why are you doing it?" response.

Tammy and Diane collaborated in an attempt to think through the relationship between whales and plants by creating a chart that compared their respective roles in the ocean ecosystem. In focusing on the humpback whale, Tammy also collaborated with Lorraina to create a story they titled "Can WE Save Them?", in which two girls tried to save some
beached whales

Tom. Because Tom was a late arrival in the fall, he did not participate in the "Getting to Know You" interviews, nor was he present when the BRI was given. Although Tom experienced some difficulty in reading orally, his attitude about reading was a positive one.

Reading: I think I am at 5th grade level. I put minimum effort into what I am reading. I think I understand what I read. I like to read a lot. (10/8/91)

Figure 18. Tom's reflection on himself as a reader.

Tom liked to "think on his feet" so to speak, as he has a facility for building on the contributions of others during group discussion. This learning-in-process attitude was reflected in Tom's response to questions about collaboration and learning.
I talk to them and hear what they have to say. And cooperate with them every way I can. Learning is something you do in your life. Like playing baseball. You learn it. (9/27/91)

Figure 19. Tom’s reflection on working collaboratively.

Tom formed a close working relationship with Victor as they teamed up on rivers. While their inquiries led to close collaboration, their stories showed their own individual perspectives, with Tom’s “The Ordinary River” involving the discovery of pollution through the observation of two boys, who then seek assistance to clean up the river.

Victor. Victor is introduced by Ally:

Victor was born October 1, 1980. He likes baseball because he’s good at it. His favorite cartoon is “Tiny Toons” because it’s funny. Victor’s favorite thing to drink if rootbeer. His favorite athlete is Bo Jackson because Bo is good at sports. Victor’s favorite book is Farside because it’s funny. His hobby is collecting baseball cards. He likes hunting. His favorite animal is a bear.

Victor was a proficient reader and a focused inquirer. The substitutions and omissions that occurred while he was reading profile a reader who had little difficulty with challenging
I understand most of the time, but sometimes I'll take out a book that is very hard to understand. I think I put a lot of effort into my reading because I really like to read books, and it's funner when you put a lot of effort into a book. I read books that are in 6th grade level, but sometimes I will read a lower level like 3rd, 4th.

(10/8/91)

Figure 20. Victor's reflection on himself as a reader.

Victor's father was a wildlife manager and his explorations were firmly grounded in his experiences with his father. Victor's inquiries were organized around the impact of people on river ecosystems, with all his activities. Hook a Fish, Catch a Mountain (George, 1975) literature group, the study of the Hudson River and river table experiments, focusing on that inquiry. This was reflected in Victor's story "The River that Went Bad" that portrays the life of a river beginning from the first human to arrive through the building of a city and the pollution of the river, to the efforts (including the
Went Bad" that portrays the life of a river beginning from the first human to arrive through the building of a city and the pollution of the river, to the efforts (including the introduction of a turtle species) to clean it up.

**Data Collection and Analysis**

This section will describe the data collection and analysis processes employed in this study. It begins with a consideration of the evolutionary aspect of questions that is particular to qualitative research of this type. This is followed by the specifics of data collection and a discussion of the data analysis process, which will include theoretical considerations and a description of the process itself.

Because this study was classroom-based and closely connected with an evolving curriculum, my questions evolved throughout the process of the study. This is indicative of the logic at the core of qualitative, ethnographic oriented studies, where often it is not until the researcher begins to engage in the collection and analysis of the data that the real questions begin to appear. Traditional hypothetical-deductive models tend to follow a linear path from question to induction. However, this does not reflect the actual process of discovery, which is circular, generated from abduction and often seems to progress through the dynamic that obtains between the theoretical and experiential.

Data collection in a study of this kind is closely intertwined with curriculum. While I began with some ideas about data collection, due to the evolving nature of my
questions it was not clear what would be the primary data sources. At the beginning of the study process, my questions included:

1. What kinds of intertextual connections are made in the process of constructing science knowledge?

2. In what ways does science knowledge get constructed through group discussions?

3. What is the relationship between dialogue during science experiences and the construction of science knowledge?

4. In what ways does the learner’s view of reading relate to the learning of science knowledge?

5. In what ways do R.M.A. discussions provide insights into the thinking processes of the learner in the construction of science knowledge?

6. What language strategies do learners use when constructing science knowledge?

However, these questions and the orientation of the study changed and evolved due to an adjustment in the time frame for the study (a one year time frame was reduced to ten weeks), and a delay between the study and data analysis which had an impact on the data analysis process itself. The potential bank of data was reduced, and the length of time between data gathering and data analysis made it virtually impossible to follow-up with any of the students. The study became more oriented to the theoretical issues with data analysis became a process involving a dynamic between extended explorations of theoretical considerations, focused on semiotics, in light of repeated cycles through the data.
Semiotically considered, this process is known as retroduction (Peirce, 1955) and involves:

...reasoning from a case to a rule that might explain that case; this rule stands as an hypothesis until subjected to the test of induction... By this I mean that hypotheses are not simply derived from the data but grow out of the interplay between those data and the researcher. (Siegel, 1984, p.254)

The theoretical memos that developed through this process made it necessary to adjust the study questions which evolved into the following:

1. What is the role of experiences in conceptualization?
2. What is the relationship between narrative and conceptualization?
3. How do learners use analogy as a process of reasoning in conceptualization?
4. What is the role of metaphor in conceptualization?
5. What is the role of student constructed narrative in conceptualization?

These questions were examined as they related to the conceptual development of fifth graders in the process of exploring the concept of interdependence through literature discussion and a cycle of self-directed inquiry. The questions changed in response to a shift in my own theoretical context, as well as the new perspectives suggested by the data. Theoretically, the change in my questions reflect movement from dualistic thinking to a more semiotic/transactional perspective. Therefore, the questions came to reflect new
knowledge-in-process that evolved through seeing data in terms of semiotic theory and seeing theory in terms of transactional data.

Questions are not engraved in stone, but are a reflexive aspect of the inquiry process. This can be seen in the composition process itself, where often the beginning of the process cannot be known until the end is somehow reached. It is then that we can know what we think by seeing what we say (W.H. Auden, cited by S. Baker, 1983). The same process applies to questions. They are how we begin, but they do not begin a linear process to knowledge. As soon as the question is asked, it sets an orientation of inquiry that immediately begins a course that changes the question.

Data Collection

The primary data sources for this study were closely intertwined with the curriculum. My initial sense was that the two were divided. Therefore, my idea was that I would begin the study focused on the initiation of a curricular course, and then turn to "collecting data" when it was underway. In a classroom study such as this one, where curriculum is a negotiated process, the curriculum and data collection can never be separated, but exist in much the same dialectic as that between theory and practice. The following primary data sources then, only came to be considered as such during the data analysis process.

1. Video and audio taped literature discussion groups (included as transcribed segments).
2. Video and audio taped study group interviews and curricular sessions (included as transcribed segments).

3. Individual interviews (included as transcribed segments).

4. Learning log entries and reflections (originals included).

5. Student narratives (typed in with typos corrected).

**Literature discussion groups.** All literature discussion group meetings were held in Cathy's office (a small room adjacent to the classroom) and were both audio and video taped. These group meetings were approximately an hour long and occurred one to two times a week. The *Talking Earth* (George, 1983) group met nine times beginning on September ninth and ending on October twenty second, and included three joint sessions during which both *The Talking Earth* and *Hook a Fish, Catch a Mountain* (George, 1975) groups met together. The *Hook a Fish, Catch a Mountain* group met six times beginning September tenth and concluding on October twenty first.

The discourse from these meetings provided the majority of "online" conceptualizations focused on interdependence. Moreover, at my request, we spent two sessions discussing interdependence and ecosystems as they related to their respective books.

**Video and audio taped focus group interviews and curricular sessions.** Video and audio taped sessions with the focus group happened for two different purposes. One purpose was closely tied to the curriculum in that the sessions were meant to assist
students in their inquiry process. One session involved a discussion focused on helping students discover a focus question for their research. On another occasion, students participated in an extended author's circle where we read and discussed in-process student narratives.

The second purpose for these sessions was associated with the study itself and involved group interviews. These occurred on three occasions. For the first two sessions, the study group was split in half, based on their literature discussion group membership. Therefore the same interview was done twice with different groups and was organized around the following questions:

1. What is learning?
2. What kinds of strategies do you use to learn?
3. Tell me about a time you learned something?
4. What kinds of connections do you make between the things you do to learn?

A concluding group interview, including all eight study participants, asked students to reflect on the process they went through as they engaged in inquiry and created the final narratives. Students were also asked to specify the kinds of connection they made, the kinds of strategies they used and to reflect on what they thought learning was in light of those reflections.

**Individual interviews.** Within the first month of the study, individual interviews
were carried out with the eight study participants. These interviews were initiated on the participants' responses to the Burke Reading Interview (Y. Goodman, Watson & Burke, 1987), which all students had filled out, and focused on their beliefs about reading. Using the Burke Reading Interview as a beginning point, we discussed more about how they saw themselves as readers and learners and the kinds of connections they saw between reading and learning. The purpose of these interviews was to make a one-to-one connection with each participant and for background information that would provide a cognitive context for later data analysis.

**Learning log entries and reflections.** With the belief that learning is a reflexive process that involves both oral and written expression of ideas, written reflection of all kinds became part of the ongoing curriculum. These are included as data from two sources: (a) the student's learning logs; (b) directed reflections.

Entries from the students' learning logs were photocopied and provided artifacts of the in-process thinking and reflections that occurred as participants were engaged with literature reflections, science experiments and project research. These logs contained the rough draft thinking that emerged through literature discussion and response, the record of science experiments complete with charts, predictions and visual and verbal descriptions of experiments; and the questions and conceptual webbing that were generated from the research project groups.
The directed reflections, also described in the curriculum section, were done by all students. Three of these reflections occurred on three different Friday afternoons and were initiated by Cathy. The first reflection occurred on September nineteenth when students were asked to give their opinion of schedule log time and to describe what they are doing in reading and writing. The second reflection occurred on September twenty-seventh and asked the students to describe how they work collaboratively and what they thought learning was. The third reflection initiated by Cathy happened on October tenth and asked students to describe how they thought they were doing in reading, writing and math.

These reflections indicated some of Cathy's accountability issues. However, they were useful in this case due to the dynamics of the classroom as a whole. Although Cathy and I fluctuated around control issues, there was a feeling of openness in the way the classroom was set up. Therefore, the majority of the students seemed to be willing to be a little more forthright with their feelings. These entries provided valuable access to their thinking and so became a primary data source.

I initiated one last reflection for closure which occurred at the end of the study on October twenty-fourth. In general, I wanted the students to write whatever they were thinking about the experience, but indicated that I would be interested in what they thought they had learned about science, how their views about learning have changed and what they saw as the connection between reading and learning.
Student narratives. The construction of conceptually focused student narratives provided a curricular focus that operated throughout the study. These narratives represent a synthesis of the student's inquiry efforts and became an important touchstone for new understandings and in this way offered a window into the participants' conceptualizations and the kinds of connections that were made.

Secondary Data Sources

The secondary data sources included:

1. Burke Reading Interview (BRI)
2. Retrospective Miscue Analysis (RMA)
3. Field notes
4. Audio and video taped classroom sessions

Burke Reading Interview. A Burke Reading Interview (BRI) was given to all students. The responses on these interviews provided background information on students' attitudes about reading in general and formed the starting point for individual interviews with study participants.

Retrospective Miscue Analysis (RMA). Originally, I had planned two to three individual RMA sessions with each study participant. This was unrealistic, given all the other responsibilities I had. Therefore, only one session was done with each study participant. The reading passages for these were drawn from either the literature
discussion book or from materials relevant to their research project. RMA was employed as another access to the thinking processes of learners as they construct meanings around written texts. However, time constraints made it impossible to do enough RMA sessions to be useful for primary data. The RMA sessions that were completed offered some opportunity to discuss their thinking about narrative and their own learning with the students.

Field notes. Field notes were taken as a way to record classroom activities, as well as providing a way in which to reflect on theoretical issues. Because I was so engaged with the curriculum, I rarely got the opportunity to just sit and take field notes, but often summarized the days happenings and entered my thoughts and reflections at the end of the day.

Video and audiotaped classroom sessions. These recordings were done primarily during science sessions, however, some of the early strategy sessions were also taped. During these sessions, say partner reading for instance, the video camera would be focused on a pair of students, rather than the class as a whole. The video and audiotaped science sessions included classroom wide as well as study group sessions. The classroom wide sessions were primarily useful in capturing the general feeling of the classroom, rather than as a specific data source. I also taped two sessions where two different halves of the study group did a science experiment that I had selected for them.
The secondary data sources provided valuable background information, which provided some reference points and a reminder of the overall sense of the classroom. The primary data provided more access to the thinking of the participants in connection with the focus concept of interdependence. The following section will describe the process through which the primary sources were analyzed in relationship to the theoretical context that introduces the section.

Data Analysis

The type of research and data analysis reported in this study can be accused of lacking the kind of tight hypothetico-deductive or inductive logic touted by quantitative studies. Often quantitative studies employ logic that, rather than providing any insight into human cognition, often mask the very phenomenon they are purporting to study. This can be seen from the way in which induction is used.

Induction has often been considered a process of reasoning from particulars to a general law through the summation of occurrences. What is the key to induction though, is the interpretive process through which observations are explained in terms of an hypothesis, rather than the number and arrangement of incidences (Hanson, 1966). Therefore, studies which seek to establish theories based on statistical sums are engaging in a limited kind of induction.

The "constant comparative" method outlined by Glasser and Strauss (1967)
provides a way in which qualitative social science data can be analyzed as a process of inductive inferences. In this way, the constant comparative (Glasser & Strauss, 1967) method provides a systematic procedure for generating hypotheses and grounded theory through the development of categories and relevant properties by comparing and sorting "incidences". But as Siegel (1984) points out:

The problem with this strategy is that comparing one datum with another presupposes a common metric on which to base the comparison. This amounts to saying that in order for the technique to work the researcher must already have an hypothesis. (p. 254)

In other words, what is missing is the underlying reasoning that led to the interpretations that seem to be suggested by the data; Peirce (1955) called this abduction or retroduction. Abduction is the generation of an initial hypothesis as a possible explanatory framework that most likely will be modified. "The first starting of a hypothesis and the entertaining of it, whether as a simple interrogation or with any degree of confidence, is an inferential step which I propose to call abduction" (p. 151), where induction involves the testing of the hypothesis "...by means of a prediction, which has been verified" (p. 153). Here Peirce makes some distinctions between qualitative investigation and quantitative by suggesting a second type of induction which he called an "abductory induction."
Induction can be employed in a straightforward manner to test a hypothesis that involves discreet occurrences, such as in the example he gives of testing a prediction about the ratio of male/female births within different ethnic groups. However, qualitative data cannot be quantified, but is instead made up of what Peirce (1955) called "characters", the value of which is relative and can only be estimated. With the initial analysis, abductions or tentative hypotheses are generated through a process that "...involves reasoning from a case to a rule that might explain that case" (Siegel, 1984, p. 254). These initial abductions then become working hypotheses or frames of reference for further analysis. This process became clear to me early in the data analysis process. When I began observing the students engaged in self-determined science experiments, I wondered what was behind their decisions to explore one path over another? The next section attempts to provide an answer to that question with regards to my own process of discovery.

Theoretical memos in process. The three hypotheses generated from this study are presented as what Siegel (1984) calls "theoretical memos." The construction of theoretical memos is a process whereby hypotheses are developed through data analyses in light of theoretical considerations and issues. The data is then presented thoroughly embedded within a theoretical context, therefore providing some indications of dynamics between theory and observation as they influence the researcher. There is no way of knowing what the final theoretical memos would consist of, as they are generated from the "surprises"
found in the data through the process of retroduction.

Keeping my original questions in mind, I began with the idea of looking at intertextuality and connections between discourse and conceptualization. The analysis process began by an initial viewing of all video tapes, during which I took field notes. Also because there was a space of three years between the study and the data analysis, the first run through the data provided an opportunity to get re-acquainted with the participants. Throughout these initial field notes, I identified some quandaries for possible future study. One example of a potential theoretical memo involved how concepts are verbalized by the teacher. This emerged after I viewed a discussion which followed a class engagement with "say something" where everyone had read an article about the seas and oceans. One student suggests an experiment where the effects of the water of the Red Sea versus the water of the Dead Sea could be studied by having two people drink the water from one of the seas. To this Cathy responds:

What he described was a scientific experiment. If everything isn't the same, (controlling for variables) the experiment is invalid. That's what science is, narrowing down to one narrow focus. (audiotaped, 8/21/91)

Thinking this was too pat of a definition, I offered an alternative approach when I asked the question: "How did these seas get this way?". This interchange, made me think about the ways in which we verbalize or couch problems and the different stances taken by Cathy and I. Although this initial observation never developed into a theoretical memo, it
provided me with a general kind of orientation as I continued through the data.

Other initial memos included observations of the way in which learners were using literature as a context for conceptualization, both in discussion and in the process of "storying", the connections being made by learners, and the social dynamics of conceptualization. From these I focused on how learners seemed to be symbolizing concepts and the kinds of connections being made by learners. The literature group discussions seemed to be the source of most of these initial memos, therefore I focused on these for the next run through the data. As I went back through the data a second time focusing on the literature discussion groups, I recorded incidences where learners were making connections or expressing concepts symbolically on colored three-by-five cards, along with the date and a reference code for the source tape. These were categorized based on whether they were examples of concepts being symbolically represented or types of connections made by learners. The types of connections were divided into three categories: a) between narratives, b) to curricular events, and c) to life experiences.

These categories were the rough organization that led to the next phase, where two themes began to emerge. When I once again went through the data with these categories in mind, I noticed that the connections made by learners were often in the form of an analogy where learners were explicating and communicating their understanding of a concept by making a comparison between the current one and past family, social and
narrative experiences. The second thing that I noticed was that each participant seemed to have their own theme or metaphor for learning. From these observations, I began to develop the three theoretical memos that would comprise the following three chapters.

My inquiry then took me on an exploration of analogy in relationship with science conceptualization and a theory of semiotics, and an examination of the relationship between experience and conceptualization. To look at analogy and science conceptualization, I examined the scholarship in the area of scientific discovery and found that analogy had long been considered an important reasoning process for new conceptualizations. This was easily connected to the field of semiotics, in which analogy was considered in terms of a particular kind of sign relationship. This made it easier to distinguish between metaphor and analogy. When conceptualization was considered as a reasoning process involving different kinds of orientations pursuant to abduction, deduction and induction, it was possible to distinguish more clearly between analogy and metaphor.

Through the scholarship in science discovery and semiotics, I came to see analogy as a particular kind of sign that was explicative and could be associated with deduction and metaphor as a collection of signs that comprised a symbol of understanding that could be associated with induction. Furthermore, as many of the most dramatic scientific discoveries occurred through accidents of life, experience also emerged as a central
aspect of scientific discovery.

I then went back through the data, re-sorting cards as they pertained to the experience of the learners, analogies and metaphor. I also looked at interview sessions, written reflections, and the completed narratives in order to discover both experiential and symbolic aspects of the learner's conceptualizations. I came to see the narratives as metaphoric symbols where the experiences of the learner converged to represent their current understandings of interdependence. Therefore, these narratives were analyzed within the experiential context of the individual participant and yielded the third theoretical memo.

The organization of theoretical memo two, which focuses on intertextuality in relationship to analogy and narrative as a conceptual resource, did not become clear until I began to see the data in terms of aspects of the concept of interdependence. In this way the broad concept of interdependence took shape in terms of the notions of the participants, which involved the construction of analogies through a process of intertextuality and included narrative as a resource.

The first theoretical memo was drawn from interviews, reflections and literature discussion where participants made connections between their life experiences for conceptualization. Although this was the last theoretical memo in terms of writing, the data and the theoretical issues contained in it seemed to provide a foundation for the other
two memos. This made sense in terms of both science discovery and semiotics, where experience can be considered as implicit in all conceptualization.

Throughout this process, abductions were generated by surprising occurrences or sudden connections through which I began to see new possibilities. Therefore, the hypothesis presented in this study could not have been predicted from the outset, but are the result of a series of surprises that caused a change in how I was thinking about what I was seeing, allowing me to explore the data in new ways. Although this study does not appear to have the tightly controlled logic claimed by quantitative studies, the data analysis process was not a pell mell romp, but a reasoned process involving the generation and exploration of emergent hypotheses.

Three theoretical memos. The theoretical memos begin with a theoretical discussion that serves to make my understandings in connection with the data explicit, followed by the hypothesis and supporting "incidences" which will be grounded within a discussion of the context in which they occurred.

The logical thread that is developed through the three theoretical memos is founded on the view that learning involves meaning and cannot be reduced to the processing of information. This is a distinction that is paralleled in the differentiation between science discovery and science education. The history of scientific discovery is a story of knowledge in process that is grounded in the experiences of individuals.
attempting to construct explanations about the natural world. Where the process of scientific discovery begins with the questions of the inquirer, science education begins with the learning of answers to questions that have not been asked (Short, 1992). Where scientific discovery involves engagement of sign systems with which to explore questions, science education involves the teaching of representational structures and relationships that define codified science knowledge or facts (Kuhn, 1962; Goodlad, 1984).

The history of science cannot be characterized as the establishment of facts about the world, but a struggle between the meaning constructions of individuals within a particular sociocultural context, generated to make sense of phenomenon, often resulting in dramatic paradigm shifts that impact the ways in which we see the world (Kuhn, 1962). This struggle is not a direct linear progression but evolves cyclicly, through the mediation of sign systems.

Mathematics is considered to be a precise sign system generic to scientific discovery and expression, however, science knowing is not strictly mathematical, but also discovered and expressed verbally (Sutton, 1993). These two sign systems (mathematical and linguistic) represent two possibilities for knowing that intersect in how they function as analogical and metaphorical signs, as was suggested earlier in an examination of Peirce's cycle of reasoning.

Science discovery has often been characterized as either hypothetical-deductive or
inductive. However, Hanson (1966) in attempting to explicate the Patterns of Discovery involved in breakthroughs in science, cites the work of Peirce and suggests that deduction and induction are simply different elements of the same process. Reasoning then, does not necessary progress in an orderly fashion through the cycle; nor can elements of reasoning be separated in cognition, but as suggested by Hanson (1966), deduction and induction can be associated with particular phases of the discovery process. The hypothetical-deductive phase is associated with the explication of an hypothesis once it has been discovered, where the inductive is the phase where inferences are being made from observation which lead to the generation of an hypothesis. But as can be seen from Peirce's cycle of reasoning, explications of scientific discovery must begin with the "ontological flash" (Gerhart & Russell, 1984) through which the "hypothesis is caught" (Hanson, 1966) or in Peirce's terms, abduction.

Two other kinds of processes are explored throughout these three theoretical memos as they arise in science conceptualization. Analogy and metaphor are considered more than figures of speech in science discovery, where they have been instrumental for the discovery and development of new ideas (Leatherdale, 1974; Gerhart & Russell, 1984; Kuhn, 1979; Hesse, 1966), and can be considered as thought processes, rather than only as linguistic phenomenon. Further definition of analogy and metaphor will follow, but for the present it can be said that based on the original definitions suggested by Aristotle.
analogy involves understanding a relationship based on a comparison of two systems of relationship and that metaphor is the expression of that relationship through the synthesis of analogical relationships. This is an oversimplification but for the moment it serves to highlight the other kind of process at work here. Peirce (1955) considered that there were really only two kinds of reasoning: (a) explicative, where ideas are laid out, and (b) synthesis, where new understandings are discovered when ideas are reconnected in a new way. These processes seem to run parallel to analogy and metaphor, respectively.

In that deduction entails the explication of a hypothesis by establishing relationships between systems of relationships, it can be considered as primarily associated with analogy. This can be clearly seen with sign systems such as mathematics, for instance, which are employed to represent relationships within one system in terms of another.

In that induction involves the synthesis of experiences focused on the testing of a hypothesis, potentially resulting in a new theory, it is associated with metaphor. On the surface, this seems impossible as this aspect of reasoning has been commonly associated with the testing of a hypothesis by summing up incidences of observation. However, according to Hanson (1966), this model misrepresents and limits the role of induction in discovery. While induction is reasoning from particulars to general law, there is also a great deal of inference that influences how those particulars are connected together. Induction involves the testing of a hypothesis through experimentation, where data is
employed to make inferences in light of a working hypothesis. These inferences are often expressed through models or metaphors, from which new meanings can be derived. These new meanings then become part of the foundation for future abductions and in this way metaphoric thought processes can be associated with both induction and abduction.

The three theoretical memos that follow will be roughly associated with Peirce's cycle of reasoning, interpreted by Short (1990) as the cycle of critical thinking. Elements of reasoning within this cycle include anomaly and abduction, deduction, and induction. While these aspects of reasoning are part of one process, for the purposes of explication, they will be highlighted through the three theoretical memos that follow in terms of:

1. Experience and discovery
2. Analogical relationships/hypothesis explication
3. Metaphor/a synthesis of experience for new understandings

The three theoretical memos in the following chapters highlight these three aspects of reasoning, in light of theoretical issues and as they emerged from the data. Theoretical memo one focuses on the life texts or experience of learners and the abductory aspect of conceptualization, with data drawn primarily from literature discussion and interviews. Theoretical memo two, with data also drawn from literature discussion and interviews, focuses on the analogies that learners constructed in their attempts to express conceptual understandings. The data for theoretical memo three is primarily drawn from student
constructed narratives and highlights metaphor as a process for establishing new understandings.

Finally, before proceeding with the theoretical memos, it will be necessary to mention intertextuality as it is considered here to be a process that operates through all aspects of cognition. Intertextuality is considered a cognitive process through which "texts" (considered here as meanings rather than necessarily verbal texts) are juxtaposed and constitute new meanings. All three theoretical memos, in that they examine connections and relationships discovered by learners, indicate the intertextual nature of learning. However intertextuality, considered as an implicit process in the first theoretical memo, will be highlighted in the second and third memos where the dynamics of intertextuality can be more clearly seen in the discourse and the narratives constructed by the students.

Through the theoretical memos which comprise the following three chapters, a view of science conceptualization as semiosis will be explicated.
CHAPTER FOUR

THEORETICAL MEMO ONE: LIFE TEXTS FOR LEARNING

This first theoretical memo will primarily be focused on question one, which focuses on the role of experience in conceptualization. The chapter begins with a discussion that highlights the experiential aspect of the historic philosophical issues discussed in chapters one and two. This leads into a discussion of the role of experience and affect in learning and how this relates to current and historical instructional practices, followed by a series of sections that define life texts in terms of views of text and sources of life texts. An analysis of the data pertaining to life texts will be concluded with further theoretical considerations of experience and knowing in relationship to the data.

Philosophical Stances on Experience and Knowing

The role of experience in learning has been highlighted in pedagogical debates concerning the conflict between student culture and school culture. Many of the issues involved in this debate are grounded in the educational paradigms that have dominated this century, which in turn have historic philosophical roots. The relationship between experience and knowing can be discovered in the historical philosophical debates between rationalism and empiricism.

For Descartes (Reichenbach, 1951; Tarnas, 1991), knowledge of the world could only be found in mathematical relationships. Descartes believed that scientific knowledge is obtained through the application of geometric and mechanical deductions that exist separately from experience, thus establishing a dichotomy between the scientific/
mathematical world and the world of experience.

This assumption was challenged by the empiricists who posited that all knowing is anchored in sensory information from the natural world. From a rational stance experience was considered inconsequential and possibly a potential interference to knowing; from an empirical stance experience was reduced to sensation. However, the rationalist/empiricist debate is founded on a false dichotomy with neither stance providing tenable explanations for the relationship between experience and knowing.

Peirce (1955) understood this when he suggested that all knowing is a process that involves the rational or cognition-dependent and the empirical or cognition-independent (Deely, 1982). To Peirce (1955), all knowing is mediated by signs that develop and change through our experience of the world. From the very first experiences, humans begin to construct a sense of their world and to orient themselves in unique ways. However, these constructions that constitute our knowledge-in-process, are neither entirely physical or entirely mental, but intrinsically both. This inseparable mutuality is key to understanding the role of experience in knowing.

Empiricist notions of experience fall within the realm of the cognition-independent. The wide discrepancies between the natural world and Descartes' conceptualizations of it caused the empiricists to claim that the source of knowledge existed in the natural physical world, rather than rationalistic constructs. This empirical backlash set the scene for an experimental approach to knowing, a positive step in light of the limitations of rationalism. This also led to a consideration of experience as simply a
collection of sense experiences. But if knowledge existed solely in sense experience, everyone should see the same thing when viewing the same object. However, as the often heated disagreements in scientific communities indicate, this is not the case. In an exploration of the role of observation in the physical sciences, Hanson (1966) points out the limitations of a sensory data view of experience:

\begin{quote}
...physics is represented as resting on sensation and low-grade experiment. It is described as repetitious, monotonous concatenation of spectacular sensations, and of school-laboratory experiments. But physical science is not just a systematic exposure of the senses to the world; it is also a way of thinking about the world, a way of forming conceptions. The paradigm observer is not the man who sees and reports what all normal observers see and report, but the man who sees in familiar objects what no one else has seen before. (p. 30)
\end{quote}

Even this seemingly straightforward aspect of experience involves complexities that render it a kind of semiosis. Deely (1982) posits that the fact that sensory data is experienced as multimodal, an interpretive dynamic is involved. Therefore, even if experience is considered to be only sense data, it still includes an interpretive process found in the coalition of sensory channels (Deely, 1982; Siegel, 1984). Furthermore, because all experience is mediated by signs, the sensory data goes beyond the physical level. For instance, knowledge of interpersonal dynamics is not physical at all, but is generated from sensory data such as "body language".

Cognition-dependent aspects of experience speak to the unique way in which
sensory data are perceived and interpreted. Those interpretations are not based on sensory
data, but involve ways of knowing such as affect, that have not been seriously considered
as part of cognition. This can be seen in Descartes' rationalist approach to knowing in
which the mind was considered in terms of mathematical abstractions. While Descartes
possited that knowledge rested in the rational mind, his idea of mind was very limited. He
did not think that everyday experiences or emotions were part of a knowing mind.

Semiotically considered, however, experience can be considered as a synthesis of
rationalist and empiricist stances. Deely (1982) makes this clear when he states:

Once cognition is introduced, the situation drastically changes. Now the same
relation existing independently of cognition can also come to exist dependently
upon cognition, and can continue to exist in cognition after its physical ground no
longer exists. Moreover, as we remarked above, relationship existing first in
cognition can subsequently be introduced into the physical order by bringing about
within that order the proper conditions. (p. 116)

Semiotically defined then, experience is a dynamic through which humans come to
understand and act on the world. It neither exists entirely in the mind, as a force to be
reckoned with, nor in the objects of the physical world, but as an inter-related process
central to cognition.

Experience, Affect and Knowing

This artificial division of cognition has not been as troublesome for the physical
sciences as for the social sciences (Langer, 1942). While the social sciences were plagued
by debates grounded in the dualism highlighted by Newtonian physics, the physical sciences evolved methodologies for knowing that combined the rational and the empirical. Knowing of both the rational kind (mathematical constructs) as well as the empirical (observational data) converge through inquiries carried out in the physical sciences, inferring that knowing is not a phenomenon that can be understood by divisions.

Peirce (1955) suggests this when he states:

"... every phenomenon of our mental life is more or less like cognition. Every emotion, every burst of passion, every exercise of will, is like cognition. But modifications of consciousness which are alike have some element in common. Cognition, therefore, has nothing distinctive and cannot be regarded as a fundamental faculty. If however, we ask whether there be not an element in cognition which is neither feeling, sense, nor activity, we do find something, the faculty of learning, acquisition, memory and inference, synthesis. (p. 94)

What Peirce seems to be saying here is that cognition is a process that contains many aspects, as well as the mental operations that have been commonly considered cognition. Emotions are considered by Peirce as an aspect of cognition or knowing. However, just as art has been considered peripheral to knowledge, affect has not been taken seriously as a way of knowing (Dewey, 1938; Eisner, 1982; Langer, 1942). Cognition has traditionally been considered in terms of verbal and mathematical operations, defining it based on abstract categories, and therefore limiting the potential to realize the scope of knowing.
The affective aspects of knowing can be seen through Peirce's (1955) modes of being: firstness, secondness and thirdness, which were discussed in chapter two and will be reviewed here. "I hold that we can directly observe them in elements of whatever is at any time before the mind in any way. They are the being of positive qualitative possibility, the being of actual fact, and the being of law that will govern facts in the future" (p. 75). However, these three modes of being are not separate entities, but indicate aspects of knowing.

Peirce (1955) considered feeling to be of firstness. Firstness is a quality "...of feeling, such as the colour of magenta, the odour of attar, the sound of a railway whistle, the taste of quinine, the quality of the emotion upon contemplating a fine mathematical demonstration, the quality of feeling of love..." (p. 80), and considered feeling to be a mode of undivided considered feeling in the realm of firstness. Although Peirce considered feeling to be an unanalyzable quality, it is connected to secondness as feelings are generated through experiences that involve the interaction between the internal and external worlds, it is the tension that exists between reality and our sense of it.

Thirdness is what Peirce (1955) called a "...synthetic consciousness, binding time together, sense of learning, thought" (p. 95) and has to do with signification or in making the relationship between our perceptions and the external world an object of thought in itself. Thirdness is consciousness that is beyond the incidences that make up the day to day incidences that form our experiences and does not reside in immediate consciousness, but refers to knowledge in process. All three modes of consciousness make up what Peirce
called cognition.

The affective aspects of knowing are highlighted by Rosenblatt (1938) who posits aesthetic (emotions, memories, experiences), as well as efferent stances in knowing. Alternative ways of knowing are explored by Gerhart and Russell (1984), a theologian and a physicist respectively, who suggest an underlying commonality when they make a comparison between the reasoning processes underlying the development of science knowledge to that of metaphysics. Affect figures strongly in their view of experience, which they consider to be phenomenological rather than necessarily sensory. Central to the phenomenological model of experience is the notion "... that basic and prior to the reports of the five senses and undergirding all of the self's experiences is an awareness of the self as human" (p. 26). In taking a phenomenological stance, Gerhart and Russell suggest that experience is more than sense perception, but is comprised of non-sensuous elements such as "recollections...[of] meaning-filled experiences" (p. 26).

These meaning-filled experiences that have been suggested as being an essential aspect of knowing, have not been made a part of school knowing. Attempts to understand cognition have been limited to the debate between rational and empirical ways of knowing as reflected in the behaviorist and cognitivist paradigms. However, it is in the commonalities found between the way these two paradigms view experience and affect in learning that suggests the influence of socio-political, economic and technological factors. Both the behaviorist and cognitivist have not considered experience or affect as part of cognition, but in terms of interference (Dewey, 1938; Eisner, 1979; Shannon, 1990).
Even while the cognitive science backlash shifted research trends towards the investigations of the internal aspects of cognition, cognition was still conceptualized in terms of linguistic and mathematical operations. The results of these philosophical stances can be seen in the twentieth century approach to education discussed in the next section.

The Technology of Learning

The roots of a bias in education towards concrete linguistic or mathematical operations can be found in the socio-political, economic and technological influences taking shape around the beginning of this century. In historical accounts of reading instruction and progressive education, Shannon (1989, 1990) posits that the socio-political context, technology, and business exerted undue influence on the public school system. To summarize Shannon's findings, industrialization and influxes of immigrants created new urban environments; where in a previously agrarian society, the center of production was the home, in the new industrialized urban environment, life was fragmented, with individuals being funneled into performing only one task: working at a job. Technology (reified as science) and business focused attention on the employment of scientific methods to increase efficiency. These attitudes were reflected in the schools where learning became the process of efficiently imparting information.

The experiences of the students and how they felt about them were inconsequential in a scientific method of education, bent on producing productive citizens that would eventually take their places in and be indistinguishable from their fellows in the great melting pot society. Therefore, there were no allowances made for experience, which can
be considered synonymous with culture, in classroom curricula.

One particularly pervasive technology that has wielded great influence on models of learning this century is the computer. Seized on by the cognitive scientists, the computer was a model through which earlier production line metaphors for learning could be fine tuned into an information processing model of learning (Gardner, 1984). In a limited sense, through schema theory, experience has been included in information processing models of learning. However, the schemata of the learner has often been viewed in terms of misconceptions to be corrected (Armbruster et al, 1985; Smith & Dole, 1989; Brown, 1993; Clement, 1993). While claiming to acknowledge the constructive nature of cognition, researchers have ignored the fact that learning begins with the unique experiences of the learner, not with set research tasks.

It is this limitation that has caused Piaget's work to be called into question. Piaget contributed to what we know about early cognition because he took children seriously enough to explore their thinking. As was discussed in chapter two, these contributions were limited by defining cognitive development in terms of spatial-mathematical concepts, in isolation from social and contextual factors. Therefore, the tasks on which Piaget has based his theory of cognitive development, were carried out in clinical settings, with the tasks themselves being so decontextualized that they either held an entirely different meaning for the child than was being assumed by the researcher (Donaldson, 1979).

Based on the performance of children on these tasks, Piaget concluded that it was impossible for children at certain stages to engage in certain kinds of reasoning. But
studies carried out using redesigned Piagetian tasks suggest that it is not a lack in
cognitive functioning, as much as a how the task is presented. When the tasks were
presented in a way that made sense based on the limited experiences of the children, a very
different picture of cognition began to emerge. Donaldson (1979) cites study after study in
which dramatically higher percentages of children were able to successfully respond to
modified Piagetian tasks. Seen in this light, experience is central, rather than peripheral to
knowing.

This perspective of experience was key to Dewey's (1938) theories of education.
Dewey viewed all learning as generated from experience whereas, "...every experience
both takes up something from those which have gone before and modifies in some way the
quality of those which come after" (p. 35). In this way a flexible web of meanings
grounded in experience is constantly being constructed and both influences our
understandings as well as being influenced by connections to further experiences.

In this way experience is considered a unique resource where, "Efforts to construct
reality, to come to know the world and themselves, to develop an active voice, all must be
grounded in the concrete experience of daily life and reflective consideration and
reconsideration of that experience" (Dewey, 1938, p.168). It is these unique aspects of
cognition or life texts as they will be called here, that have frustrated attempts to engineer
cognition through the manipulation of schema.
Life Texts

It is these life texts that were in operation throughout the study and will be the focus of the data presented in this theoretical memo. The following two sections will define text as it applies to life texts and will discuss aspects of life texts before proceeding to the data section.

Text as Meaning

Perspectives on text summarized by Beaugrande (1981), who provides an historical overview of the study of text, led him to propose seven standards of textuality. Early scholarship in linguistics, termed structural or descriptive, had a molecular approach, breaking text into minimal units such as phonemes, morphemes etc. (Beaugrande, 1981). This approach was limited because as Beaugrande points out:

...one can analyze a text into levels or minimal units as depicted, but there is no guarantee that we will have uncovered the nature of the text by doing so. On the contrary, the extraction of tiny components diverts consideration away from the important unities which bind a text together. (p.21)

What Beaugrande (1981) suggests, is a description of text based on what he calls "seven standards of textuality": cohesion, coherence, intentionality, acceptability, situationality, informativity, and intertextuality, with "The mechanisms which combine texts as single contributions into DISCOURSES as sets of mutually relevant texts directed to each other, reveal major factors about the standards of textuality" (p.19). Rather than only looking at text in terms of surface structure, Beaugrande defines text in terms of the
activities of both the producer and receiver of text within the communicative context.

This greatly expanded view of text, while acknowledging the activities of text producers, suggests a dualistic relationship between text producer and text receiver. Text is seen as an entity that is processed by the receiver and either understood or not and either rejected or not. While this textual processing is seen by Beaugrande as being influenced by the receiver's previous experiences and global patterns such as frames (knowledge about a concept); schemas (arranged by time and causality); plans (goal oriented patterns leading to a state or event); and scripts (intact pattern that identifies the roles of the participants), the text is still seen as a separated identity and the social cultural context to a large extent is excluded.

A transactional theoretical view of text is a perspective that suggests unity between all elements of textual events, and considers text to be an enmeshed element of the active meaning construction role of the reader. Rosenblatt (1981) describes this view of text as, "...an open-meshed woven curtain, a mesh of flexible strands that hold a certain relationship to one another, but whose total shape and pattern changes as anyone part is pulled or loosened" (p.76). The agreed upon conventions of text have an impact on the meaning making process, but only as a blueprint with the reader constructing an entirely new text. Also, Rosenblatt (1981), sees the context as an important element within the meaning making process. "A more dynamic phrasing, we have seen, is that the context guides the reader in the process of selecting out---from the range of inner possibilities---the kinds of responses, referential and affective, that are appropriate" (p.
This inclusion of context has pedagogical implications that are ignored by Beaugrande's model. Text cannot be defined as a separate entity but rather as verbal symbols operating as signs included in the meaning making activities that take place within a particular social and cultural context such as a classroom. These verbal symbols, until becoming part of a transaction, can be considered "text potential". "What is out there is a 'text potential'; what we create in our heads is text." (Harste, Woodward & Burke, 1984, p. 169). This description of text as an "in-head phenomenon" defines text in a much broader sense as any potential meaning making signs that are recognized and transacted with (Short, 1992). "When text is viewed as an event, literacy is seen as a psychological and sociological partnership. Meaning is not something inherent in the print, but created in and through interaction. Text moves from being something created on paper to being a psychological and sociological event" (Harste, Woodward & Burke, p.169).

If text is considered to be any configuration of meaning, it can no longer be necessarily associated with a linguistic sign system, but as a dynamic that obtains through all sign systems. Experience and affect can be considered as kinds of "texts", which I will call life texts. These will be discussed further in the next section.

Three Life Texts Defined

Life texts then are considered to be meanings that are grounded in experience and therefore text is used here in the manner suggested by Harste (1984), as a socio-psychological event. It is with this perspective in mind that I have generated the term life
text to designate three broad categories of experiences that characterize the web of understandings through which we interpret and make sense of our world. These categories include:

1. Family culture experiences
2. Community culture experiences
3. Reading the world

When, in the process data analysis I focused the discourse of individual students, a theme for each student emerged. These themes were characterized as a particular orientation to learning or acted as a resource for new conceptualization, and were drawn from their unique experiences. However, there were some commonalities that also began to emerge. The students seemed to be drawing from their family and community experiences as a resource for understanding. It is from these commonalities that the life text categories were derived.

Alternative ways of knowing can be found through the meanings grounded in the transactions that take place within the family context. Families provide the initial social context as they characterize the environment or Umvelt of the infant organism. These initial transactions, are meaning rather than linguistically oriented. Infants engage in primary acts of cognition that are intended as a way to make contact with the social context by constructing signs and establishing early connections between the environment and their experience of it (Halliday, 1975; Donaldson, 1978). In this way, along with coming to know the world through physical sensation, the young child develops meanings
that are embedded in interpersonal dynamics and affective states.

While always being modified, these meanings are resources for knowing, the importance of which can be seen when the family culture of the children is in conflict with or denied by the school culture. Studies such as those done by Au (1991) who investigated the relationship between home and school participation patterns in Hawaiian children, and that of Tharp and Yamaguchi (1994) who conducted a similar study with Navajo children, suggest a close tie between interpersonal knowing and the structure of learning experiences.

In terms of a broader sociocultural context, the role of experience in learning has been highlighted by critical theorists who view schools as institutions through which social order is maintained by denigrating and denying the experiences of the minority culture (Giroux, 1983). By doing this, the learner is cut off from the experiences through which meaning is constructed. This has prompted such scholars as Freire (here paraphrased by Giroux) to observe that literacy "...only becomes relevant if it is grounded in the cultural milieu that informs the context of the learners' everyday lives" (Giroux, 1983, p. 228).

Such studies as the extensive one done by Heath (1983), comparing the discourse styles of two communities in the Southeastern United States or that of Moll et al (1990) whose investigation into funds of knowledge operating within an Hispanic community, suggest that meaning is imbedded in the interpersonal dynamics of families and the community. Therefore, life texts can be considered as a reservoir of experiences that are generated through transactions within family and community contexts.
The exclusion of experience as an aspect of cognition is most noticeable when there is a marked difference between the community culture and school culture. However, due to the cognitive bias' of schooling, this is often the case in general.

Reading the world is an aspect of life texts that is built up through signs constructed from observations and experiences of the physical context. For instance children growing up in the desert will probably have a different experience of space than urban or island dwellers and will have had such experiences as seeing a bone dry wash suddenly erupt with a wall of water. They are grounded in their specific physical context, as well as being generated from the broader social context.

The following sections will examine the life texts of learners as they seemed to be operating in conceptualization. The first section is a general discussion of life texts as conceptual resources and will be followed by sections that explore the previously stated categories of life texts. These three aspects of experience emerged as learners reflected on their own learning process and attempted to construct science concepts. Life texts cannot be really considered as separate entities of experience, just as experience cannot be separated from knowing. Taken together though, the following data highlights the dynamics of life texts in the process of knowing.

**Life Texts as Conceptual Resources.**

The importance of life texts, established on the first day of school, was made apparent through various curricular engagements. Cathy began the year by telling the students about herself and her family in a way that indicated that they were an important
referent for her as an educator. In fact Cathy makes this explicit when, on the first day of
class she described her family and then stated:

   Later I'll bring in a picture of them and tell you about them. Then
   you'll know why I run the class the way I do. (8/19/91)

Cathy provided two opportunities during the day for learners to engage in private
and public reflection. One occurred immediately following lunch, when Cathy used a daily
strategy where she asked each student to rate how they were feeling from one to ten and
state why. The other one, journal writing, occurred at the beginning of the day.

Daily writing journals, a curricular engagement that was not necessarily the focus
of the present study, was something that Cathy had included as a curricular focus for the
past several years. It was through these journals that Cathy made contact with students
based on free ranging individual reflections and stories. Beginning on the first day of
school, almost every day started with journal writing, followed by a few students sharing
that writing.

   Cathy: These are your writing notebooks. I'll be curious to see how
   you use them. Cathy then excuses students by table to choose a
   notebook and write for 5 minutes.
   C: What kinds of things did you write?
   This is followed by discussion, during which Cathy begins to list
types of writing, personal narrative figured prominently. (8/19/91)

Although I had access to many different sources of data, I unfortunately did not
have access to these journals. They were considered to be the most private realm in an
otherwise public domain, and therefore the students made them off limits to me. I might
have pressed the point, but I felt that the participants needed some area that was closed to
Our methodological framework was based on the authoring cycle (see methodology), a semiotically oriented conceptualization of learning, developed by Harste, Short and Burke (1988) through their experiences in classrooms with a literature and process writing curricular focus. Because Cathy had also focused on literature and process writing for the last nine years, the authoring cycle made sense to her. We also decided to introduce the authoring cycle to the students as a way to reflect on learning.

Because the authoring cycle begins with the experiences of the learner, the connection between experience and knowing was highlighted. A picture of the authoring cycle was presented to the students as a focus for a brainstorming discussion, introduced by Cathy: "If I told you it's about authoring, what would you make of it? What do you think it's about?" I recorded what the students "made of it" in my field notes:

- **We are focusing in on the beginning of the cycle.**
- **Con:** She's thinking of a story.
- **Cathy wants to put this somewhere else on the cycle.**
- **Hal:** She's going to write about what she did in her life.
- **Thinking of a story about her life.**
- **Betsy:** She reads a book and she could write about it. She'd be reading a book and she would have an idea to write about.
- **Holly:** She could use the character's experiences from a book. She could use life experiences in a book.
- **Hal** She could think of her life and write an autobiography.
- **Lynn:** Something that happened in her life but saying it happened to another person in the story. You could become a name on the book and the character would be you or what happened to you.
- **Mary:** Sometimes author's will dedicate a book to the person it will be based on.
- **Holly:** You read a book and writing down about that story only changing the phrases.
- **Bonny:** Reading a book and write about the same thing but a different issue.
Mary: Taking thoughts you have from life experience and then writing them down. (8/19/91)

Through this discussion, which highlights life experiences in the authoring process, learners explored the connections between experiences of themselves and the process of authorship. These kinds of connections were also found through interviews done in a study by Cairney (1990) where students were asked to reflect on their own writing processes. While this is a tentative exploratory discussion, there is a sense that many of the participants saw their experiences as a resource for knowing.

In a later discussion that took place in The Talking Earth (George, 1983) literature group, Lindsey makes this notion clear. Because many of the students had listened to a taped interview with Jean Craighead George, they became interested in her process of authorship. In discussing the origins of the characters in her stories, we began to speculate about their existence, causing Lindsey to observe:

She probably saw someone like Billy Wind. Like when she got off the plane and saw that girl (referring to the inspiration for Julie of the Wolves). (10/15/91)

Another engagement that highlighted the making of connections to experiences was "getting to know you", essentially the creation of a book of interviews between pairs of students. This gave the students the experience of moving through the authoring cycle as interviews were conducted, in order to construct mini-life stories of the participants. These stories were then illustrated and bound in an anthology.

While these curricular engagements were employed as a way to generate the personal involvement that I intuitively understood to be essential to learning, it wasn't until
in looking through the data, that I began to see the connections learners made to experience. Just as life texts affect the inquiry of the scientist, the questions asked and interpretations offered by students was grounded in their own unique life texts. Life texts are an experiential dynamic and in that it is impossible to separate them from each other or cognition. Even though the following life texts are presented in family and community culture, and reading the world categories, cognitively speaking, they exist as a whole.

**Family Culture Life Texts**

In order to get a sense of the participants' understandings of their own process of learning, I conducted two study group interviews. One at about the mid point of the study and another at the end. The following example comes from an audiotaped group interview that took place on 10/2/91 and included Diane, Holly, Lynn and Tammy. This group was part of the group I had selected to focus on for data collection, and were also all participants in *The Talking Earth* (George, 1983) literature discussion group.

In this interview, I was trying to get them to reflect on what they thought learning was in general with questions that were meant to elicit reflections about various aspects of learning. As the questions asked them to think metacognitively, they were having a difficult time responding to the questions. In fact previous attempts to conduct this interview on an individual basis were abandoned in favor of a group interview in the hopes that the collaborative atmosphere would help them in responding to these difficult questions.

In response to the prompt: Tell me about a time you learned something, Holly and
Lynn responded with vignettes set within the family context. These involved parents, extended family or older siblings.

**J.W.:** Tell me about a time you learned something.

**Holly:** Learning how to read. I was sitting with my dad, it was the year I was going into first grade. It was this book, *Hop on Pop* is what I think it was. I asked my dad if I could look at a few of the pictures in this book and he wanted me to read it with him and I said I didn't know how to read it and he said, "Well do you know the alphabet" and I said "Yes" and he said, "Then you know how to read". And so he started and he showed me that's a T and that's an H and that's an E and he said, "O.K. what does that say?" and I said "Tai". And he said, "When you put a T and an H together it sounds like th." So I, that's when I learned to read. (10/2/91)

Throughout literature discussions, it was evident that Holly's family context played a central role in her attitudes about learning and problem solving, as well as being a reference point. During a discussion of interdependence in terms of ecosystems, Holly suggests that solutions were a matter of our knowledge and of thinking hard.

*We depend on.* If one thing that would be important to us like cars. It would really be depressing because we depend on cars to get us places like transportation. If like an important thing like that didn't happen, I bet the human mind, if they think hard enough would be able to find out something better than cars. (9/30/91)

It can be inferred that this approach to problem solving is connected to Holly's previously described learning to read experience communicated to her by her father. The attitude seemed to be that we have the resources, it's just a matter of using them or to paraphrase Holly's father, you know the alphabet so use that knowledge to read.

Holly also made direct reference to her family as a resource for understandings she expressed in literature discussion. Throughout these discussions she often cited her father.
One example of this emerged in *The Talking Earth* (George, 1983) literature discussion group. Because the plot of the book was organized around discovering whether or not the animals and the earth talk, the group was discussing alternative communication systems.

My dad says that our language is very lazy. Because like if we could understand the way cats languages are, the way all animal's languages are, I bet a lot of things on this planet would be better. (9/16/91)

Interpersonal family dynamics acted as an interpretive resource when learners were faced with difficult to grasp concepts. Interdependence was explored as part of the literature discussion groups. Students were not expected to come up with a pat definition for this complex concept but, we made some beginnings by attempting to define the word in terms of dependence. Within this discussion, Ally used her family as a way to begin to understand this concept:

I depend on my mom to take care of me and she depends on me to do what I am supposed to do. (9/26/91)

What can be seen through these examples is the implicitly and explicitly expressed influences of family culture experiences. These influences were a subtle force as the participants constructed meanings through interpretive webs characterized by understandings of interpersonal dynamics, and the discourse, which Atwell calls "kitchen table conversation" that takes place as a part of family life.

**Community Culture Life Texts**

Life texts are also generated from various experiences that take place outside the family context, such as experiences with peers and narratives as they occur in books.
movies, television and music. The site of this study was located in a small satellite community north of Tucson, and could be described as a rustic fairly isolated suburb. The population is economically diverse, with the main ethnic groups being Hispanic and Anglo. While the economic status is wide ranging, the bulk of the population can be described as middle or working class. Moreover, while isolated geographically, the perception of the school's vice principal was that the majority of the residents of the community were well informed about the broader social context.

With the exception of one student who is Hispanic, the students in Cathy's fifth grade class were Anglo. All students had access to television, frequented such places as Skate World or Shakers (a water park) for entertainment, and had access to movie theaters. Like adult residents, many of the students were aware of the broader context. This was reflected in a level of awareness that surprised me and led me to record the following observation in my field notes:

I go to get Tammy to interview her. She is trying to answer my questions but is having a hard time with it. I am beginning to think I will do a group interview instead of individual ones. I have her read Baaa by David McCauley (a book that shows a cycle of waste and self-destruction repeated by sheep after humans are gone) and ask her to tell me about it. It must be really scary for kids now. She tells me how the earth is going to disappear if we are not careful and that it probably will. She talks about pollution and waste and I ask her how she knows about all this. She responds that she listens to the news and hears about it from her parents and when other people talk. (9/24/91)

The students' experience of the community's social context, as well as an acute awareness of the broader social context, influenced their inquiries and interpretations. The
discussions that took place in the literature groups were organized around questions that were generated by the group. These questions reflected their perceptions and concerns, which sometimes differed greatly from mine. When The Talking Earth (George, 1983) group asked: "Why did Billy Wind and Oates Tiger separate at the end?", I was a little mystified as to why this question was asked at all and did not consider it to be very important.

Billy Wind and Oates Tiger met at the end of the book when they took shelter together from a hurricane. When the hurricane is over, they part to continue on their own journeys. Members of the group considered this to be an anomaly and could not understand why the book ended this way. While not always expressed explicitly, the sense seemed to be that expectations based on community culture life texts was violated. A comment by Amanda in an earlier discussion of this, "Usually in movies they have happy endings", seems to foreshadow the nature of future discussions.

**Lynn:** I did the first question which was why did they separate at the end. And I put so that they could go on with their different ways and maybe so they could go on with their different ways and their different paths maybe fate will bring them together again or maybe it will keep them separated. I really don't know and I'm really, really curious. I just wish Jean Craighead George would write a sequel of it. So we could find out why they did or if they could get back together.

**Diane:** I did what you did. Mine's sort of close to you. I think they separated because she needed to fill her needs like he did. I thought they would live together and fall in love. Cause of the fact that they were so close as friends. And they were so giving to each other. **J.W.** You thought they were close friends?

**Diane:** Yeah, cause they really took care of each other.

**Lynn:** Yeah. That's how she really expressed it.

**J.W.** Really?

**Group:** Yeah!

**J.W.** Let's look at the ending. (10/9/91)
We re-read the relevant passage. As we read through the five pages pertaining to the storm, for Diane and Holly, two contact points in the text were: "His face grew solemn, and he pressed his full lips tightly against his teeth. I am out adventuring to get a new name"; and "He's beautiful, [she] (miscue for he) said licking his fear-dried lips". At this point in our discussion I commented that it is the panther that is being talked about here and state that I think they read a different story than I did.

Rather than poor reading, however, it provides a "window" into the kinds of life text connections that were being made. This phenomenon is observed by Rosenblatt (1938, 1981) in examining reader responses that have no apparent foundation in the text. In this case, their hypothesis about the relationship between Billy Wind and Oates Tiger was so strong that the discussion continues with members of the group providing more justification for the outcome that the two characters would fall in love or continue a relationship later. The next example is a continuation of this discussion.

**Holly:** They helped each other and they kind of showed each other kind of like the way and she gave him a new name and he helped her get shelter and all those things. So they kinda worked together, that's why they were good friends.

**Tammy:** It was kind of going along like you think they kind of fall in love. She's a little girl and he's a little boy. I mean, not little but in their ages, they are 14.

**Diane:** I think, finally they're going to fall in love and she goes, he goes where you going? Home bye.

**Lynn:** I was thinking they're going to end up separating. I thought that but before that they'll just go and say I will see you soon and then when they are both in their 30's they will meet again. (10/9/91)

In order to resolve this conflict between the story and their expectations, the group then engages in a discussion of a possible sequel.
J.W. So that's how you would write the sequel?
Lynn: To me they started out differently they crossed, stayed there for a little while and they go on and then I think they'll go back again and cross again.
Holly: She set it up so perfectly.
Lynn: You need a sequel because you still have questions. You still want answers. You still have questions and she has the answers cause she wrote the book.
Holly: See, she set it up so easy so us 5th graders could write the sequel to the book. Because it's not a usual story to make it that way. They separate and after they helped each other through things. They all of a sudden separate [unintelligible] and make your head go, what is going on. You want to write a sequel. (10/9/91)

This anomaly violated what their life texts told them about how stories should go.

Their life texts and their understandings of social relationships made them predict that Billy Wind and Oates Tiger were going to somehow connect in the end. Even in the face of evidence to the contrary, the group as a whole is led to believe that even if they separated, there has to be some future connection between them, leading to the sequel discussion.

Cultural community life texts also played a significant role in this groups conceptualization of the book itself. One expectation was that the literature discussion groups would present their book to the group somehow. We met and began discussing possible strategies for this. It eventually became clear that they already had an idea, and they were not willing to share it with me. I was politely asked to leave the group, which I did, and my role from that point became one of facilitator in order to create time and space for them to practice their presentation.

The presentation for The Talking Earth group was organized as a news broadcast,
complete with anchors, weather reporter, sports reporter, special interest and commercial
breaks. (10/26/91)

This presentation was connected with the broader cultural community and
reflected all the conventions associated with television news broadcasting. They also
incorporated a kind of farewell to me in a special interest component when they
interviewed me about the new and fantastic book called The Talking Earth (George.
1983). Not only had they transformed their experiences of the book into a format that
reflected community culture, but they also included a current community event (my exit)
in their presentation.

Reading the World

In constructing his own understanding of literacy, Paulo Freire (1987) focused on
the notion that we read the world before we read the word, therefore rearranging the
dynamics of the knowing/language relationship. Rather than language leading knowledge,
it is considered a dimension of learning how to mean about the world that exists in a
mutual relationship with knowing. In Freire's (1987) words:

- The texts, words, letters of that context were incarnated in the song
  of the birds---tanager, flycatcher, thrush---in the dance of the
  boughs blown by the strong winds announcing storms; in the
  thunder and lightening; in the rainwaters playing with geography,
  creating lakes, islands, rivers, streams. (p.30)

In other words, knowing is grounded in sign relationships through which we come to
understand the dynamics of our world. In a more specific sense, this was defined by Peirce (1955) in terms of indexical signs which signified a contiguous, dynamic relationship between object and representation where the sign "...is in dynamical (including spatial) connection both with the individual object, on the one hand, and with the senses or memory of the person for whom it serves as a sign on the other hand..." (p. 107). Making sense of the world then, often involves the construction of explanatory indexical signs.

The examples in this section show learners drawing from their "reading of the world" in their attempts to explore new concepts through the construction of these kinds of signs. The participants in this study seem to draw implicitly on their experiences of the natural world to generate questions and mediate understandings of new concepts. Diane made this sense of experience as resource clear with the following interchange that took place during an interview in which she was being asked to reflect on what she thought learning was.

**J.W.** So what do think learning is?

**Diane:** I think its when you use some source to know more about another source.

********

**J.W.** What other sources besides books?

**Diane:** The earth because it shows us information about things. (10/2/91)

**Hydro and aerodynamics.** The following discussion took place in a joint session with *The Talking Earth* (George, 1983) and *Hook a Fish, Catch a Mountain* (George, 1975) groups. Because this was the first time they had met together, the meeting began with the groups each providing a retelling for the other group. During a retelling of *Hook a Fish, Catch a Mountain*, the concept of hydrodynamics came up in relationship to water...
conditions that affect fish hatching. One child wondered if aerodynamics and hydrodynamics are the same thing. This lead to the following discussion in which students employ numerous analogies in order to make sense of these concepts.

Beginning with a discussion of aerodynamics, Tom immediately draws from observations made as a part of day-to-day experience:

Cause, aerodynamic means it's like, it can, it's straight. You know like those new minivans that are coming out they're like aerodynamic. They have a slant in the front of them so they can go fast. The wind doesn't hit em and like push em, like a point, like an arrow. (9/10/91)

By making a connection between an arrow and a minivan, Tom has suggested what Bates (1979) calls discovering "...underlying iconicities holding seemingly arbitrary vehicles and referents together" (p.63). Bates argues that this process is generic to science, which she defines as, "...a process of discovering iconicities to explain contiguous events" (p.63). Initially, Tom attempts to make sense of this concept by constructing a relationship between physical form (straight, arrow shaped) and velocity. He also introduces the concept of pressure into the discussion, therefore suggesting a relationship between shape, pressure and velocity.

The discussion then turns to hydrodynamics. But rather than making the obvious connection between the shape of an object and its velocity, the discussion moves to one that explores water velocity, shape and pressure.

Victor: It's like water that goes fast or something. You know like in a stream, water goes faster than sitting in a lake. (9/10/91)

Although Victor's comment can be viewed as a misconception that should be corrected,
what is interesting is his exploration of the concept in a novel way as he attempts to discover the relationship between shape and velocity, building on Tom's previous comments about straight and arrow. Next Tom attempts to use shape again to grasp hydrodynamics by referring back to the minivan analogy.

Tom: Well you could have maybe like the tip of your hose and it makes a slant like aerodynamic, no. Oh I know why, if you have a little hole like not really big so it pushes the water, the water all wants to get through and only a little comes out at a time so it goes further, like the water is pushing it out.

J.W. So if you put your thumb over the hole in a hose?

Tom: Yeah and that goes further.

J.W.: So you restrict the amount of space the water has to go through and it goes faster?

Tammy: I don't know why it does that. It goes faster and further, why does it do that? (9/10/91)

This interchange re-introduces the relationship of pressure and velocity that generates some honest questions about observed physical phenomenon. The next series of interchanges elaborates on this mysterious phenomenon by citing experiences with it.

Tammy: Another thing you can do is bend the hose the water pressure builds up and as soon as you unhook that it goes shooting up.

J.W.: Well how does that relate to a stream or a river? You're saying when you restrict the flow, you make it go faster?

Tammy: It's like a fire hydrant.

Tom: If you build like a dam halfway in the river, it goes halfway, you have the dam and it blocks off three quarters of the water all the water will be urging to go through that little space. So it might go faster.

Diane: If you put, just like they were talking about, it will go straight out because you can't stop rivers and lakes, I don't know how they stop em. If you tried to stop it and the river was coming and it hit the dam, it would break. If it would hit the dam it might. It hits the dam, it might go back but then the power coming this way is going to keep it here. But then when you open the dam it
goes real fast.

**Tammy:** The hose is like a river because, see you put a dam on half of the river, it's like a thumb on half of the hose. So then on the other side you take away half of it's space to go through so it's going a little faster and it goes a little bit further. If you put a dam up that covers the hole way and you take off, it goes spuush. Because it goes higher and higher and there's so much pressure. (9/10/91)

Although a definition of aerodynamics and hydrodynamics is never really established through the discussion, learners explored related concepts that were grounded in their interests and experiences. The fact that a definition of hydrodynamics was never made explicit to the participants would probably be considered wrong by many science educators. However, pat definitions provided by a knowledgeable person (teacher) signal learners to stop thinking, as the answer has been given. If I had stopped Victor at the beginning of the discussion to define hydrodynamics, the previous discussion may not have taken place. Instead, how they discussed hydrodynamics had direct relevance both to the concepts being explored through their literature books, as well as to their lives. Using life texts (water play) that provided them with notions of pressure, and the analogous relationship based on shape (hose-river) as reference points, participants employed iconicism in their attempt to understand observed indexical relationships involving shape, velocity and pressure. While not explicitly related to interdependence, these concepts provided the foundation for further explorations of the relationships between water dynamics and the health of river ecosystems through other avenues such as the river table.

The river table was a large box with legs, lined with plastic and filled with sand and
rocks. Water was circulated by a pump that moved water in a circuit from a bucket into the water table, and drained back into the bucket. When Victor and Tom began to develop a hypothesis about the relationship between water velocity and temperature, they proposed an experiment in which water temperature and velocity would be measured and compared, therefore, connecting notions of velocity, shape with temperature. This became a reference point for their understandings of the relationship between water temperature and the health of river ecosystems.

Reading nature's signs. The last example is drawn from a discussion of *The Talking Earth* (George, 1983) that involved the sighting of a hawk. At one point Billy Wind is stranded in a pit by a wild fire and is wondering if it is alright to come out when she spots a circling hawk. Billy Wind wondered what the hawk is saying to her. Initially, the opinion of the group was that the expressed purpose of the hawk was to tell Billy Wind it is safe to come out. This prompted Bonny to state:

I was reading a book about hawks. Sometimes they circle around for the food. When they go around in a circle there's something dead or dying there. (9/26/91)

Circling hawks are a regular feature of the desert environment, therefore, Bonny seemed to be making a connection between her actual experience of hawks, information she has read about hawks and the situation in this story. By making these connections, Bonny communicated her understanding of the indexical relationship between hawk and the existence of animals or prey. This extended the understandings of the group, who came to realize that the hawk is not talking to Billy Wind but that Billy Wind is reading the hawk.
Experience and Ways of Knowing

Throughout this theoretical memo, it can be seen that experience is central to conceptualization in that it provides a cognitive resource that gives both meaning and direction to learning. But, the importance of experience and affect in conceptualization has been virtually ignored in science instruction. This is not surprising given that experience has also been ignored within the scientific community.

The role of experience in science discovery has not traditionally been considered part of what Holton (1973) calls "public science". Science has been thought of as a reasoned and orderly progression towards knowledge. This misconception has been carefully maintained by institutional standards for the presentation of ideas. Public science is what gets presented in terms of the interplay between empirical and rational considerations, making scientific discoveries appear as the result of the testing of the logical consequences or deductions of a proposed theory. This does not reflect the real process of discovery, found in what Holton (1973) calls private science, often dominated by intuition and seemingly irrational choices. In reviewing works on science history, Holton (1973) observes that:

The detailed analysis of published scientific contributions generally only reinforces this feeling. Most of the publications are fairly straightforward reconstructions, implying a story of step-by-step progress along fairly logical chains, with simple interplays between experiment, theory, and inherited concepts. Significantly, however this is not true precisely of some of the most profound and most seminal
work. There we are more likely to see plainly the illogical, nonlinear, and therefore
"irrational" elements that are juxtaposed to the logical nature of the concepts
themselves. Cases abound that give evidence of the role of "unscientific" pre-
conceptions, passionate motivations, varieties of temperament, intuitive leaps,
serendipity or sheer bad luck, not to speak of the incredible tenacity with which
certain ideas have been held despite the fact that they conflicted with the plain
experimental evidence, or the neglect of theories that would have quickly solved an
experimental puzzle. None of these elements fit in with the conventional model of
the scientist; they seem unlikely to yield to rational study; and yet they play a part
in scientific work. (p. 18)

Holton (1973) goes on to explain this confusion in terms of X, Y, and Z domains
using a graph analogy where the X axis refers to the phenomenological or empirical aspect
of a science concept; the Y axis is in reference to the "heuristic-analytic" domain. Public
science then is presented in terms of X and Y axes. Holton suggests that at the heart of
scientific discovery is what he calls the domain of Z which is "...the dimension of
fundamental presuppositions, notions, terms, methodological judgements and decisions---
in short, of themata or themes..." (p. 57).

These themata of the Z dimension do not reduce to and cannot be attributed to
either axis, but act as a kind of unseen force in the process of scientific discovery that
causes inquirers to explore in a particular direction and in a particular way. Moreover
themata are reflective of the socio-cultural context within which the inquiry takes place.
This can be found in Kepler's work through voluminous, often scattered and tangential, writings (Holton, 1973), which provided valuable insights into the process of scientific discovery.

In his search to discover the organizing principles of planetary motion, Kepler engaged in what Peirce (1955) called retroduction (abduction) and what Holton (1973) calls the engagement of themata. Kepler was trained as a theologian who was drafted into physics, as well as living at a time of transition between the Christian Era and the Scientific Revolution. Aside from his brilliance in physics, his search for knowledge was embedded in his metaphysical experiences, providing the dynamic of the themata that was Kepler's abDUCTory resource.

In his search for a law of planetary motion, Kepler had Tycho Brahe's meticulously collected observational data as a resource. This data could not be reconciled with the theory of concentric circles that was current at the time, therefore Kepler was searching for an explanation that would fit the data. This was a very difficult task for Kepler, as the idea of the planets in unitary motion along concentric circles was entrenched by the conviction that the motions of the planet must be harmonious. But what Kepler did by proposing an elliptical orbit for the planets was to discover a deeper, less obvious harmony of the solar system. This process is described by Holton (1973):

But Kepler recognized the orbits---after long struggle---as ellipses on which planets move in a non-uniform manner. The figure is lopsided. The speed varies from point to point. And yet, nestled within this double complexity is hidden a harmonious
regularity which transports its ecstatic discoverer—namely, the fact that a constant area is swept out in equal intervals by a line from the focus of the ellipse, where the sun is, to the planet on the ellipse. (p.79)

It could be said that this discovery was made simply by employing rationality to explain empirical data. At the heart of Kepler's progress are the abductions from which Kepler derived the series of working hypotheses that led him to discover a truly heliocentric planetary system (Peirce, 1955). These abductions, drawn from what Holton (1973) calls themata are not only mathematical (the rational heuristic available to him) or physical (observation), but metaphysical. Along with the mathematical and physical aspects, Kepler's abductions were influenced by the notion of a deity that exists at the center of the universe.

The sun at its fixed and commanding position at the center of the planetary system matches the picture which always rises behind Kepler's tables of tedious data—the picture of a centripetal universe, directed toward and guided by the sun in its manifold roles: as the mathematical center in the description of celestial motions; as the central physical agency for assuring continued motion; and above all as the metaphysical center, the temple of the Deity. (Holton, 1973, p. 81)

Kepler's dramatic discovery could not be reduced to theorizing about observational data, but came about through a process of hypothesis generation that emerged from abductions grounded in the themata of his experience. It is these themata and the experiences that comprise them that began to emerge in the discourse of the participants
of this study. When conceptualization took place through a free-ranging kind of discourse, learners made explicit and implicit use of experience in order to construct meaning.

These themata became evident in the students' discourse, as was seen when Tom attempted to understand aero and hydro dynamics by drawing from his experiences of the world. His first response concept was to search in his experience of the world to find some way of understanding the puzzling concepts of aero and hydro dynamics. This was also evident when Bonny was able to draw on her observations of hawks in order to make connections that extended her understanding of the indexical relationships that obtain within a complex ecosystem, she was constructing meaning that was thoroughly grounded in her experience. These experiences cannot be classified as linguistic or mathematical, but as meaning configurations that act as conceptual resources. In this way experience, rather than being viewed as an interference, is seen as a resource for learning.

The importance of experience in knowing can also be seen through Peirce's cycle of reasoning and theory of signs. That all cognition is embedded in experience can be clearly seen in this cycle of reasoning, which begins with anomaly born out of experience, and continues as both an implicit and explicit dynamic throughout inquiry. The examples here highlight explicit incidences of experiential dynamics, however, semiotically considered, it can be suggested that experience is cognition.

The dynamic of experience and affect can also be seen in Pierce's taxonomy of signs which are constructed from all modes of consciousness, and are not limited to verbal
expressions or mathematical abstracts. Peirce classified signs into three trichotomies based on the modes of existence, discussed in the introduction to this memo, and the relationship between the aspects of the triad which defines a sign. To review, this triad is comprised of a representamen (sign vehicle, also another term for sign), object (cultural construct) and interpretant (another sign); these three elements of the triad are related respectively to firstness (a quality of feeling or sensation), secondness (perceptions of the here and now) and thirdness (something which brings a first into relationship with a second).

As was seen in chapter two with Sheriff's (1994) chart of the ten classes of signs derived from these trichotomies, the categories are arranged according to qualities or the mode of existence of the representamen, the relationship between the representamen and its object or the relationship between the representamen and the interpretant. Therefore, "Signs signify because of their qualities and their relations" (p.41).

But as Sheriff points out, while all signs in order to be considered signs are an embodiment of what he calls the formal categories of firstness, secondness and thirdness, they are differentiated by the material categories of the modes of being. This can be seen in the two charts shown in Figure 21.

Signs such as qualisign and sinsign, which refers to a quality, or an actual thing or event respectively, and include the formal category of modes of being, do not include all of the aspects of being in the material category. Therefore, they are an aspect of cognition, but cannot be linguistic. These classes of signs reflect Pierce's construct of cognition
which includes all potentialities for meaning such as feelings, and other non-linguistic as well as linguistic signs.

Figure 21. A comparison of Sheriff's conceptualization of Peirce's taxonomy of signs

When the members of The Talking Earth (George, 1983) group assumed an attachment between Billy Wind and Oates Tiger, it was drawn from their experiences and obtained through their affective stances. That discussion provided an important lesson in the role of affect in knowing, but it also provided the opportunity to let experience and affect be seen as a resource for learning, rather than something to be eliminated.

This broader view of cognition can be found in the work of Howard Gardner.
(1983), whose extensive research has led to the proposal of a theory of multiple intelligences, which he has identified in terms of: linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, interpersonal and intrapersonal. The symbol systems for interpersonal and intrapersonal intelligences refer to the construction of meaning through operations that are not necessarily linguistic or mathematical, but affective and experiential. Gardner summarizes what he calls the personal intelligences as:

...discerned in the directly experienced feelings of the individual, in the case of the intrapersonal form, and in the direct perception of significant other individuals, in the case of the interpersonal variety. In these senses, the personal intelligences conform to our working notions of a basic intelligence. Yet is undoubtedly true that the diverse forms that personal intelligence can eventually assume are among their most outstanding features. And particularly in the West, it seems reasonable to deem the individual's sense of self as a kind of second-level regulator, an overall metaphor for the rest of the person. (p.275)

The "overall metaphor" of self that emerges from experience is, as we have seen, dynamically connected to the broader social context. The interpretations of the learners highlighted by this theoretical memo were also seen as a dynamic for the group construction of meaning, conceptualizations discovered in the transactions between the experiences of the individual participants. The learner's experiential reservoir then became a group resource, as well as an individual one. This was evidenced in numerous literature discussions where the initial interpretation by one child would be built on by others.
In conclusion, it is this pervasive sense of self, built up as signs of our transactions within the sociocultural context that textures our knowing and forms and is formed by future experiences. This will be seen throughout the next two theoretical memos, where life texts provide an experiential and affective grounding for the mode, direction and content of the inquiries carried out by the students.
CHAPTER FIVE

THEORETICAL MEMO TWO:

ANALOGY. NARRATIVE AND SCIENCE CONCEPTUALIZATION

This theoretical memo will focus primarily on analogical relationships as an intertextual, semiotic process and on narrative as related to science conceptualization and as such pertains to questions two and three. Question two, which involves the relationship between narrative and conceptualization will be developed through a discussion of perspectives on language and science instruction as highlighted through an examination of content area reading studies. Question three involves the use of analogy as a reasoning process for conceptualization. The theoretical context will be developed through: (a) a discussion of intertextuality as it relates to analogy; (b) a discussion of analogy, which is here considered associated with the deductive aspects of reasoning, and (c) a discussion of issues concerning the use of analogy in science instruction.

Analogical reasoning has long been considered a key element in science discovery (Hesse, 1966; Leatherdale, 1974; Gerhart & Russell, 1984), and therefore holds great potential for understanding the cognitive processes involved in science conceptualization. This can be seen in studies of verbal analogies as a point of convergence between cognitive psychology and linguistics (Esper, 1973). Although analogies were first defined by Aristotle in terms of a stable numerical proportion between terms, verbal analogies expanded the potential for understanding while introducing ambiguity into the situation. The ambiguity of language as dynamic embedded in the socio-cultural context has caused
difficulty for the study of analogy within a positivistic model, which depends on the existence of absolute terms. The potential of analogy in conceptualization is founded in ambiguity. This can be seen in dramatic scientific discovery where the explication of analogical relationships was not restricted to abstract reasoning, but grounded in the life stories of the participants.

Narrative constitutes an element of those life stories, and figures prominently in this study. Therefore, narrative experiences and analogical reasoning are considered in this section as dynamics of science conceptualization. Also, it has been noted through current classroom research on intertextuality that cognitive development is a process of making connections between meaning configurations. Because analogies can also be thought of as the recognition of relationships, it is considered here as associated with the broader process of intertextuality. A review of intertextuality will therefore begin this section.

**Intertextuality**

Intertextuality, a process which highlights the connective nature of cognition, was identified through the literary theory of Kristeva (1986), who found evidence that literary response involved readers in making connections between texts; put in the simplest terms, intertextuality is the "juxtaposition of different texts" (Bloome & Egan-Robertson, 1993). Various perspectives on intertextuality have located it within literary texts (Frow, 1990), the reader (Kristeva, 1986; de Beaugrande, 1980) and the social interactions of participants (Bloome & Egan-Robertson, 1993). However, a broader definition of text as a sociological and psychological event, makes it possible to consider intertextuality as the
basic meaning making process used by learners to "make sense of their world" (Short, 1993) by making connections between domains of meaning.

This view of intertextuality can be understood in terms of semiosis. Peirce (1955) believed that all thought was mediated by signs and that signs can only exist through their connections to other signs. Sign action has been characterized by Peirce as iconic, indexical and symbolic, indicating varying relational aspects between the representamen and object. An iconic sign refers to the Object (cultural construct) through characteristics that are similar to the object, or in other words an analogical relationship obtains between an iconic sign and its Object.

The relationship between an indexical sign and its Object has to do with contiguity, rather than similarity and is indicative as it, "...marks the junction between two portions of experience." (p. 109). In this way indexical signs relate to their Object through inductive inference; I see X, therefore Y must be so. Peirce's third category----the symbol--- has more to do with the creation of metaphor and will be discussed in theoretical memo three. For the moment though, what can be said is that narrative is considered a symbol that is a conglomeration of various kinds of signs and as such is based on the establishment of analogical relationships. The basic assumption that intertextuality can be considered as synonomous with sign action can be seen in research carried out using both narrative and information texts.

Studies done by Crafton (1981) and Hartman (1990) investigated intertextuality through the reading processes of individuals separate from the classroom. Crafton looked
at the connections made by readers between related passages, where Hartman investigated what he calls "on-line" connections between five related passages, using a think-aloud strategy. It seems that there is always a trade-off between experimental control and live data. These studies, while offering insights into how learners build meanings through connecting texts, are somewhat limited by their controlled settings. Materials were not selected by the participants and the study was conducted away from the dynamics of the classroom context and spontaneous group discourse.

Through naturalistic studies carried out in a first grade classroom, Cairney (1990, 1991) explored the types of intertextual connections made by students in the construction of stories. Categories for the types of connections made were generated from the first grade data, but are almost identical to the categories that were established from a previous interview study. The types of intertextual connections that Cairney observed in the first grade classroom included:

1. the inclusion of fictional characters in real life accounts;
2. story transformation using the original story as a springboard;
3. content links between texts read and written;
4. copying a single text element or idea without copying the plot;
5. detailed retellings of the story;
6. creating a text from a number of separate narratives;
7. copying the plot but using different events, characters and setting.

Intertextuality, in the sense highlighted by Cairney, can be seen as a kind of analogous
process where learners are recognizing relationships and building on those relationships.

Studies done by Short (1986, 1991, 1993) and Rowe (1986) investigated intertextual connections as they occurred through various forms of discourse within the classroom context. As a participant observer, Rowe (1986) studied the intertextual ties made by three-and-four-year-olds in a preschool setting. While focused on literacy learning, this study highlights the social and nonverbal aspects of intertextuality. Two types of links were found: (a) Children linked their existing knowledge about literacy to demonstrations provided by other authors, and (b) children interpreted their experiences by flexibly linking their current observations to aspects of their past experiences creating context-specific hypotheses about literacy. If literacy is removed from these connections, what has been highlighted is the dynamics that exist between the experiences of the participants and between the experiences and observations of individuals.

In a study of intertextuality using "text sets" by Short (1991), various types of connections were highlighted. Text sets are thematically or conceptually grouped sets of materials that include both narrative and non-narrative books as well as miscellaneous materials such as maps, charts and pictures. Learners were encouraged to engage in discussion and to use various strategies to explore the themes or concepts highlighted by the text set. Several types of connections emerged from this investigation. Connections were made that focused on: (a) elements of the story, (b) illustrations, (c) lives of the authors and illustrators, and (d) life experiences and previous texts. The connections made through text set discussions also moved students to expand their knowledge and led into
extended research. In summary, Short (1991) states that:

The focus on learning as a search for connections was a general perspective they began to bring to a variety of learning situations in their classrooms. They were more aware of the need for connections and the ways they could go about searching for these connections. (p. 21)

This study makes a strong case for the role of narrative in conceptualization, while at the same time highlighting intertextuality as a basic cognitive process.

A broader view of intertextuality involving connections made between meanings that are not necessarily verbal can also be found in further investigations by Short (1993) who defines text as "...meaningful configurations of signs intended to communicate" (p. 315). While verbal texts are often involved in intertextual connections, intertextuality is not necessarily defined by them. Moreover, Short suggests that intertextuality can be considered as a process of abduction, where a kind of new seeing emerges from sudden novel connections between previously unconnected meanings.

Abduction is most dramatically highlighted as an instance of intertextuality, however I would like to argue that intertextuality, defined as an integral process in the configuration of meanings or signs, is a process that underlies all aspects of reasoning. Just as intertextuality can be considered as abduction where hypotheses are suggested by seeing new relationships, deductions are established through the recognition of possible relationships when a hypothesis is extended to its implications. The recognition of relationships is the basic sign operation that defines analogy.
Analogy

Aristotle (1954) defined analogy in terms of a proportional relationship between "...four terms so related that the second (B) is to the first (A), as the fourth (D) is to the third (C)...", whereby something new is understood in terms of an already known relationship. Analogy has been considered generic to the explication of relationships inherent in natural phenomenon. Inherent in analogy is a kind of deductive reasoning process, whereby if A term is related to B term in a particular manner, then deductions can be made about the relationship between two other terms. Also, analogical relationships are said to be based on likeness.

Aristotle considered metaphor as a term that emerges from analogical relationships, and therefore, metaphor has been so closely associated with analogy that attempts to differentiate analogy and metaphor have caused difficulty. But analogy and metaphor can be more clearly differentiated based on the aspects of reasoning with which they are most closely associated.

Where analogy can be associated more with the deductive aspects of reasoning, metaphor can be considered in connection with induction. Metaphor will be explored more thoroughly in theoretical memo three, however, for the present, what can be said is that metaphors are inductive in that they can be considered symbols that emerge through inferential connections made between particulars. Considering the connectiveness of all aspects of reasoning, it is easy to see why analogy and metaphor are often considered as almost synonymous.
Because it is associated with the deductive aspect of reasoning, analogy tends to be considered explicative (Holton, 1973) more than creative. Gerhart and Russell (1984) suggest this when they describe analogy in terms of finding a way to explain an unknown.

First, it should be apparent that new meaning is created by this process. It can be thought of as an enlargement of our knowledge by the application of something that we know already to a new situation. If we wish to explain something we know to a person who does not know, we try to find an analogy, a corresponding route in a separate field of meaning, that is known both to us and to the other person. Second it should be realized that, although there is new knowledge, the form that this knowledge takes is not very different (in size, scale, general shape, etc.) from that which was known already. (p. 111)

New knowledge is said to exist based on similarity relationships that are explicative. But analogies are creative in that the similarities or iconicities can be drawn from all manner of things. A classic example of this was the discovery made by Archimedes (300 B.C.) when he was faced with how to measure the weight per volume of a crown whose design was of such an irregular nature that the standard technique of measuring the area of the object to be compared with its weight was not possible (Goswami, 1992, p. 1). Archimedes solved this problem by noticing that when he got into the bath the water level rose. He discovered a new relationship between weight and volume by making the observation that his body displaced a particular volume of water. He then deduced that the crown he needed to measure would too.
If examined from a semiotic perspective, the previous analogical example highlights the kind of sign relationships involved in analogy. Semiosis or sign action, considered by Peirce (1955) as the universal process of cognition, involves a triadic relationship between representamen, object and interpretant. Because signs do not exist in isolation, but become the objects of further signs, meanings are configurations of interlocking signs.

Sign action was outlined by Peirce as a taxonomy of ten classes of signs based on three trichotomies. One of the trichotomies, icon, index and symbol, is differentiated by the relationship between the representamen and object. Because iconic signs are interpretations based on similarities, Peirce (1955) designated analogies as belonging to this class of signs. Iconic signs also involve indexical relationships which can be seen in the previous example (see theoretical memo #1). The indexical aspect of Archimedes' discovery was the relationship between weight and displacement of water.

Peirce (1955) primarily suggests that analogies are a kind of iconic sign. These he divided into three types: image, diagram and metaphor. An iconic sign that is an image exhibits obvious visual similarities; a diagram is iconic in that it represents a thing based on its relationship to its parts, and an iconic sign that is representative by representing parallels in something else is considered metaphoric. It is unclear what Peirce means by this last category, however, what seems to be implied is that a sign relationship is established based on the representational properties evoked by the metaphoric icon.

Eco (1979) rejects the iconic categories of Peirce summarized above and suggests
that "...what matters is not the relationship between an image and its object but rather that between an image and its content" (p. 199). Eco defines an iconic sign as possessing: "(a) optic (visible), (b) ontological (supposed) and (c) conventionalized properties of the object" (p. 207). In other words an iconic sign can possess the properties of an object that can actually be seen or the properties that are known but not necessarily made visible.

With the final category, "conventionalized properties of the object", Eco seems to be referring to the relationship between the object and the representation of the ideas or properties associated with the object, which is established as:

...either a correlation between a graphic sign-vehicle and an already coded perceptual unit, or one between a pertinent unit of the graphic system and a pertinent unit of a semantic system depending on a previous codification of perceptual experience. (p. 208)

The iconic sign relationship can be generated based on visible properties, the evocation of known properties or ideational commonalities. It is this last category of Eco's that seems to clarify what Peirce may have been getting at with his category of metaphor. Also, it can be inferred from the examples given by Eco that he considers iconic signs in terms of the relationship between content and expression planes. This differs somewhat from Peirce who seemed to focused on the specific sign relationships that comprise the various types of icons.

The differences between the respective definitions posited by Peirce and Eco are more relevant to a definition of metaphor and will be taken up in the chapter that follows.
For the present an analogy will be considered to exist when a relationship is established between configurations of meaning, which are not universal givens, but constructions that are contextually and culturally bound. Broadly speaking this definition of analogy can be considered as an aspect of the process of intertextuality.

**Science Discovery vs Science Instruction**

What has been established so far about analogy and science discovery is that analogical relationships are drawn from all modes of existence, and exist as interpretations that are grounded in the socio-cultural context. Analogical relationships are potentials for science discovery, however, this potential has been limited by the constraints of a pedagogy based on the assumptions of subject/object dualism and the consequent establishment of a paradigm based on logical positivism (Langer, 1942).

The information processing model of learning assumes that knowledge is contained in external representations which are assimilated by internal representations. Rather than employing sign systems such as language for problem solving and discovery, the teaching of the sign systems themselves become the focus. How language is used in scientific thought differs from how it is used in science instruction, where language is viewed as storage for information.

Both the study of analogies in science instruction and reading in the content areas are based on this information storage view of language and science instruction, where concept development is a matter of making changes in representational structures or schemata that will allow the learner to "correctly" process the facts associated with the
target concept.

**Analogy and Science Instruction**

Studies of analogy in science education have taken the assumption that if the discovery of relationships is at the heart of science discovery, then teaching those relationships will result in the learning of those concepts. In content area reading, the assumption has been that efficient "unlocking" of the information in text will lead to the learning of science concepts.

Investigations of analogies in the field of science education have been limited to researcher or teacher constructed analogies (Wong, 1993) and focused on schema change in the novice. This can be understood in terms of Piaget's (1970) notions of assimilation and accommodation, where we process some information by assimilating it into already existing cognitive structures or schemata and make accommodations in those structures in order to process the information we are unable to assimilate. From this perspective, the learner gains science knowledge by assimilation (linking new information to familiar) or through accommodation (changing schemata through the discovery of new relationships). Therefore, it is not surprising that Piaget investigated analogical thinking in children.

The studies of analogical reasoning carried out by Piaget (Goswami, 1992) and his colleagues investigated analogies using tasks that involved the matching of picture pairs based on some kind of functional relationship, and then matching pairs in groups of four based on that relationship (Goswami, 1992). The failure of individuals to recognize relationships was attributed to the child's developmental stage by Piaget who described
stages for the development of analogical reasoning that essentially parallel his stages of
cognitive development (Goswami, 1991).

In an analysis of Piaget's studies, which prefaces her own investigations of
analogical reasoning, Goswami (1992) observes that the discovery of analogical
relationships, rather than being the result of a deficiency in the child's cognitive abilities,
are a function of experience and knowledge. The Piagetian tasks assumed that the child
understood the relationship of the terms in the analogy, but failed the task due to the lack
of ability to apply those relationships. But what Piaget considered to be clearly established
relationships between terms is an interpretation relative to knowledge and experience.

This problem can be considered in terms of the notion of univocity, discussed by
Hesse (1966), who examines the role of analogical reasoning in scientific discovery. The
problem of univocity has been associated with analogies since Aristotellean began using
analogical reasoning as a logic for the classification of the natural world. Aristotle posited
that some terms were indivisible and therefore represented universal qualities that were
referent anchors from which stable analogical relationships could be established (Hesse,
1966). It seems the task devised by Piaget assumed a kind of univocity when standardized
meanings are attributed to the terms and their relationship. However, because language is
formed and forms the transactions of individuals within a particular socio-cultural context,
the assumption of univocity is untenable.

A combination of Piagetian principles and information processing approaches to
learning can be seen in studies of analogies and science learning, where analogies are
constructed by the expert for the novice in order to bring about conceptual learning by making a change in the schematic structures of the student (Brown, 1993; Clement, 1993; Flick, 1991).

In a review of analogy studies, Wong (1993) suggests that the potential of analogies has been limited by studies that emphasize the use of analogies "...to overcome student misconceptions (Clement, 1987, Spiro, Feltovich, Coulson & Anderson, 1989; Stavy, 1991), or as an aid to comprehension and memory when reading text (Halpern, 1990)" (p. 369). Studies that attempt to use analogies to overcome student misconceptions, such as the one done by Flick (1991), investigate conceptual change relative to the understanding of teacher constructed analogies. Diagrammatically and verbally defined analogical relationships are employed to shape conceptualizations, rather than exploring how learners use language to construct analogies in the process of actually solving a problem. While these studies certainly suggest that analogies can facilitate learning, they provide a limited view of the potential role of analogies in the process of scientific discovery.

An exception to the trend of science analogy research can be found in a study done by Wong (1993) where science education students generated their own analogies to understand and explain scientific phenomenon. Here, analogical descriptions were constructed in the process of understanding and explaining scientific phenomenon, paralleling "real-world" scientific discovery.

Content Area Reading and Science Conceptualization
The two previously described studies, while highlighting the difference between science discovery and science education, also highlight different views of the role of language in conceptualization that is parallel in the area of content area reading. Studies such as Flick's (1991) reflect an information processing approach where knowledge is considered to be static information packaged in text. The assumption is that cognition can be determined by correctly processing verbal information, an assumption shared by content area reading studies done from both a transfer and interactional stance.

This can be seen in the studies conducted in the area of reading and science concepts. In sum, content area reading studies fall into four categories:

1. Identifying word meanings (vocabulary research)
2. Text structure
3. Schema studies
4. Macro-processing

The first category contains research that investigates various ways of teaching content vocabulary (Mezynski, 1983; Nelson-Herber, 1986; Lloyd, 1985) with the assumption that concepts are developed through the collection of word meanings. Category two studies focus on the structure of the text to facilitate recall of information (Mandler & Johnson, 1977; Johnson & Mandler, 1980) through text analysis (Duchastel, 1984; Hill & Erwin, 1984; Meyer et al, 1986; Lloyd, 1990; Armbruster, 1981); the relationship between text structure and comprehension (Golden et al, 1988; Meyer et al, 1980; Armbruster & Anderson, 1984; Bauman, 1986; Crismore & Vande Kopple, 1987;
Sagerman & Mayer, 1987; Covey, 1985; Rapier, 1984); through the identification and teaching of text structure (Alvermann, 1981; Simmons, 1988;).

The third category, schema studies, includes investigations with experiences that will encourage readers to create, activate, and maintain mental structures that will facilitate comprehension by using advanced organizers (Ausubel, 1960; Bricker, 1989), prior knowledge activation (Alvermann et al, 1985; Dole & Smith, 1989), mnemonic imaging (Williams et al, 1988; Levin et al, 1986) and pre-reading strategies (Yore, 1977, 1985, 1987; Schmidt, 1989; Heller, 1986).

The fourth category, macro-processing or summary studies are based on the assumption that the ability to summarize texts is a strategy for both recall and comprehension monitoring (Hidi & Anderson, 1986). The effective summarization and recall of text is related to the ability to form and use macro-propositions (Kintsch, 1974, 1877), a higher level of text processing. This category includes research using written retellings to evaluate comprehension of concepts presented in texts (Taylor, 1986); and investigations of relationship between good and poor reader's knowledge of the summary task and conceptual understandings (Winograd, 1984).

In all these previously cited studies, language is considered a package for information and in a static relationship to its word packages. But trends in language theory, grounded in sociolinguistics (Harste, 1984, K. Goodman, 1984), characterize language as a way to construct and communicate meanings as related to a particular context through the experiences of the individual. In clarifying his "functional---
interactional approach" to language learning, Halliday (1975) summarizes this position:

In this way the functional interpretation of the child's meanings implies a sociolinguistic approach, in which the learning of the mother tongue is interpreted as a process of interaction between the child and other human beings. From this perspective, which is complementary to the psycholinguistic one, not in any sense contradictory, the focus of attention is on the linguistic system as a whole, considered as having a (functionally organized) meaning potential... (p. 5)

Seen in this light, language is a dynamic system of meanings that is relative to culture and context, and reading is not the processing of information but the construction of meaning around engagements with text. Meaning is more a function of the purposes of the reader than of the text itself.

With the vast majority of content area reading studies, the purposes of the reader are largely ignored, and the meaning seen to reside in the text. From this viewpoint in order to establish that the concepts in the text were understood, it is considered necessary to use highly controlled texts. With few exceptions, texts were specifically designed for the study, rather than using whole, real texts. Because narrative was not considered as content material, it was not included.

In contrast, another group of studies, which hold a sociolinguistic view of language, focus on the thinking strategies of the learner reading whole narrative texts. Think-aloud techniques have been used in investigations that exploring the thinking
strategies of learners. In one study, Langer (1989) studied the think-aloud protocols of middle and high school students while reading both narrative and informational texts. While Langer's interpretations of the differences between the reflections generated when readers are engaged with narrative vs informational texts seemed arbitrary, the transcripts themselves provided valuable insights. As the readers in this study engaged with the ideas encountered in the various texts, they were developing meanings by constructing analogies that connected to their own experiences of life and understanding novel information in terms of the known.

Retrospective Miscue Analysis (RMA) (Y. Goodman, 1989; Marek, 1989), another technique that provides a "window" into the cognitive strategies of the reader, is an extension of Miscue Analysis, a technique devised by K. Goodman, which focuses on the discovery of reading strategies through the analysis of recorded readings of whole texts. Such miscues as omitted or substituted words are not considered mistakes, but a sign of the meanings being constructed by the reader, thereby potentially offering insights into the cognitive strategies of the reader. RMA expands this potential by following up with a discussion, during which the reader is asked to reflect on selected miscues. RMA was employed in a study of seventh graders directed by Y. Goodman and Marek (1989). The RMA discussions, as well as the miscues themselves, showed readers making connections between ideas in the text as well as drawing from their own experiences to construct meanings.

In summary, these two studies highlight the dynamic, constructive nature of
language as a system of meaning. Both studies touch on the potential of narrative as an avenue for constructing concepts. Theoretical foundations for this potential can be found in the transactional theory of Louise Rosenblatt. Rosenblatt (1978) has identified aesthetic and efferent as two possible stances taken by readers, where aesthetic refers to a lived through experience and efferent refers to the attainment of information. In identifying these stances, Rosenblatt does not suggest that they are separate entities, but occur together as connections are made between domains of meaning. Each of these stances provides avenues of interpretation for the other, broadly defining a semiotic process.

Studies focusing on literature discussion discourse have explored the semiotic potential of literature. One study by Short & Armstrong (1992), which looked at how literature was used in classroom inquiry, highlighted the role of aesthetic experiences in science conceptualization. What was found was that students used literature in a variety of ways such as topic identification, wide ranging explorations of content and the making of connections between that content and life experiences. One strategy, "Paired Bbooks", in which students looked at a concept through the intersection of two narratives highlights the potential of narrative as a resource for analogical thinking. At the core of this study is the process of scientific thinking, where problems are identified and possibilities explored through a variety of avenues. It is in the connections made by learners in the discovery of analogical relationships that the potential for new conceptualization exists.

These studies indicate that language is a personal system of meaning that is characterized by the socio-cultural context. The study by Short & Armstrong (1992) also
suggests that the potential for the development of science concepts is not restricted to
efferent experiences, but expanded by aesthetic engagements.

Conceptualization Through Narrative and Analogy

With the previously cited research and theoretical issues in mind, the following
theoretical memo examines concept development in light of both narrative resources and
analogical reasoning. The first section examines the students' use of narrative as a resource
for conceptualization. This will be followed by a series of discussions, organized around
the conceptual perspective of interdependence they highlight.

Narrative as a Conceptual Resource

That narrative was considered a strategy for conceptualization was evidenced to
the students through the numerous curricular engagements described in the methodology
section. Cathy made this notion clear when on the first day she prefaced the reading of
The Riddle (A. Vernon, 1987) with: "The reason I chose this book was because I think
it's a thinking book." This was communicated further by our use of narrative as part of
daily curricular engagements through read-alouds, literature discussion and trade book
materials.

There were two kinds of read-alouds that were almost a daily occurrence. A
picture book was read to begin the day. I often suggested titles to Cathy as I considered
them to be part of the content curriculum we were exploring. Two themes ran through
these books: (a) the use of creative thinking to solve problems, and (b) interdependence
and the environment. The titles included: (a) Just a Dream (Van Allsburg, 1990), (b)
A chapter book read-aloud took place after lunch. These books had a strong survival theme, with the exception of *Hare's Choice* (Hamley, 1988), which was a fantasy book that was organized as a series of connected stories produced by the children in the book. These titles included: (a) *My Side of The Mountain* (George, 1959); and (b) *The River* (Paulsen, 1991). Through these engagements, students were encouraged to see narrative as a conceptual resource.

By providing these narrative engagements, Cathy and I were essentially acknowledging the value of narrative and putting learners in touch with the aesthetic aspects of learning. The assumption here is not that we needed to teach students to do this, but that those connections are generic to cognition and therefore provide a "window" into how learners construct and communicate meaning.

Attitudes of the students towards narrative were communicated through reflections and interviews. Narrative figured prominently during an interview with four study group participants, who were asked to think of their projects and reflect on the kinds of connections they made to learn something. As might be expected, reading was an often cited resource in this discussion. Lynn suggested one viewpoint by describing learning in terms of reading and collecting data to be placed in mental files for future use, with many
of those mental files containing narrative. Holly expressed narrative resources in terms of a lived through experience:

**Holly:** When you read a book say like *The Talking Earth,* I didn't read it because I wanted to find something out about the book. And I didn't read it because I wanted to find out things in the book. I read it because I thought it was interesting. I don't read a book just to get information. Although you can do that with a straight information book.

**J.W.** What do you experience when you read a book like that?

**Holly:** Well you feel like, if they are really good authors like Jean Craighead George, you can feel like you are in that person's body, like and its really, it feels like you are the one that is going on that adventure and that's why I like reading. Like *Superfudge,* I thought I was Peter. I get mad at my little sister a lot. And I thought I was Peter and you can understand where they are coming from. (10/23/91)

For Holly, narrative provided a way to experience the lives of others, but it was also a confirmation of her own feelings about life. She was expressing the mutuality that exists between her own life and narrative experiences. Not only did she come to understand the experience of others through engagement with literature, but also her experiences within her own family constellation.

The importance of conceptualization as a lived through experience was a factor in Holly's selection of topic of study. Holly decided to study about rainforests, which she focused around the theme of survival in the narrative she created about a girl who lives in the rainforest and is trying to prevent the deforestation of her home.

She had to survive and the trees had to survive. I like books where it's on the edge, where she has to survive. And I like to be in the rainforest because I want to help the trees. So I picked rainforest because of the connections of survival. (10/2/91)

Holly made a connection with Billy Wind, a young girl who journeys through the
rainforest as part of her education in The Talking Earth (George, 1983), her literature discussion book. In this way, literature became a resource through which she increased self-knowledge as she explored survival as a lived through experience. The information that Holly acquired was then embedded in meaningful narrative experiences.

The literature discussion books were also resources for explicit conceptual understandings. Hook a Fish, Catch a Mountain (George, 1975) is organized around a question about fish population. The two main characters, Spinner and Al, attempt to discover why there are not many cutthroat salmon left by going on a journey up into the mountains. Through their inquiries, the discussion group came to understand the connection between the trees cooling the water and the ability of the fish to reproduce. Tom expressed this discovery in terms of an analogy:

   It's like a science experiment. If you make a wall in front of the water, it will make it stay cool. The trees are like a wall. (10/8/91)

This narrative was a source for conceptualizations that were extended by Tom through other curricular engagements. Tom's narrative involved a boy who discovers pollution in a river through observation and measurement of the water. The notion of the relationship of water temperature and river health was an idea for initial experiments with the river table, a piece of apparatus through which students could explore aspects of water related to rivers. The connections Tom made in the story were a point of interest for him and provided a reference point through which he was able to structure his own meanings.

Narrative also provided a starting point for some surprisingly complex concepts.
In a discussion of interdependence in relationship to their literature discussion books, Holly shared her thoughts on interdependence in light of *The Talking Earth* (George, 1983).

Holly: I wrote Billy Wind depends on food, the food depends on its food, [unintelligible] depends on Billy Wind, fire depends on the trees, the trees depend on water, the water depends on air. Then I wrote, what is ecosystem, cause I didn't know what ecosystem was.

J.W.: How does the water depend on air? I'm not saying you are wrong, I'm just curious.

Holly: Water has most air in it.

J.W.: Water has air in it, what's water made up of. I think that's an interesting thought, I hadn't thought about.

Holly: Manox.

(Several people say oxygen)

Holly: Oh and hydrogen.

J.W.: So what do people sometimes call water?

Holly: H2 O

J.W.: O.K. so that's interesting that air depends on water and water depends on air.

Holly: They both depend on each other.

Tom: They work together. (9/30/91)

Through her reflections, Holly intuits a relationship between air and water while being unsure as to the basis for it. The discussion this inspires provides a way of understanding the molecular workings of non-visible elements as an interdependent relationship that results in the existence of another element. The language is not precise or specific with just a vague reference to air, rather than the interaction of specific gases. However, it is certainly a beginning point for further exploration and generates a connection to the water cycle as a function of the interactions between water and air.

Victor: The air evaporates and so it can rain in different places. It takes the water from the ocean and it rains and it makes....and it rains, I know that, on the land in different places.
Tom: If its hot in that area, it will evaporate and it will go back up and then it will rain somewhere else. (9/30/91)

By making this observation, Victor and Tom have extended the concept of the interdependence of air and water by making a connection with an observable phenomenon known to them. Not only do they extend the potential meanings of the oxygen/water relationship, but they also extend the groups meaning potential for understanding a familiar phenomenon.

The next example occurred as part of a discussion of The Talking Earth (George, 1983) group which was a continuation of the exploration of the question: Why did Billy Wind let the otter Petang go? In the two weeks previous to this discussion, we had been thinking about the concept of interdependence in terms of the relationship between organisms within ecosystems. Holly used this concept to reflect on the current discussion focused around the ramifications of Billy Wind keeping Petang.

Holly: The animal or whatever that Petang's enemy, that eats him, if that doesn't get that amount to have that to eat whatever eats that thing will die and whatever eats that. It affects the whole....(10/15/91)

Holly's interpretation of this question is generated by making a connection between meanings built through previous literature discussions focused on interdependence. Through this connection, narrative acted as a resource into which she had embedded the concept of interdependence in a fictional, but whole context.

The notion of narrative was a resource is summed up by Diane during a group interview participants reflected on the new connections they had made when they re-
engaged with the book to construct their presentation. The consensus seemed to be that things changed in the book, which caused Diane to observe that: "The book is like the world" (10/23/91).

This apt analogy sets the scene for the next section in which narrative can be seen as resource for the analogical reasoning that was employed by learners as they built conceptualizations. As was seen through the previous examples, narrative is a resource for the discovery of interests and lived through conceptual experiences, as well as a catalyst for what Peirce (1955) called abductions: initial hypothetical flashes that initiate further cycles of inquiry.

**Analogical Reasoning: Building Conceptualizations through and between Narrative**

The concept of interdependence provided the conceptual focal point around which curricular engagements were organized. The narratives selected for literature discussion provided different avenues for the exploration of interdependence. The four literature discussion groups were: (a) *The Green Book* (Walsh, 1982), a futuristic story centered around the experiences of the last group of people to leave a destroyed planet earth to establish a colony on another planet and three books by Jean Craighead George; (b) *Watersky* (1987), the story of Lincoln whose search for his uncle who lives in Alaska, finds him living with a clan of Eskimos in the process of capturing a whale; (c) *Hook a Fish, Catch a Mountain* (1975), a kind of ecological mystery story that centers around the quest to explain the diminishing cutthroat salmon population in the Snake River; and (d) *The Talking Earth* (1983), the story of the journey of a young Seminole girl who questions
the belief held by her tribe that the earth talks. I was directly involved with groups (c) and (d).

Two types of literature group meetings took place. Usually each group met separately, however, on two occasions there was a joint meeting between The Talking Earth (George, 1983) group and the Hook a Fish, Catch a Mountain (George, 1975) group. These joint meetings took place as a way for the groups to make conceptual connections between the books, as well as to engage in discussion resulting from an assignment I had given them that focused explicitly on interdependence.

Ideally, the discussions were to be focused around questions that were generated by the participants. This was eventually accomplished by The Talking Earth (George, 1983) group. But the Hook a Fish, Catch a Mountain (George, 1975) group was unable to generate many of their own questions. The questions they did generate being tied to specific information or vocabulary in the book. I feel that this was mostly a result of past experience with literature discussion, and with group dynamics as three of the four participants were somewhat reticent to speak.

In general, based on comments made in initial literature discussion meetings, free ranging, student generated literature discussion was something that the participants had not experienced. They were familiar with reading literature, however, their previous experiences included reading the book and then telling what they liked about it and either making a report or sharing it somehow. To the students, reading the book and either recommending it or not and telling why was the ending point of literature discussion.
However, I considered this to be the beginning point.

As the identification of a question or problem is considered a significant aspect of scientific thinking and discovery, I felt conceptual understandings needed to be generated through discussions focusing on the questions of the participants. I had highlighted the broad problem of exploring interdependence, however, the way in which the concept of interdependence was developed depended on the aspects of it that were focused on by the group, as well as the kinds of connections made between meanings. The kinds of connections made by the groups in exploring interdependence can be organized into five sections: (a) cycles and balance, (b) human/habitat relationships, (c) habitat and the dynamics of evolution, (d) adaptation, and (e) locus of control.

**Interdependence, cycles and balance.** At the end of our third literature discussion meeting I provided a focus for the next discussion. I gave both groups an assignment to reflect on their literature discussion book and to think about, write or draw pictures about interdependence and ecosystems. The first example is drawn from the resulting discussion which took place during a joint meeting between the two groups.

To begin, each member of the *Hook a Fish, Catch a Mountain* (George, 1975) group was asked to comment on the book as a way to share it with the other group. *Hook a Fish, Catch a Mountain* (George, 1975) takes place on the Snake River in Montana. Spinner, a city girl comes to visit her cousins and catches a cutthroat in a place that cutthroats have not been seen for awhile. This and the quandary concerning the dwindling cutthroat fish population, sends Spinner and Al (Spinner's cousin) on a journey
into the mountains.

I began the discussion by asking Tom what he came up with. He seemed to be unclear about how to make a connection between interdependence and the book, but eventually came up with a question about what Spinner and Al (the two main characters) are doing with the eggs. Victor's answer to this sets the discussion in motion:

Victor: They are going to put the eggs in Desperation Creek so they can hatch. They wanted to know, they had the question that why can't they go up to desperation creek and so they were going to put the eggs up there. (9/30/91)

Victor has identified the question or problem for the group and sets the scene for further explorations. We eventually returned to this question after I attempted to get Tom to talk about interdependence. He then came up with the notion that Spinner and Al depend on the cutthroats because, "if they don't learn about them it would have been a waste of time."

Victor: They met a lot of animals and a couple of people up there. And the cutthroats...they were trying to survive with the trash fish. And so they were thinking up a way to get the trash fish out and move the cutthroats to get...they (trashfish) eat their young. (9/30/91)

Building on Tom's observations, Victor clarified the problem in terms of ecosystem functioning. Victor's apparent expertise in framing this problem can be found in a connection between the situation in the book and his experience with his father, who was a state game manager. Victor was able to identify the problem by making a clear connection between the narrative situation and his own life text. This process of identifying the problem, considered just as important for scientific thinking as discovering the answer, is
often absent from traditional science education, where concepts are taught and problems presented which can be solved by using the appropriate concept (Wong, 1993). Victor later built on these notions through his fiction piece, which involved recreating balance in a river through the introduction of a species of turtle.

As the discussion continued, participants built on the basic problem identified by Victor through the concepts of balance and cycle. Tom, who had been a little mystified up until this point, introduced these ideas when he attempted to elaborate on Victor's contribution.

Tom: If they eat...if the trash fish die, then the cutthroat will have a better chance of living. It's like, it's almost like a cycle. [begins drawing] Here's like the river here's the trash fish here's the cutthroat. Say you eat half of the trash fish, then there'll only be this much left, the cutthroat will have a better chance of growing and getting more. Cause the trashfish, they sometimes they eat the baby cutthroat eggs, so they would have a better chance of living if there weren't as much trash fish. (9/30/91)

Tom introduced cycles and balance as aspects of the interdependent relationship between organism and environment. Further understanding of this aspect of interdependence was expressed through an analogy to a meaningful aspect of Tom's life.

J.W. So the, the cutthroats are kind of dependent on some form of balance in order to survive. Tom: It's like when you play soccer, you need the teams to be evened out so if you even out the cutthroat and the trash fish it will be fair and you will have.... J.P. They will have an even chance. (9/30/91)

With Tom's explicit analogy between balance of population and balance of soccer teams, he was drawing from his "...past experience to explain or otherwise describe unfamiliar or novel phenomenon" (Flick, 1991, p.215). This concept could have been
explained to the group through the construction of an analogy, however, it would not have had the same power or meaning as one that was self-generated and grounded in the individual's life experience.

The group's understanding of interdependence in terms of balance and interspecies relationships was extended into a broader context by J.P., who had created a diagram.

J.P. I drew a picture of a fish and then put a line to a tree, cause the fish depend on all the trees to keep their water cool. The trees depend on people to plant new ones after they cut em down, so that they can grow. People depend on the fish for food. The bears depend on people for trash. (9/30/91)

Figure 22. J.P.'s interdependence diagram

J.P.'s diagram provided an iconic image that communicates his understanding of how interdependence functions within ecosystems. J.P.'s diagram, which began as a line linking the elements, was redrawn into a circle during discussion to reflect the change in conceptualization that took place when Tom introduced his circle.
Figure 23. J.P.'s interdependence diagram revised.

J.P.'s understanding of the cyclical nature of ecosystems emerged later as an organizational factor in his story about a shark, which begins when the main character, a shark named J.P., is hit by a speed boat; and ends with J.P., now turned human, hitting a shark with his speedboat presumably setting the whole cycle in motion again.

Interdependence and human/habitat relationships. The next examples are drawn from discussions of Watersky (George, 1987). The story has similarities with The Talking Earth (George, 1983) in that the main character, Lincoln, goes on a journey to Alaska to find his uncle. He stays with an Eskimo clan to which he has family connections. Within discussions that explored cultural differences, students explored the concept of the interdependence between humans and their environment, and the symbol of the whale. During Lincoln's stay, all the clans are attempting to catch a whale, therefore much of the discussion centered around the symbolism of the whale for survival and the relationship
between the Eskimos and their physical environment, which generated the following analogies.

**Jim**: We depend on rain to get the grass growing and they depend on these whales. (9/12/91)

Jim drew from his own understandings of survival in a desert environment. In making this analogy, he was drawing from a known relationship between rain and grass as important to our survival to understand the relationship between the Eskimo culture and the capture of whales. Also, in making this comparison Jim extended his understanding of the narrative at hand by connecting his own experience to it, but it also extended his understanding of his own experience through his engagement with narrative. The notion of the whale symbolizing the interdependent relationship between humans and their environment, was extended by Linda who makes the following connection:

Linda brings in a book *Whales, the Gentle Giants* that she is using for her whale project. In this book there is a story about a group of people who are stranded at sea, but find an island and set up camp, only to discover that they are camping on the back of a whale. (Field notes, 10/2/91)

What can be inferred from this is that Linda was making a connection between the symbol of the whale for survival of the Eskimos and the image of people literally surviving on the back of the whale. While on the surface, the analogy was a fantastical one, what Linda found the most interesting was that the people had no idea that they were depending on a whale. This provided a symbol for a concept that had come up in discussion dealing with the differences in the relationship between native culture and their environment and white culture and their environment. This concept was expressed through the following
two analogies between related narratives. *My Side of the Mountain* (George, 1959), the read-aloud Cathy had begun the week before, figured in the first analogy.

**Hal:** This is a lot like *My Side of the Mountain*, because he finds an animal. He (Lincoln) finds a seal and he's surviving out in the Arctic and he's (Sam, main character in *My Side of the Mountain*) surviving out in the woods and finds a falcon. (9/18/91)

Hal seemed to be expressing his understanding of survival in terms of the awareness of and contact with fellow creatures in the environment. By connecting survival to the relationship between humans and animals, Hal understood interdependence as a function of that relationship. Hal communicated this understanding in his fiction piece which began with a boy catching a carp from Itasca Lake, and rather than eating him, puts him in the Mississippi River. After learning about the river and all the pollution problems, the carp began a clean up effort, which made a connection between human/animal relationships and the survival of the environment.

The next example highlights the relationship between humans and the environment as a function of the use of resources through a discussion about how Eskimos use all parts of the whale.

**Linda:** Like this book. It's *Sign of the Beaver*. They're related because the talk about how they use everything and in this book the Eskimos use everything. (10/21/91)

Linda makes this connection as part of a discussion comparing the difference between Eskimo and white cultures. What comes out in this discussion is an environmental awareness based on the differences in how cultures use resources. This awareness adds
another dimension to the concept of interdependence.

In the previous examples learners were developing conceptual understandings through the construction of signs by making implicit and explicit connections between domains of meaning drawn from life texts which included current and previous narrative experiences. The participants were able to understand survival in terms of the relationship between humans and animals and as a function of cultural attitudes, such as how resources are used or squandered.

**Interdependence, habitat and the dynamics of evolution.** The Talking Earth (George, 1983) enabled an exploration of interdependence as a function of habitat integrity. Not only did Billy Wind discover the language of the earth and its creatures, but she came to understand the underlying network of relationships that made the survival of those creatures possible. After a slow beginning, The Talking Earth group eventually generated a number of questions. One of the questions that figured in a number of subsequent discussions was: Why did Billy Wind let Petang go? Through discussion of this question, the group was able to extend their understanding of interdependence by delving into tangible aspects of it.

Petang is an otter who travels along with Billy Wind as she journeys through the Everglades. Eventually, when Petang meets up with a female otter, he and Billy Wind separate, which provide the origin of the question. The discussion began with Lanna making the following analogy:

**Lanna:** If she took him home he wouldn't live because it's not his nature. It's not
his habitat thing. Like horny toads, they can't live in a can. Even though you put
dirt in the can. That's what my brother thinks though, oh but there's dirt and every
thing in it they can still live. (10/9/91)

It was evident throughout our many discussions that Lanna considered her family as a
cognitive resource. Her contributions to discussion were connected to her family context,
especially her relationship with her brother. She also drew from her community culture life
text to construct an analogy that began an exploration of the complex relationships
underlying the function of habitat integrity.

Beyond the obvious analogy between wild creatures was the analogy between the
respective relationships of Petang to his habitat and the horny toad to his. What can be
inferred is that not only did Lanna express an understanding of the functional relationship
between animals and their habitat (indexical sign), but that habitat was defined by elements
other than the obvious features such as dirt and water.

Continuing this discussion, Lynn offered an analogy through which she extended
Lanna's observation and broadened the concept of habitat integrity into an exploration of
what can only be termed evolution in terms of ecosystemic relationships.

Lynn: Like we don't know but we kind of have a plan set up for us. We don't
know what it is until it happens but we have a plan. And um if you take something
away from it it's going to screw up the rest of the plan. Well um, if you want to
build a building and you decide to take out a certain stone or a certain brick or
something. You decide that you don't need a certain level or you don't need an
extra floor. Well it could screw up the rest of the whole building. It could really
mess it up. (10/9/91)

This analogy was more complex in that the concept was explored by highlighting
the relevant similarities between two apparently dissimilar objects. Werner and Kaplan
(1967) identified this as a type of sign-referent relationship, where obvious expressive features are transcended and similarities are highlighted between two dissimilar objects. This analogy highlights the broad sense in which Peirce (1955) defined iconic signs as being established through a variety of modes.

Lynn has transcended the obvious expressive features and made a novel connection, expressed the underlying relationships among the elements of these two diverse systems. In expressing habitat in terms of some kind of plan being changed through the removal of something, Lynn seemed to be on the verge of constructing a conception of evolution. This idea was developed further by Lynn, in terms of the rainforest ecosystem:

**Lynn:** The rainforest have a certain plan set out for them. They can’t just suddenly grow legs and grow arms and a face and say oh I’m hungry. They have a part and all they do is just stand. Whales have a part to play, trees have a part to play, humans, our main part to play is to save the earth. The earth is the support to humans. (10/9/91)

Lynn extended her ideas of interdependence through a global comparison of the relationships between all living things and their habitat. Lynn produced two different analogies that were comparisons of whole systems of relationships. The interrelationships suggested by the various elements of a building and the interrelationships of a rainforest habitat were connected in order to construct the concept of evolution as a function of interdependent relationships. Therefore she developed some notions of the systemic networks underlying habitat and the effects of altering certain aspects of that network. In other words, everything exists in an interdependent relationship with everything else.
This complex concept grew from the discourse of the group, where knowing entailed the collaborative construction of signs. Those signs were constructed through analogical reasoning involving the engagement of all possible domains of meaning.

**Interdependence and adaptation.** The previous discussion of organism/habitat relationships is continued along the vein of animal captivity when Bonny suggested that some animals can overcome captivity:

**Bonny:** Another thing, if you like let animals go, if you just keep um and let them go, they will find out how to live. Like a dog. (10/9/91)

This suggestion, which is rejected by the group, lead to an exploration of the concept of adaptation, expressed by Holly who constructed an analogy drawn from her personal experience with animals:

**Holly:** My cats a city cat. We moved from Tucson to Catalina. And my cat didn't know anything about, it used to stay in our yard and stuff like that and we moved here and it ran all the way around in the night time and he didn't know what cactus was. So my cat came back with a whole eye frill of cactus and we had to pick it out. (10/9/91)

This discussion, which culminated with Holly's cat analogy, highlights the notion of adaptation with regards to organism/habitat relationships, and added a new dimension to the groups' understandings. Obviously things do happen that vary from the natural scheme of things, therefore requiring adaptation, which is what Bonny seemed to be getting at. However, building on the previous habitat discussion, the group rejected Bonny's idea and considered messing with nature in negative terms.

**Interdependence and locus of control.** The lack of a locus of control as an aspect
of interdependence was explored through a discussion of the relationship between Billy Wind and Petang, a continuation of the 10/9/91 discussion. Attempting to understand phenomenon strictly in terms of cause and effect relationships has proved inadequate both in the natural (Newtonian Physics) and social sciences (behaviorism). The web-like dynamics that underlay interdependence indicate complex relationships lacking an obvious locus of control. This aspect of interdependence was highlighted by the following discussion focusing on the relationship between Billy Wind and Petang (Billy Wind's otter).

The questions generated by the group were discussed on more than one occasion. While I was tempted to try to push the group elsewhere, they seemed to be re-engaging with these questions on different levels each time they were discussed. Holly brought up the question about why Billy Wind let Petang go and some suggestions were made. The following discussion began after we had gone back and read aloud the section where Petang left.

**J.W.** So what does it sounds like happened?

**Lynn:** He wanted to go. Like he was playing near her in his regular playing spot but um what ends of happening, he ends up going back with the new one, whatever that one was, Petangette. (10/15/91)

With the realization that it was up to Petang to stay or go, the question and the focus of the discussion changed. Rather than viewing the situation as one where Billy Wind has control and makes a choice, the discussion changed to an exploration of the relationship between the two.
Lynn attempts to describe this relationship by comparing it to a situation where her parents had died and another person or animal like a cow would take care of her, and uses an analogy based on size where she makes a comparison between a human being raised by a cow and Petang being raised by Billy Wind. This generated much laughter and joking around and suggestions about odd inter-species combinations. As the discussion continued, however, the group began to explore less obvious aspects of this relationship.

**J.W.** O.K. we got the point. So it's like an older sister?

**Lynn:** Yeah helping him know the ways of the land and the ways he should go.

**J.W.** But how do you think Petang felt about Billy Wind?

**Lynn:** As a big sister, someone he really loved. (10/15/91)

Lanna built on this by again constructing an analogy to her own family as a way of expressing this relationship.

**Lanna:** If I were him. I haven't got through the whole book but she did treat him like she was taking care of him, but letting him do things he wanted to do. Like me, I babysit my brother, but if he wants to go outside and play, he can go outside and play. (10/15/91)

Lanna seemed to be getting at the notion that interdependent relationships lack a definite locus of control. This inspired further exploration of the illusive nature of interdependent relationships as a function of human relationships, which cannot be defined in directly causal terms.

**Lanna:** She cared about him at the same time as she let him be himself.

**J.W.** Do you thing she loved him?

**Lanna:** Of course.

**J.W.** What do you think about that, loving something and letting them...

**Holly:** That's love. That's true love.

**Lynn:** You care about them and you try not to let them get hurt.

**Diane:** There's a song about love. It talks about love.
Lanna: There's a poem about a prince who loves her and she doesn't love him except but her Dad, the king still gets them together. And it's like saying I am a river who flows into the ocean and you can never find me and he says, if you are the river that flows, I'll be the ocean and catch you in my arms. And it's like, he had to let her go, because pretty soon she found something else that he could not be to catch her. (10/15/91)

The group had a sense about this concept and attempts to express this by drawing on previous experiences or life texts. Lanna then constructed an analogy by making a connection to a previous narrative experience, and provided a way to explore the illusive nature of interdependent relationships. Lynn built on this further by constructing two analogies that were drawn from her life texts:

Lynn: I heard this and it is really Petang. Do not judge by how much you love, but how much you are loved by others. Petang was loved and he loved Billy Wind and it was really sad, he was like a loving person.
J.W. Yeah, that's a hard decision to make. That's an interesting point, because he does come back. It's like you were saying, he almost had this idea in his head, he didn't know what decision to make. What decision would you have made, would you have stayed with the human or gone with the otter friend?
Lynn: I would have gone with an otter. Like "The Jungle Book", there's a movie for you at the very end, where he goes with the humans instead of going back to the jungle with Baloo.
J.W. Who does?
Lynn: The boy. It's like he and Petang are like they have the same plot.
J.W.: But different, ones an animal and ones a human.
Lynn: So one goes back to its own, but they both end up going back to their own kind. (10/15/91)

This discussion highlights the relational understandings that underlie concepts.

While the discussion was centered around social relationships these understandings generated broader notions of interdependence, a concept which connects scientific meanings with social meanings. The examples throughout this section show the analogical
reasoning that emerges when learners are given the opportunity to reflect on their own questions, suggesting that analogical reasoning, a function of semiosis, is generic to cognition.

**Science Instruction Versus Scientific Learning**

Through the discourse presented in this memo, learners engaged in science conceptualization through a process of discovering and building relationships. These relationships were not constructed for the participants, but evolved through discussions around literature where learners were able to draw on their life texts and narrative experiences to extend their understandings. The picture of science conceptualization which emerged through this theoretical memo is contrary to the conventions that have dictated the teaching of science. Based on an information processing model of learning, the research on conceptual change is founded on the assumptions that: (a) concepts are discreet packages of information, (b) conceptual change has taken place when that discreet package has been produced under appropriate conditions, and (c) conceptual change means the replacement of student's mis-conceptions with the correct ones.

These assumptions are evident in an article by Duit (1991), which reviews the research done in the use of analogy and metaphor in science education. Studies of the use of analogy are described in terms of positive findings where the use of analogies was helpful by "forcing them [students] to view the new knowledge within the framework of analogy...and...to modify the existing cognitive structure." (p 654). The negative findings suggest that students were unable to apply analogies to new situations and that they were
unable to formalize (Segre & Giani, 1987); that students were unable to "see" analogies; and some claims that students failed to reason analogically (Enyeart, 1979; Gilbert, 1989; James, 1983; Nagerl, 1980).

What is assumed by these studies is that concepts are definable information packages that can be transferred into the students cognitive structure through analogy. Analogies are generally defined in terms of target and analog, therefore assuming that the concept will be obtained when the relationship between the two is "seen" by the student. This assumes that the analogical relationship defined by the researcher is "the" relationship and that conceptual change is a process of students seeing concepts in the same way.

These assumptions cannot hold in light of the data presented in this memo. Interdependence was not defined as a concept until the participants began to explore aspects of it through literature discourse. It was not a tightly controlled situation and there were not target sub-concepts. While this could be considered a weakness, I would argue that the conceptualization that took place allowed students to come to understand interdependence as the myriad of complex relationships that define it. Participants came to understand interdependence through cycles and balance, as a dynamic operating within habitat/organism relationships, and as an ontological dynamic. This could not have necessarily been predicted at the onset of the study, however what was most surprising was the complexity of the conceptualizations constructed by learners.

All the studies cited were based on the assumption that analogies were to be used as a kind of instructional tool to be directed towards conceptual change in students. The
students' conceptions were almost always considered as misconceptions. This is indicated in the research cited by Duit (1991) which includes investigations involving: (a) multiple analogies, where it was posited by Spiro & others (1989) that analogies function as "antidotes for analogy-induced misconceptions" and the use of multiple analogies to "avoid the misguidance caused by a single analogy" (p.655); (b) familiarity with the analog (student must see the connection); (c) the direction of the learners attention to analogies; (d) access to analogies as governed by surface and higher-order similarities; (e) target domains; and (f) analogy use and ability level of the learner.

The limited studies of analogy use in the classroom cited by Duit (1991) involved the study of analogies used by science teachers during instructional discourse. Duit provides a summary of approaches to using analogy to teach science such as: (a) structural mapping; (b) the general model of analogy teaching (based on the schema theory of Rumelhart and Norman); and (c) teaching with the analogy models and the bridging analogies. The common features of these models are that the analogies are constructed for the student where a concept is understood in terms of the relationship between familiar and target analogs.

Nowhere in all this research are there any investigations of the analogical reasoning of students as a resource for conceptualization. By focusing on a target concept and tightly controlling instruction, the dynamic thinking taking place about science concepts is missed or considered in terms of misconception. In a model such as this there would be no opportunity for the kinds of discussions highlighted by this theoretical memo. All of the
tentative beginnings, speculations and unusual connections that were the starting points for the evolution of the complex conceptualizations highlighted throughout the literature discussions in this memo would have been considered in terms of misconception to be eliminated, leaving learners cut off from their own cognitive resources.

Through this study it can be seen that students not only constructed their own analogies, but that they were an important part of their own unique reasoning process. When Holly made a connection between the removal of Petang from his habitat and population balance within ecosystems she was engaging in a reasoning process that led her to new understanding. The assumption of these studies is that analogies are to be constructed for students, however, to do this is like saying that one is going to think for someone else. Not only is it impossible but not very constructive.

It is the reasoning process in which learners discover analogies that is important. This is eliminated when analogies are used as pre-formed instructional tools. Through the numerous examples of self-generated analogies presented in this study, it can be seen that the construction of analogies occurs as part of the reasoning process where participants came to understand concepts in terms of discovered relationships in response to a problem or anomaly.

The potential for self-generated analogies as part of the process of reasoning in science conceptualization can be further understood in terms of the process of scientific discovery. Hanson (1966) explicates the Patterns of Discovery of scientists engaged in making historic discoveries by associating specific elements of reasoning with various
aspects of the process. Hanson begins a chapter on theories by defining physical laws through a comparison between induction and the hypothetico-deductive (H-D) system. An oversimplified view of induction, where laws are said to be discovered by moving from the particular to the general or observation to the law has been, according to Hanson, a misleading understanding of induction, "So the inductive view rightly suggests that laws are got by inference from data. It wrongly suggests that the law is but a summary of these data, instead of being what it must be, an explanation of the data" (p. 71).

Hanson then goes on to suggest that, "H-D accounts all agree that physical laws explain data, but they obscure the initial connexion between data and laws, indeed, they suggest that the fundamental inference is from higher-order hypotheses (laws) to observation statements" (p. 71). These elements of reasoning are not considered by Hanson (1966) as discreet systems of logic, but as aspects of the knowledge in process involved in scientific discovery. Where H-D reasoning tells what happens after the scientist has generated the hypothesis, induction is the inferential process that begins the discovery of the hypothesis. To Peirce (1955) a theory is already at work with induction, which is associated with testing a hypothesis once it is established. Therefore Peirce used the term abduction to differentiate between the first flash of a hypothesis gained from observation and the testing of a deduced hypothesis.

The role of abduction in conceptualization as previously suggested by Short (1985; 1993) can be seen through the analogies created by the study participants as a matter of course as they attempted to explicate conceptual notions. These analogies were generated
through abductions grounded in the experiences of the individual, as well as serving to explicate notions about concepts. This allowed students to engage in reasoning that parallels the process of scientific discovery.

Because the students were able to create their own analogies, the analogies became a powerful resource through which to explore a concept as complex and intangible as interdependence. Through self-generated analogies such as Lanna's analogy which explicated organism/habitat relationships or Lynn's analogy which extended the group's understanding of interdependence to include evolutionary dynamics, the concept of interdependence came to be understood through analogies constructed within narrative discourse.

In this way engagement with narrative, which is both analogical and ambiguous, provides the potential for learners to engage in the kind of reasoning that parallels scientific discovery. From the literature used in this study, learners were able to discover their own anomalies such as with the relationship between Petang and Billy Wind. The discussion that arose from this question led us through a process of critical thinking (as cited earlier from Short, 1985), which resulted with the group being able to extend their understanding of interdependence in terms of the complex relationships that are at its core.

This can be seen through a semiotic perspective of conceptualization or critical thinking. To Peirce, abduction, induction and deduction are elements of what he described as a "cycle of critical thinking", considered not as separate components but aspects of reasoning (Short, 1985, 1990). In an article in which she describes reading in terms of
Peirce's cycle of critical thinking, Short points out that, "While induction and deduction
are commonly discussed by many other philosophers, abduction is often omitted as part of
critical thinking" (p. 13). Both science and content area instruction provide induction-like
experiences (providing lab experiences or learning facts from text) and deduction-like
experiences (application of given laws to answer science questions or schema
preparation). But because these experiences are selected and organized by the "experts",
the possibility of abduction is virtually ignored. As Peirce pointed out, abduction,
deduction and induction are inseparable aspects of thinking. Therefore, the use of elements
of reasoning to teach concepts only slightly resembles how they are actually employed in
science discovery.

The absence of abduction is key to the difference between science instruction and
science discovery. Because abduction involves the formation of an initial tentative
hypothesis with which to explain an anomaly or a surprising occurrence, it is through
abduction that the possibility of new concepts exists (Short, 1985; 1990).

Many science texts employ a kind of anomaly in the form of a problem as a preface
for the information to follow. But providing the problem for the students precludes the
process of abduction, which begins with a feeling of tension leading to the identification of
a problem and the formation of a hypothesis. Narrative provides the possibility of anomaly
and the ambiguity through which new conceptualization can occur. It is these tentative
hypotheses, drawn from experience and narrative, through which learners developed the
analogies thereby extending their understandings.
Because critical thinking is generic to cognition, it can be argued that learners are always engaging in critical thinking. However, what is evidenced from the studies cited at the beginning of the chapter and those cited by Duit (1991) is that, rather than allowing learners to engage in critical thinking with sign systems as a resource for new science understandings, the majority of science education and content area reading curricula seems to focus on teaching components of reasoning and the representational structures through which reasoning is carried out.

Because science discovery is also a process that is also embedded in a social context (Eco, 1976), as well as the social context being embedded in science discovery, the importance of conceptualization through literature discussion groups is highlighted. In an article analyzing the relationship between language and scientific understandings Sutton (1993) suggests that scientific knowledge is an interpretive process that takes place within a social context.

Science is understood as a social activity for the production of reliable knowledge, carried on in communities that build provisional consensus of understanding through their communications. This then forms a basis for further semicooperative enquiry within the shared framework of thought. (p.1219)

Sutton cites many incidences where science conceptualizations evolved as a process of employing new language in order to explain phenomenon, often using language "...imported from some other area of use, in an attempt to figure out and reinterpret what is going on" (1219).
This is at the heart of the relationship between narrative, analogy and science conceptualization. By engaging in literature discussions, learners are building science knowledge by communicating their interpretations of phenomenon as part of a collaborative social context. This occurred as a natural part of literature discussion where concepts were built and extended as learners contributed and built on the analogies of the other participants. When Tom suggested his tentative idea about the fish egg problem in *Hook a Fish, Catch a Mountain* (George, 1975), it became the core of a conceptualization of cycles and balance that was constructed by the entire group. In this way, discourse around narrative can be seen as a resource for the interpretations of learners as they make connections between narrative and conceptual domains of meaning. In this way, narrative provides a catalyst through which abductions arise and a resource from which learners can draw analogies.

Analogical relationships can also be characterized as explicative and therefore highlight the role of analogy in the deductive aspects of reasoning. In this they communicate the learner’s theory or conjecture about the phenomenon being considered. In analogy, thinking and speaking converge in a dynamic that can be called conceptualization.

The discourse contained in this theoretical memo, then provides a picture of cognition where conceptualizations emerge and are expressed through analogical relationships. These relationships arise through a web of individual and social meanings comprised of connections between and among individual life texts and narrative
experience within a community of learners.

The last theoretical memo, which involves the analysis of student constructed narratives, focuses on the metaphorical aspect of conceptualization. Through these narratives, learners synthesized and symbolized their understandings of interdependence.
CHAPTER SIX

THEORETICAL MEMO THREE: "STORYING" AS CONCEPTUALIZATION

Theoretical memo three addresses questions four and five, which pertain to the role of metaphor and student constructed narrative in science conceptualization. Three theoretical contexts, transmediation as an incidence of intertextuality, metaphor, and narrative writing, are of concern here. Transmediation will be considered in sections on metaphor and narrative construction. Within the section on metaphor, transmediation will be considered as an instance of intertextuality within the conceptualization process, as well as a way to clarify differences between analogy and metaphor. The section concerned with the construction of narrative will discuss the potential for transmediation within the linguistic sign system when science conceptualization is approached through narrative.

Metaphor

The distinction between analogy and metaphor can be made in terms of Peirce's cycle of reasoning and aspects of sign action or semiosis. Metaphor is considered associated with induction and will be defined here in terms of symbol or as Peirce (1955) defines it, a configuration of iconic and indexical signs. In that metaphors are symbols of new meanings emerging from analogical sign configurations, they also highlight the intertextual and specifically the transmediational nature of conceptualization.

Metaphor was defined by Aristotle as being made up of analogical relationships. This is easy to see with proportional analogies constructed from mathematical terms; if a/b = c/d then a/b can essentially be c/d. In the simplest terms, metaphor could be defined as
substituting one set of terms for another. However, if analogies and metaphors are extended to verbal terms, the "values" become ambiguous, extending the possibilities for meanings obtainable through the creation of metaphors. Not only did the meaning become ambiguous and context related, but the meaning of both terms being juxtaposed changed relative to their relationship with new meaning being obtained.

These two perspectives on metaphor are reflected in the substitution and interaction models of metaphor. The substitution definition of metaphor is based on the terms being considered unambiguous or literal. Metaphor is defined in terms of the substitution of a novel term for a literal one; this supposes a view of language where meanings are static and context free. Right away, there is difficulty with the notion of literal; the assumption is that there are established, context free meanings for words. An interactive model, attributed to I.A. Richards' work on metaphor (Black, 1962; Ortony, 1979; Leatherdale, 1974), defines metaphor in terms of a mutual change of meaning between terms. Terms are not considered as literal and not literal, but as primary and secondary. From an interactive perspective, metaphors emerge when it is impossible to express meaning within a particular domain and expressions from another domain are imported.

The interactive view provides a broader notion of metaphor and indicates an understanding of language as a system of signs that are referential, mutable and context relative. This view while being an improvement over a substitution view, is inadequate to describe the dynamics of the metaphoric processes involved in scientific discovery, but
simply suggests that two systems are changed by each other.

This two views of metaphor are primarily associated with definitions restricted to literary interpretation. This has left metaphor in a state of circular definition which does not reflect the complex cognitive processes involved in the construction of metaphors. But the possibility of clarification can be discovered if metaphor is considered as an aspect of cognition. According to Eco's (1984) interpretation of Aristotle, metaphor can be see as a "cognitive instrument" where, "...the best metaphors are those in which the cultural process, the dynamics itself of semiosis, shows through" (p. 102). This notion of metaphor as an aspect of semiosis is paralleled in notions concerning the role of metaphor in scientific discovery.

Leatherdale (1974) provides an extensive review of scholarship that has emerged through the exploration of metaphor in the process of science discovery. In tracing the historical roots of metaphor, Leatherdale cites Mueller, who considered metaphors as the necessary symbolic process through which humans were able to extend knowledge.

Man was compelled to speak metaphorically, not because he could not control his poetic phantasy, but rather more because he was compelled to strive to the uttermost to find expression for the evergrowing needs of his soul. It was completely impossible to grasp and hold the outer world, to know an to understand. to conceive and to name, without this fundamental metaphor, this universal mythology, if you will. Metaphor in this sense was much less the carrying over of determination of a new concept by means of an old name. (p.125)
The human propensity for symbol construction provides a hint to what many scholars have found at the heart of the relationship between metaphor and science discovery. Progress, rather than being found in the orderly establishment of theories, is found in the ambiguous residue resulting from the forging of a relationship between aspects of wholly unrelated domains. Metaphors emerge from the need to find a way to express previously unthought of meanings.

This view of metaphor is suggested by Gerhart and Russell (1984) who define metaphor as a bending of the field of meaning in order to establish an analogical relationship where one does not apparently exist. They define metaphorical thinking as creative and suggest an example where there is a sudden change from monocular vision where "We would see the world as having no depth" to a moment of binocular vision. This results in a vision that:

...distorts our world of meanings, it takes a naive understanding of a new experience and insists that it conform to our mediated understanding of another experience. In so doing it warps our map of the world of meanings. We have come to know by means of metaphor. (p. 115)

Where Peirce’s definition of metaphor as a type of iconic sign is both confusing and limiting, his definition of symbol seems to shed more light on metaphor as it is being considered here, and as such is complementary to definitions arising from science philosophy scholarship. Symbolic signs are defined by Peirce as complex meanings that emerge from configurations of other signs.
They come into being by development out of other signs, particularly from icons, or from mixed signs partaking of the nature of icons and symbols. We think only in signs. These mental signs are of mixed nature; the symbol-parts of them are called concepts. If a man makes a new symbol, it is by thoughts involving concepts. (p. 115)

Symbols are sign configurations whose meaning indicates a kind of general law or idea, but whose meaning is dependent on the dynamics of the context in which it is used. Peirce considered narrative to be a symbolic sign in that it is the embodiment of many sign configurations that are dependent for meaning on the context in which they signify. It is in the inductive aspect of reasoning that metaphors function as symbols for understandings gleaned from the inferential configuration of meanings.

Peirce's (1955) definition of symbol runs parallel to what Leatherdale (1975) calls the metaphorical claim for scientific discovery. In his exploration of this claim, Leatherdale cites Robinson who makes a "...metaphorical claim in relation to science made on the general grounds of the relation of thought to language..."(p.132). Robinson states:

What is here maintained, however, is the view that science receives the greatest benefits from ambiguity, not merely in virtue of the poetic elements inseparable from any scientific statement, but also in its strictly scientific aspect. This begins to appear when we ask how we are to symbolize new things for which there is as yet no symbol. (p.132)
In the broadest sense, metaphors can be considered as paradigmatic symbols through which we gain some general way of organizing our thinking. This can be seen in the machine metaphor, which for several centuries was the interpretive tool through which progress in science was made. Eco (1984) suggests this when he states that,

The success of a metaphor is a function of the sociocultural format of the interpreting subjects' encyclopedia. In this perspective, metaphors are produced solely on the basis of a rich cultural framework, on the basis, that is, of a universe of content that is already organized into networks of interpretants, which decide (semiotically) the identities and differences of properties. (p. 127)

If considered associated with the inductive aspects of reasoning, metaphor is both an interpretive and a symbol producing process. Eco (1984) alludes to this when he suggests that an aspect of the construction of metaphors is "symbolic interpretation", where,

"...from one or more metaphors the interpreter is led to an allegorical reading, or to a symbolic interpretation, where the boundaries between metaphor, allegory, and symbol can be very imprecise"(p. 124). Although Eco (1984) takes care to differentiate between metaphor and symbol, he also recognizes that metaphor is more than a linguistic category, but "a tool of cognition" (p. 100).

It is this notion that links metaphors and symbols. The act of creating a symbol where, "...the symbolic activity does not 'name' an already known world, but establishes the very conditions for knowing it. Symbols are not translations of our thought, they are its organs" (Eco, 1984, p. 135), can also be considered a metaphorical act when new
meanings are forged that represent current understandings of the material world. These new meanings are forged through the interplay between a content and the expression of that content. In this way, metaphors can be considered symbols of new understandings, whose power to extend knowledge lies in the sense that symbols do not "...express a 'final' meaning" but "...that with symbols and by symbols one indicates what is always beyond one's reach" (Eco, 1984, p.130). Both symbols and metaphors are created through the interplay between ideas and the expression of those ideas.

This definition also highlights the abductory aspect of metaphor. While this chapter focuses on metaphor as an inductive process, it can be seen from the definitions of metaphor above, that metaphor can also be associated with abduction. Abductions are flashes of insight, where previously unseen connections are made in response to a recognized anomaly (Peirce, 1955; Short, 1985). There is less obvious logic to abductory metaphors, as they represent a kind of rough idea that guides further inquiry. However, with induction, metaphors can be considered interpretive symbols of current knowledge, that are a part of the conceptual resource for future abductions. Induction and abduction, like all aspects of a cycle of reasoning, are connected as aspects of a whole process--cognition-- and are almost inseparable. The distinction in this case can be made based on what is produced during these two processes. With abduction, a novel connection directs future inquiry, with induction the notions that have been explored are developed into symbols that represent a more reasoned interpretive process.

It is in this juncture that the cognitive commonality of metaphors and symbols can
be linked with the concept of transmediation. The construction of both metaphors and symbols involve the interplay between interpretants from different modes of expression called sign systems in relationship to a particular content or idea. This has been identified as a process of transmediation by Charles Suhor (1984). Siegel (1994) summarizes transmediation in terms of semiotic theory with the following:

Eco suggests that sign-functioning involves the correlation of an expression plane (the sign-vehicle or representamen in Peirce's terms) to a content plane (the object). Though this definition sounds more like Saussure's signifier-signified dyad than Peirce's semiotic triad, Eco's interpretation of this correlation is firmly rooted in a Peircean perspective which emphasizes the role of the interpretant. The advantage of talking about sign-functioning as a correlation of content and expression planes is that it can help sort out the complexities of using two different sign systems to make meaning. In transmediation, the learner does not simply correlate a content and an expression plane, but takes the interpretant that arises from that correlation and maps it onto the expression plane of a new sign system. (p. 13)

It is this relationship between the medium of expression and ideational content or the relationship that obtains between the content and expression planes that provides the key for understanding both metaphor and transmediation. When learners cross boundaries between sign systems, where "...one sign system is explored in terms of another" (Siegel, 1994, p 13) an experience that "...warps our map of the world of meanings" (Gerhart &
Russell, 1984, p. 115), occurs, yielding metaphoric symbols.

Through a perspective of metaphor as an inductive cognitive process, transmediation can be profiled as a process that is in operation in the formation of metaphoric symbols through the interweaving of sign configurations or "text" as it has previously been defined.

By definition, transmediation involves an interpretive process across sign systems. This most certainly occurred when students engaged experiential and affective aspects of cognition, or "life texts" as seen in chapter four. The process of transmediation could also be seen when some students constructed visual images of their budding conceptualizations of interdependence. Due to time constraints this was not pursued, however, a transmediation-like process occurred with the construction of conceptually focused narratives. This cannot be considered transmediation, as by definition there has to be movement between sign systems. However there was a transformational experience that took place when the relationship between the content and expression planes was shifted within the linguistic sign system. Because transmediation is, in part, defined by a shift in the relationship between content and expression planes, there is a core commonality between transmediation and what I will call trans-literation or what Rosen (1984) terms "storying".

What was made evident from studies of the science discovery process was that inquiry was not only dependent on non-narrative forms of language, but involved (Rosen, 1984) "storying". This was done by the students through the construction of
narratives focused by the concept of interdependence. "Storying" allows learners to engage in the process of trans-literation, by constructing metaphoric symbols in the form of narratives that communicate and test their current understandings.

"Storying" Metaphorical Symbols and Trans-literation

The computer is the dominant metaphor for knowledge in this information processing age. Knowledge is considered to exist in hierarchical structures of bits of information, with avenues of knowing being limited to knowing protocols for accessing that information. In this context, stories are mostly valued as entertainment, rather than for what they contribute to conceptual understanding.

The construction of narrative or "storying" (Rosen, 1984) where content is expressed through nontraditional means, trans-literation can be said to occur. In both the construction of narratives and the construction of models in science, new meanings are established through the synthesis of previously unconnected realms of content and expression, making clear the potential for science conceptualization through narrative.

Stories have long provided metaphors for understanding, as well as being a vehicle for sharing those understandings. This is pointed out by Rosen (1984) who notes that the conceptual power of narrative has been overlooked. "We might be disposed to take stories much more seriously if we perceived them first and foremost as a product of the predisposition of the human mind to narratize experience and to transform it into findings which as social beings we may share and compare with those of others" (p. 12).

The narrative impulse is an entrenched characteristic of human cognition with deep
historical roots. These roots can be found in a range of narrative dating from the surviving early mythologies, which functioned both as explanation of natural phenomenon, and as a way to reflect on metaphysical and social issues. This is described by Langer (1942) as the propensity of the human mind for engaging in "symbolizing" or "The transformation of experience into concepts, not the elaboration of signals and symptoms." (p. 126).

As a "transformation of experience into concepts," the act of "storying" can be considered "...as a cognitive resource—a meaning making strategy" (Rosen, 1984, p. 13) which can extend our understandings into unexplored territory. It must have been with a clear sense of this that Einstein suggested fairy tales as good reading material for a budding scientist. Moreover a sort of poignant mutuality can be seen between the fantastical and "reality" in the realization of such inventions as the submarine which came about through the imagination and "storying" of Jules Verne.

This mutuality is developed by Rosenblatt (1981) in terms of aesthetic and efferent stances of reading; an aesthetic stance refers to a "lived through" experience, whereas an efferent stance is grounded in the information the reader is conscious of. These stances are never separate but are in an everchanging relationship with the character of any reading event being determined by the purpose and stance of the reader, rather than necessarily by the text. Just as these stances suggest the range of response to text, they also suggest a multitude of avenues for knowing. Primarily aesthetic texts such as narrative always have efferent potential and primarily efferent texts have aesthetic potential. It is through this lens that the power of student created narrative for
conceptualization can be seen.

One study that highlights interplay between the aesthetic and efferent stances as a resource for science conceptualization, is a study conducted by Woolsey and Burton (1986) that took place in a third/fourth grade classroom. In this two month study, students who were studying the human body engaged in curricular engagements that highlighted both efferent and aesthetic experiences. Students were asked to create and illustrate narratives that communicated their understandings. Narrative experiences that highlighted aesthetic aspects of knowing were provided along with information sources on the human body. The stories created by the students presented information embedded in the experiences of the learner, which included both their own life texts, as well as the intentional blend of the aesthetic and efferent stances of knowing experienced through curricular engagements.

Science instruction, as pointed out earlier, has not paralleled this process of scientific discovery. Science knowledge is reduced to facts presented in the most literal way possible. Even attempts to connect science lessons to the daily life of students is based on pre-formed questions that do not arise from the experiences of the learner. These textbooks can only be understood as symbols of someone else's understandings; it is someone else's learning story. Therefore, it can be argued that to extend knowledge, learners need the opportunity to tell their own stories and construct their own symbols. This is where metaphor, transmediation and "storying" meet.

The previous theoretical considerations are the foundation for the analysis of the
primary data of this section, comprised of three student created narratives. These narratives will be considered as metaphorical symbols that highlight the intertextual nature of conceptualization and the potential of narrative metaphors in the construction of new understandings.

Telling Stories, Discovering New Meanings

The narratives that make up the bulk of the data for this theoretical memo were constructed through the participants' engagement in self-selected project groups. The only parameter was that the focus of study be connected to water, leading to some fairly diverse explorations. The concept of interdependence was also highlighted through engagements with literature and discussion, as well as communicated through the collaborative nature of almost all curricular engagements.

The project groups began with a multi-media blitz (Robinson cited in Harste, Short with Burke, 1988), where students are given time to browse through all kinds of materials relating to topics connected with water. In this case, the focus was rather broad so there was an unusually large variety of topics represented which included all kinds of sea life, rivers, oceans, and lakes. These topics were represented through fictional and informational books, magazine articles, posters and audio tapes. Rather than being provided with materials that were already organized for them, it was necessary for them to pull from various sources and experiences to select a direction for their inquiry.

Initially the goals were that the students would: (a) engage in a research project focused around a question on a student selected topic that had to do with water and
interdependence; (b) create a group visual representation that communicates the understandings resulting from their research question; and (c) create a fiction/information piece resulting from their explorations.

From these first free-ranging explorations, students formed into research groups organized around the topics of whales, dolphins, rivers, ocean pollution (oil spills), and rain forest. During the first phase students were expected to form a question for further explorations and around which their visual representation and fiction piece was to be organized. This meant that students spent a lot of time collecting and recording information in a variety of ways such as charts, webs, notes and drawings. The gathering and recording of information, essentially writing a report, was a process the students were used to doing. However, finding a question was not something they had ever been asked to do and they were somewhat baffled by this.

This prompted me to have a question discussion with them. I took half the class and we discussed what they were researching and what kinds of questions they had come up with. Many were strictly factual, yes/no questions that reflected the information they had gathered so far. After this discussion the whale group (Lynn, Tammy, Betsy, Linda, Con, Diane, Lanna) decided to focus on the questions: (a) What is the relationship between humans and whales?, (b) How does the whale fit into the ocean ecosystem?, and (c) What is the relationship between whales and plants? (with the exception of Con who wanted to explore whether or not there was a prehistoric whale in existence). The Hudson River group (Victor, Tom) focused on exploring the impact of people on the Hudson
River, and Holly, who was the only focus student in the rainforest group (Mary, Andy, Johnny), was interested in exploring the impact of the elimination of trees from the planet ecosystem.

It had taken about six weeks to get to this point and it was two and a half weeks from the end of the study. What eventually became clear to us was that we had too many things going on at once and that the students were being challenged to think in ways they were not used to. Something needed to be eliminated, leading to the decision to abandon the visual representations for two reasons: (a) Cathy questioned the validity of what she had seen of the visual representations so far; and (b) the students' interest and passion seemed to be with their fiction pieces.

Throughout this study, the conceptualization of the various artifacts to be constructed varied. I am not exactly sure what Cathy had in mind, but she saw what the students were doing as not very challenging; "not fifth grade work". This was a tension that was ever present. Cathy was really comfortable with using literature and process writing, however, she also had concerns about whether or not what we were doing really constituted learning. This took me a little by surprise, and made me start questioning what I was doing. I decided to support Cathy in this as I had become unsure of myself and it was important to maintain her comfort level as well. However, when I began reflecting on and analyzing what the students had done, I came to see them as challenging themselves in an attempt to develop some fairly complex understandings.

For example, before the assignment was dropped, Tammy and Diane had two
questions that they explored through their visual representation: (a) How do whales fit into the ocean ecosystem? and (b) What is the relationship between whales and plants? To explore these questions they created a pyramid for the ocean ecosystem and attempted to understand the relationship between whales and plants by making two columns under the pyramid which listed what each one depended on in the ecosystem. Cathy perceived this as simply copying out of a book and listing information, however, what I saw was an attempt to understand the relationship between life forms in a large complex ecosystem by using a conventional representation as a starting point. When they presented this, it was clear that they had put a lot of thought into how whales and plants fit into the ocean ecosystem.

Also, despite the visual representation being dropped as an expectation from us, the students found their construction to be useful. Through Lynn's instigation the whale group created a huge semantic feature analysis chart to record information about a variety of whales as part of their wide ranging information gathering stage. Victor and Tom were exploring the impact of people on the Hudson River and created a fairly detailed drawing of part of the river which showed both pollution sources and strategies that were used to clean it up. Con created a timeline for his prehistoric whale study. These artifacts were working, rough draft conceptualizations from which learners seemed to draw as they were attempting to write their stories.

The next section will examine some of the narrative written by the students. These narratives show how students made connections between their experiences and curricular engagements around their focus questions. For instance, Con's exploration in search of a
prehistoric whale led him to seek out information about the evolution of whales and write a fiction piece that was a time travel story. The connections found in these narratives are considered as examples of intertextuality that includes all experiences of the learner. Through these intertextual processes learners have constructed metaphors for their learning by connecting elements from diverse meaning domains to establish new understandings.

**Whales and Humans**

The initial phase of gathering and organizing of information was drawn from both nonfiction and fiction sources. The whale group browsed sources, interviewed each other, as well as people not in their group, made webs and decided to create a semantic feature analysis chart with all the whales they could find, comparing their characteristics.

Lynn and Betsy focused on the relationship between whales and humans. The following section will be an analysis of some of the connections that were made in the narratives produced by Lynn and Betsy, which can be considered symbols of their understandings.

**Lynn.** Lynn was an only child in a household with two working professional parents and has close contact with extended family. In listening to Lynn talk, it was clear that she has been treated almost as an equal by the adults in her family. Lynn had a very strong sense of herself as a learner and reader. In discussing herself as a reader she states:
I really understand what I read most of the time. When I don't I go on and see if I can get it if not I list what it might be and then either ask someone or look it up. I'm really trying hard to read a lot of books because I heard once: What you read is what you are. Well I like that so I like to read a lot. I think I'm reading harder books than 5th grade level. I love to read and I've really grown to love them and go harder. (10/8/91)

Figure 24. Lynn's reflection on herself as a reader.

Another curricular component of the study involved free ranging science experimentation with water. Students were supplied with various equipment such as droppers, plastic containers, food dye, aluminum foil, wax paper and instructed to explore
water in some way and record their experiments. Through these experiments and our
discussion of them, students developed a sense for the thinking processes involved in
scientific study, which for some students became an analogy for learning. This was
expressed by Lynn during an interview in which I asked her to tell me what she thought
learning was.

Life is one big science experiment. You put in one ingredient at a time as needed
and stir them to see what will happen. Every moment of your life is an experiment.
When I come to school they are stirring me (10/1/91).

Lynn also had a fairly consistent computer file analogy for learning.

You're reading or you listen to something and then you can say it over and over or
read it over and over and you have it in your head for future use, if needed... To me
its like they get put into a file and you can mark it books. Have a big ol' file
marked books. You can mark a file say Talking Earth, um Hans Contian Anderson
um Maniac McGee. I just put in the most important facts you find or the funny
parts. (10/2/91)

When asked to reflect on other ways of learning, Lynn expressed a strong sense of
creativity and discovery in learning that communicates her independence as a learner.

They tell you something and then give you an example... Examples are so you just
don't have directions. Or this is how you do this and that. You have an example so
you can see how its done a different or one way to do it and you can do it a
different way. They give you an idea of exactly what you are supposed to do if you
can't understand the directions. Like a storyboard they have basic things you have
a beginning middle and end. You have a plot in there. It kind of gives you an
outline of it. (10/2/91)

Lynn also expressed her notions concerning the value of story for learning with two
incidents. The first one came up during a group interview when she was asked to tell
about a time she learned something; she responded by telling about learning to tie her
shoes: "My mom told me a little story. It’s easier with a story" (10/2/91).

The other one occurred as part of an individual interview. In discussing the relationship between fiction and information books, Lynn remembered that she had read a story about somebody getting lost in the desert to a friend, who later got lost in the desert and thanked her because she was helped by the information.

The relationship between science learning and narrative is further developed when Lynn suggested the need for imagination. When discussing what was learned from The Talking Earth (George, 1983) about science Lynn responded:

I learned that you really have to use your imagination when you are doing science and other things. Cause you could um like experiments and stuff. You could see one thing and another person could see another. Another person could see logical and another person could see creative. What I was thinking of when Billy Wind brings the spider lilies to Charlie Wind saying they were lightning bolts. I was thinking imagination you gotta really use it especially in science. (10/23/91)

The preceeding background provides a context through which to examine Lynn's fiction piece, which follows. An analysis of the narrative will highlight some of the connections between experiences Lynn made in the process of constructing her story.

"A Whale of an Answer"

After a hardy breakfast of 4 lbs. of plankton or krill as some people call it, Joe Blue went to find his mother. He took a mouth full of plankton on the way, plankton is microscopic sea animals. He found her eating just that, preparing to go north by eating a lot of plankton.

"Hey mom!", he yelled.
"Yes, dear", she answered.
"Mom, are there other whales?"
His mom replied, "I don't know, go ask your grandfather."
"O.K. mom, see you later. What time should I be home?"
"I'll come pick you up."
Joe hummed as he swam across the warm sea to his grandfather Beluga blue, who was as old as whales are known to be; 60 years old. He was a cool grandfather whale. His grandpa B. was asleep. Young Joe decided to take a nap too. He slept for about 5 min. When he woke up, he saw a group of whalers. Joe was frightened because his father had been killed by whalers. So he splashed his grandfather's tale. Beluga Blue (B.B. for short) woke up, saw Joe and the whalers, and motioned for Joe to follow him. After getting a safe distance away, B.B. spoke.

"Hello Joe. What are you doing here? I hope you know that it is almost time to go North. But why have you come? I wish to know".

Joe went to breath and returned, saying, "Grandfather, are there others?"
"Others? Others what my child?" B.B. replied.
"Whales B B "
"Oh yes quite a few. I only know some though."
"Tell me grandpa, please," Joe said with a pleading face.
Beluga Blue answered saying, "O K. I will tell you about us though. I know more about us."

Joe listened intently for almost a day. The only pauses were for air. This is what Joe heard:

"Joe, the Blue Whale is the biggest and a legendary animal. Everything we do, is wondered about. I'm a hundred feet long and people really appreciate me for that reason. The reason being, I'm the longest of any whale ever recorded."

Beluga Blue paused for a moment, breathed and continued.
"If those humans would have killed me, they would have been happy while other humans sad. I'm a legend Joe. Being a legend is a family trait and I hope they don't kill you before you become a legend".

They both breathed.
"Joe, I weigh the most that's been recorded, 180 tons."
"What's that gramps?"
They breathed again and B.B. said,
"It's almost 63 days of food."
"Wow, where did you learn that?"
"Trial and error, Joe, trial and error." Beluga Blue said with a sigh.
"What about the others? Not just us, others. I want to learn about them too."

Joe asked
"Well Joe I know about three different whales besides us."
"Tell me please," Joe asked again.
"Joe I'll tell you first about a whale called narwhal."
Beluga Blue breathed and returned saying,
"The narwhal is the oddest looking whale and much, much smaller than us."
Joe said with astonishment, "Really gramps?"
"Yes Joe," said Beluga Blue.
He breathed and he continued, "They are about 15 feet in length and weigh about 2 tons."
Joe said, "Grandpa, how much food is that?"
"Well, not even a days worth of food."
"That's not a lot grandpa."
B.B. answered, "I know, remember Nero? He's a narwhal also. They have two teeth and Nero and his dad have their left tooth coming out, twisting and becoming 8 to 9 feet long tusk."
They breathed and B.B. spoke again, "That's all I know about them."
Joe replied saying, "You said 2 or 3, where's the other 2?"
I did didn't I? Well they have some cousins called the Beluga whales. My dad's best friend when I was growing up was a Beluga whale. That's where I got my name. They weigh about 2 tons or not even a days worth of food. They are 15 feet long and are white all over by age 5. Beluga Whales and narwhals stay up north all year round. Neither have a dorsel fin.
Joe yelled at his grandfather saying, "Let's take a breath now." So they breathed and B.B. finished up his story with the last whale.
"The last one is a Sei whale. And all I know is, they are the fastest whale and swim at 10 to 12 miles per hour and reach 50 feet in length."
"Wow, thanks gramps," said Joe.
"Alright dad, the stories over," said Sylvia, Joe's mom. "Let's go north."
To an astonished son and dad, she said again, "Let's go north."
Joe thought of the food and was quickly ready to go north. Joe swam off between his grandfather and mother to see Nero and meet new friends.

Lynn's thinking about the relationship between whales and humans, and the notion of migration are immediately apparent. The little whale expresses fear of humans and this is further confirmed by his grandpa. The idea that some whales migrate and others don't, gets communicated when the young whale looks forward to going north to meet new friends.

The fact that Lynn has written the story from the point of view of a young whale living in his "tribe" can be drawn from early discussions of The Talking Earth (George,
Early in the discussions of *The Talking Earth*, the notion of learning from taking the point of view of animals arose. At this time Lynn discussed human relations in terms of a wolf pack analogy:

"O.K. I'm going to compare it to a wolf pack. I have wolves at home and that's what I compare everything to. The elders [Billy Wind's] are like a dog called Notch. He's the head of a wolf pack and my dog is like his wife, sort of and the mother of about a million kids, I don't know. But it's top dog and when one of her puppies were growing up, both her puppies, we'd do it too, but when she was [unintelligible], she'd grab their neck a little and shake it. And she'd have the elders do it too. Just to tell them to behave, those are your elders. You screw up, you're in a different pack. (9/16/91)."

She described her own observations of how animals interact, and drew from what can be learned by attempting to understand the point of view of the animals. Billy Wind's central quest was to discover if the animals talk, and in doing this attempted to see things from the point of view of the animals with which she comes into contact.

The image of the young whale surrounded by adults seemed to be a picture of Lynn in her own family constellation. Lynn's wolf pack analogy connected with her own extended family situation and communicated her sense of the tension between independence and guidance. The young whale sought knowledge from his elder, yet was characterized as questioning, almost challenging. While maintaining respect for the elder for the most part, the grandpa whale was given a nickname that seemed to diminish his authority.

Lynn's experience with *The Talking Earth* (George, 1983) and her own ideas about learning came into play here. Billy Wind challenged the tribal traditions about the
animals talking but not out of a desire to rebel as much as a desire to know and understand; in other words, she was an independent thinker who, with the guidance of elders was propelled to increase her knowledge of the world. This tension between independence and guidance was expressed by Lynn when she became frustrated at what she saw as too many constraints by Cathy and I:

In my head I've really wanted to go get on with my fiction piece & visual. But to me it seems that Mrs. W. and Mrs. Crockett are holding me back & it's starting to get to me mentally and I'm well getting bored... I want to expand my dendrites (10/9/91)

Figure 25. Lynn's reflection on her own learning process.

It can be inferred from Lynn's notions about learning from example, that examples were a way of expressing ideas within a realistic, relational context. This was seen when the young whale was provided with a comparison by his grandpa. When grandpa told Joe Blue that he weighs 180 tons, and Joe Blue asked what that is, grandpa answered that it equals 63 days of food. In a more subtle way, Lynn did this when she incorporated breathing breaks into their conversation; rather than saying that whales breath air, she provided examples of this behavior.
To construct this story, Lynn had drawn from all aspects of her life, which converged into new meanings. Lynn's life texts could be seen in the interpersonal dynamics of the story, as well as how the information was presented. Moreover, Lynn incorporated her new understandings, such as the trial and error concept, as well as the more subtly expressed notions about whale/human relationships.

**Betsy.** While Betsy's questions and explorations ran parallel to Lynn's in many ways, Betsy's story reflected their different personal and classroom experiences. Betsy comes from a large family and was adept at working collaboratively. She usually operated by quietly observing, reading the situation and finding her own way to contribute. Her reflections on learning and collaboration illustrated this:

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Contribute and encourage everybody working together and discussing out the right answer and not fighting arguing. Listening asking questions and try to understand and practicing and accepting.
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...contribute and encourage everybody working together and discussing out the right answer and not fighting arguing. Listening asking questions and try to understand and practicing and accepting. (9/27/91)

**Figure 26.** Betsy's reflection on working collaboratively.

Betsy felt confidence in herself as a learner and a reader, "Yes. Compared to some I am fast". Her genre of choice was adventure mystery stories, Betsy stated this initially in her
"Getting to Know You" interview and later when reflecting in her journal. After realizing that her selected literature discussion book (*Hook a Fish Catch a Mountain*) was a mystery adventure she stated:

The book is sort of a mystery adventure book. It's not that bad of a book. The beginning besides when Spinner catches fish is just plain OK but after like the 3 chapter it was great I'm not done and I want to read (undated log entry)

**Figure 27.** Betsy's literature log reflection.

When responding to a "What are you doing and why are you doing it?" probe she expressed some sense for the drawing power and the symbolic nature of narrative.

I am writing in my writing notebook to get my story done. I was trying to create a story for a young robot and trying to think of metaphors to facilitate them. Maybe some thing unreal. I thought it was hard and it took all of my time just to write 5 sentences.
I am writing in my writing notebook to get my story done. I was trying to create a story for a young child and trying to think of metaphors to fascinate them. Maybe something unreal.

Figure 28. Betsy's "What are you doing and why are you doing it response"

Betsy expanded on this theme in a literature group discussion when asked what she thought Spinner (the main character in Hook a Fish) will be like on returning to New York City. She seemed to project herself into her response:

She'll like school more to learn about animals and strategies like what if's. What I mean by what if's, like me and my brother sometimes just blurt out what would happen if a mountain fell on me? (10/21/91)

Betsy's early questions, like Lynn's, concerned the relationship between whales and humans. She wrote in her learning log:

Ideas group decision on it
1. why do whales beach themselves
2. why do they come near humans
3. how do whales react to whalers
4. how do they react to fresh water
5. are they scared of humans

Figure 29. Betsy's learning log entry.

These questions connected in Betsy's narrative:
"The Escape of the Mayor's Lipstick"

Oct. 21, 2300, there was an employee that had orders from the lipstick palace president to find 4 whales to make some fine lipstick for the mayor's cow that was in the save the earth day parade. If anyone saw him taking those stupid whales, they would have his head. So he caught the whales and was holding them captive in a tank on a jet. The 4 whales were discussion a plan to escape.

The gray whale said, "Like, the biggest should like jump out and go tell the other whales."

Everybody agreed. "So who's the biggest whale?" asked the sperm whale.
"I am 62 feet," said Mrs. Humpback.
"I am 50 feet," said the bossy old right.
"I am like totally 60 feet," said the gray whale who just arrived 3 weeks ago from California.
"Well little guys, I am not bragging. I am 65 feet and 40 tons," said the sperm whale.

"So you just have to jump out and tell the other whales, and they'll help us get out," blurted Mrs. Humpback, as she was trying to understand what Lipstick Palace Factory meant. Whales can't understand cursive.

But the Sperm Whale was confused, "Well where do we go after that?"
"Here," said Mrs. Humpback. The sperm whale wormed his way through the other whales. It was very cramped. On the side of the wall it said Lipstick Palace Factory. Then he jumped out of the tank without another word. Five hundred and fifty feet down. A minute later they heard a splash, he was free. The pilot didn't hear it because of the noise of the engine. He swam away quickly to find his dad. When he got there his could not understand him at all. He was so tired of swimming, he could not even catch his breath. His big heart was the size of a Geo truck. His dad made him rest for a second.

Then right at the very moment he was slowly telling him the story, the jet with the other whales landed in front of a big, big white painted building that said Lipstick Palace Factory. Then 20 muscle big men, one by one, took them inside. The men were in their uniform: L.P.F. kill all whales dead shirts.

Meanwhile, the sperm whale got his dad to come to rescue his friends. They headed for the L.P.F. that was just three feet away from the water. The factory was in a place where the cops could not find it.

Back in the factory, the men put the whales down on a board in a small red room. Then a rich looking man came through the door. The whales were scared and desperate for water. The man said, "Now I always tell my prey what they have gotten into. My boys took you little good for lipstick and nothing else whales into my fortress to make our specialty lipstick. As for the save the earth parade right over the hill, the mayor's cow Annabelle is needin' some Sure Fine Lipstick and
you are it. You won’t feel a thing.”

Just as the man was about to pull the trigger to a harpoon gun, the 2 sperm whales jumped right through the wall. With a wham they hit the floor. The man was squinting his eyes because of all the splinters.

He said, "Well, now I have 6." Then suddenly there was a great big splash. A big wave came in. The whales got the men on their backs to decide what to do with them later. The 6 whales went to the shore and with all their might the they kicked their tails up and the men went flying and landed right in the middle of the parade.

By their uniforms everybody at the parade was against them. Someone called the police. The police were happy when they arrived because of what the uniforms said. It was a big law, no whale killing was allowed. They would get a promotion for catching these guys. The whale killers were finished. And as for the whales, they were happy out breaching in the ocean.

The community found a new way of making lipstick and wax. The mayor was happy to announce a new parade with their new inventions to be held on first avenue. Annabelle the cow was now very popular, because she was on everyone’s shirt. She was a new model to try out the new inventions. The whale killing place was now a recycling place.

Betsy’s story not only incorporated her love of “what if”, her love of the mystery adventure genre, and humor, but showed her understandings in subtle ways. What especially stands out is her sense about the cynicism and dishonesty of the political system around environmental issues. This was a connection she made to *Hook a Fish Catch a Mountain* (George, 1975).

The kids in this book discovered that the reason that there were less cutthroat trout was that illegal clearcutting had warmed an essential part of a stream, which fed into the Snake River. This came as a great surprise to the adults who tell the kids that the trees were supposed to be replanted. In other words there had been a lot of “lip service” around conservation, but no action. This came out clearly when she had the whales being killed to make lipstick for the mayor’s cow for the earth day parade. It seemed that she had a
grasp of how environmental damage often goes on right under the noses of everyone, and that adults in authority seemed to lack any knowledge about it (as in the case of the senator in Hook a Fish) or choose to ignore it for their own purposes (as in the case of the Mayor in "The Escape of the Mayor's Lipstick").

Betsy's personal outlook on life was also evident. There was a collaborative, democratic feeling about the conversation the whales had to deal with their dilemma. Although the whales seemed to be helpless, they calmly discussed how they were going to get out of their tight situation. When discussing experiences that changed our lives, Betsy described a road trip to Michigan she had taken with her large family:

We were going up to Michigan to meet some friends up there. We went in a car. We went two times. The first time was pretty, well I hated it. We were all squished together and we couldn't afford a motel or anything because we had to spend most of our money on food and gas. We had to sleep in the car and then we went all the way up to Michigan and it took us like three or four days, and when we got to Michigan we were really stiff and it was always raining there. And it was pretty cold and the mosquitoes always bit you and stuff... I didn't really, really ever want to go on a car trip again... I really appreciated our food at home and our refrigerator and our own space. (10/8/91)

Being in close quarters with a large family and dealing with discomfort was really communicated as "The sperm whale wormed his way through the other whales."

Moreover, the story ends with the whales "...happy out breaching in the ocean", obviously glad to be home.

Betsy used several devices to communicate information in an engaging way. The conversation among the whales provided a clever forum for presenting comparative sizes. She also developed the characters of the whales. For instance she used the name of the
whale, ("I am 50 feet," said the bossy old right"), or "valley speak" for the gray whale. ("I am like totally 60 feet," said the gray whale who just arrived 3 weeks ago from California") to characterize the whales and made them interesting to the reader. By using the metaphor "His heart was the size of a Geo truck", Betsy employed a device she observed in the many information books on whales and used it to give the reader a sense of relative size that was easily pictured.

And finally, Betsy's hopeful conclusion suggested an understanding of the potential for the interdependence underlying our lives. Thinking inspired by discussions about ecosystems, which focused around speculations concerning the removal of something from the environment, was evident when she concluded with the community finding "a new way of making lipstick and wax". These discussions were partially brainstorming sessions about different ways of doing things that would not harm the environment. Moreover, "the whale killing place" became a "recycling place".

**Why Do Whales Beach Themselves?**

**Diane.** Diane was an independent, serious thinker and aware of life on an emotional level. She expressed her independent, serious thinking in a number of different ways. Diane responded to a "What are you doing and why are you doing it?" probe, which consisted of a photograph where she was silently observing a group working with a model community game. In this game, participants can create a community by placing various elements on the board. The participants were looking at what would happen if a community was overpopulated. Holly was directing the group and Diane was observing.
Diane stated that she was

1) Watching interesting points.
2) Waiting for turn to make interesting points.
3) Waiting to share my idea of what they were doing that I would change.
4) Chose to watch them the minds of other kids and info.
5) To know what other minds want to know.

Figure 30. Diane's "What are you doing and why are you doing it?" response

Here is a portrait of a learner who was observant, curious about the thinking of others and reflective about her own understandings.

Diane expressed her frustration with wasting time and what she perceived as a lack
of seriousness of other students in a reflection she wrote about schedule log time (see chapter three for original entry):

If we didn't have to go in groups people would get with it. And it's hard to work with people that don't want to do that. Most of the time they don't get in group and talk (9/27/91).

Diane's serious approach to learning seemed to be laden with an awareness of responsibility that was almost beyond her years:

I try to understand, but when in comes to long words & that aren't use alot. I give all I can to get the meaning in my head. Some times it's hard to understand but I want to give all my effort for school. So I don't wast time when I'm older. If I screwed around I would be wasting mine & other peoples money.

I try to understand but when in comes to long words & that aren't use alot. I give all I can to get the meaning in my head. Some times it's hard to understand but I want to give all my effort for school, so I don't waste time when I'm older. If I screwed around I would be wasting mine & other peoples money (10/18/91).

Figure 31. Diane's reflection on herself as a reader.

Diane's feelings and emotions were an important part of her understandings. In reflecting about writing she stated, "In writing I like because I can get alot of my feelings
When asked how she decided on what to learn, Diane stated that her feelings were part of the process. Learning was expressed by Diane as a process of questioning and connecting domains of knowledge such as books and the earth.

When you have a question or when you see something and you wonder. And then you find out the information by books. More information by books and stuff and the earth. If you've never seen some kind of plant and you want to know what that plant is. You ask everybody and no one knows. So you go through a book and it tells you what it is. And you've never seen that plant and you always wished you could (9/25/91).

Diane's main question about why whales beach themselves was also connected to an interest in plants in general but specifically in the role of plants in the ocean ecosystem:

I don't know much about plants, underwater plants. And I had things coming at me from left and right. Why this, why that. You can't actually see them grow. Like you are away for a day and you come back and it has grown (undated log entry).

Diane's story reflected these interests as well as her own emotional stance.

"The Polluted Atlantic"

Many whales were put in the Atlantic ocean and they all were killed because no one cared what their pollution did to the ocean. One whale lived. It was a boy named Jim. He wanted to live in a clean ocean. He thought he could do something to clean the ocean. He thought, what will the fish be like when he is a 105 years old. Will there be new kinds of fish, plants and other life in the Atlantic? I hope so, he thought to himself. Not if it's still polluted. Will he not be wanted by his friends when he is so busy cleaning the ocean? Will the people give us clean surroundings and if not why don't they pollute their own grounds?

I remember when I was born, everyone was there. They were happy but sad. They were happy because a new whale was part of everyone. They were sad because I might not live very long since it was so polluted in the Atlantic.

The whale's family is very special. They travel with their family to keep each other safe and to do boring and fun things together. Jim's family, like all other families, were really special to each other. It would be like us being put on this earth alone and not have anyone to live with to share feelings, happenings and last but not least, love.
He sparked an idea about how to get the pollution on land. I know, I will get people to take boats and nets and scoop the pollution on land. Jim began to attract people but some hunters almost killed him. Kids made fun of him because of the fact that he was a humpback whale and humpback whales have spots called birthmarks. People didn't understand what he was doing. Jim felt that it was his fault that people didn't care and help.

He found the perfect idea, Jim could travel to the Pacific Ocean and begin to talk to the other whales. But when he did, no one answered because their ocean was the same as Jim's.

After six months he said that he would put all the trash at one part of the ocean. He would live in the pollution so the pollution won't go anywhere past him. He tried to think of a way to push the pollution on land. He couldn't think of anything so he thought he would think of something when it was time.

Jim began to clean the ocean. Schools and schools of fish passed, wondering what he was doing. Every day he ate the polluted plants and fish. When plants get polluted the pollution begins at the roots and moves up in about three weeks. Then the plants will die.

Day after day Jim got weaker and sicker. The other fish finally understood what he was doing. They all began to lend a hand. Baby fish would die. So Jim said stop! stop! You will die. The fish still helped but ninety baby fish stopped. Jim got so weak that he could barely think of how to get the pollution on land.

He said he would get it on land on his tail. But he thought I'm too sick and weak. Jim decided he would have to beach myself to save the other fish and plants. He thought of beaching himself so he could have clean surroundings for plants, fish and other life in the ocean. It would be better if he could show people what ocean pollution would be like. He would beach himself so pollution would stop everywhere. It took him 15 days to get half the pollution on land. When he got all the pollution on land people began to understand why he suffered.

People think they beach themselves because of confusion and sickness or because they lost their way but they realized that everything that they did made the whale suffer. The ocean after that was honored and became the cleanest in the world. The fish will always remember Jim for what he did for them.

The understandings about why whales beach themselves generated in Diane's story revolved around her sense of herself as a lone actor who takes life seriously. Jim accepted the total responsibility for dealing with the polluted ocean to the point of the ultimate self sacrifice. Her understandings about the interdependence of all living creatures was
communicated when she concluded that people "...realized that everything they did made
the whale suffer".

Diane also communicated her understandings of the relationship between people's
actions and the extinction of the species when Jim speculated: "Will there be new kinds of
fish, plants and other life in the Atlantic?". Diane's sense about the importance of
interdependence was also communicated by Jim's bleak situation. By juxtaposing a
description of the importance of the whale family, with Jim, a lone whale. Diane
presented a desperate, unnatural picture.

Diane's sense of affect came through very strongly. She discussed the sadness for
the future around Jim's birth; the importance of having someone to share feelings with; his
self-blame for the uncaring attitude of people. There is also a sense of someone always on
the fringe of the group; a lone whale attempting to do something; a lone student
struggling with her own learning process.

Diane's story, while containing less "facts" than the others, communicated some
broad understandings of the relationships between all creatures on the earth. Her notes
reflected that she had spent a lot of time exploring and recording information on plants,
whales and the ocean ecosystem. However, what she chose to communicate in her story
focused around her feelings about what she discovered and how she saw herself within the
social context.

Conclusion

The writings generated by the students, while symbols of their current scientific
understandings, also communicated who they are as learners. Lynn's story highlighted her orientation as she navigated her way through a world of adults, while maintaining the nuances of whale life. Betsy's story reflected her sense of humor in facing life's predicaments, as well as her sense of the ironies of life, as symbolized in the very title of her story "The Escape of the Mayor's Lipstick". For Diane, meaning was oriented through affective aspects of knowing and symbolized by the loan actor in a troubled world.

The construction of these narratives provided learners with the opportunity to push beyond the creation of a catalog of facts to explore broader relational concepts. The act of trans-literation or "storying" allowed students to step beyond factual acquisitions and synthesize their experiences into new understandings of science conceptualizations. These conceptualizations were not established knowledge, but were a response to questions that may or may not be answerable. In an essay in which Maxine Greene (1988) asks: "whatever happened to imagination?", and cites Rilke who in writing to "the young poet" suggests that learning is a process of loving and living unsolved questions, and that in this way, "Perhaps you will then gradually, without noticing it, live along some distant day into the answer" (Greene, 1988, p. 52). Greene goes on to suggest that, "If teachers and parents, along with the young, could love the questions and live the questions with the 'distant day' somehow in sight, the spaces in which they lived would be infused with wonder and imagination both" (p. 52).

It is this kind of experience that was portrayed in these narratives: questions were not necessarily answered as much as they were lived with and explored. There can be no
one map or chart for those explorations, which are guided by experience and mediated through signs. In writing about *How Texts Teach, What Readers Learn* Meek (1988) discusses the entrance of children into the narrative world, which mediates their understandings of the world. These experiences become a reservoir of "texts" through which we tell the stories that change in the telling as they come to symbolize our conceptualizations about the world, grounded in our unique meaning filled experiences. Therefore, more important than the lessons of textual conventions, is a lesson,

...learned early and relearned every day, as each one of us stretches our language to reconstruct, remake, extend and understand our experience of living in social contact with each other. When we want to make new meanings we need metaphor.

(Meek, 1988, p. 16)

This sense of reconstruction is captured in the construct of transmediation as developed by Siegel (1984) through a study of how children communicate their understandings of discourse through the creation of sketches. Siegel describes transmediation as a process where, "...the children had to rotate the content and expression planes of these sign systems, an activity that called for the invention of a new code" (p. 458). While the sketching studied by Siegel (1984) highlights the interplay between sign systems in the construction of new codes to communicate meanings, the process of transmediation is closely related to trans-literation or "storying" which can be considered at work in the creation of the new linguistic codes which arose through the construction of these narratives.
However, as seen throughout this chapter, a claim can be made for transmediation based on the students use of nonlinguistic, (experiential and affective) signs to construct narratives oriented towards science conceptualization. Based on previous discussions of science instruction, science concepts are considered to be efferent in nature, existing as discreet bits of information. But through the narratives constructed by learners, science conceptualization can also be seen as an aesthetic enterprise as well, which includes the engagement of nonlinguistic sign systems. This occurred when the exploration of science concepts moved through the alternative expressive plains offered by narrative experience. Jean Craighead George offers a kind of transmediational metaphor in the conclusion of *The Talking Earth* (1983), when Billy Wind, in coming to understand the interdependent nature of the world states: "Spider lilies were lightning bolts and lightning bolts were spider lilies. Albert Einstein had said the same thing in physics, E=mc², but that had been destructive. So it must be said in spider lilies" (p. 151). Therefore, the process of transliteration or "storying" involves learners in a semiotic enterprise where both non-linguistic and intra-linguistic signs can be synthesized to construct metaphoric symbols of new conceptual meanings.
CHAPTER SEVEN

CONCEPTUALIZATION AS SEMIOSIS

The intent of this study was to investigate the science conceptualization process as it occurs through a variety of experiences including avenues such as narrative, that have not traditionally been included in science curriculum. To do this a study was carried out in a fifth grade classroom which involved the development of a thematic unit organized around the concept of interdependence as it relates to water.

The fieldwork for the study involved working with the classroom teacher to develop an integrated curriculum, organized around the concept of interdependence that would encourage learners to carry out independent and collaborative investigations. Curriculum was developed that would encourage students to engage in inquiry through self-selected research projects, science experimentation, and literature discussion groups using books highlighting the theme of interdependence. Data sources were of two main types: (a) As part of the unfolding curriculum such as video and audio taped literature discussion groups and; (b) more formal group and individual interviews and written reflections.

Through a data analysis process which took place within the context of extensive theoretical readings, the initial study questions evolved into:

1. What is the role of experience in conceptualization?
2. What is the relationship between narrative and conceptualization?
3. How do learners use analogy as a process of reasoning in conceptualization?
4. What is the role of metaphor in conceptualization?

5. What is the role of student constructed narrative in conceptualization?

Data from literature discussion groups, interviews, written reflections and student constructed narratives were analyzed using a constant comparative method within a semiotic theoretical framework. The data analysis was embedded in theoretical considerations and presented in three theoretical memos.

Throughout these theoretical memos, conceptualization proved to be a semiotic enterprise where learners, when given the opportunity, constructed and communicated conceptualizations through the use of signs that were constructed from unique connections made between experiences; in this way intertextuality was seen as a process generic to semiosis. Semiotically considered, these signs were taken as symbols of their own unique conceptualization process. The findings from the three theoretical memos are summarized in the following section.

Summary Conclusion

The findings from this study indicate close parallels between a semiotic perspective of conceptualization and the process of scientific discovery. Studies of the discovery process have indicated that new conceptualization involves more than a dualistic interaction between empirical and rational factors. It emerges from initial hypotheses or abductions that arise from experience as anomalies are recognized (Holton, 1973). This can be seen when both the processes of concept development and scientific discovery are characterized in terms of a cycle of inquiry.
Knowing considered in terms of semiosis or sign action lead Peirce (Short, 1985) to suggest a model for conceptualization in the form of a cycle of inquiry or critical thinking. A cycle of inquiry begins when an anomaly, a surprising or unexpected occurrence, is recognized and abductions are generated. Experience is an important factor in this process in that an anomaly can only be recognized as such because it runs contrary to our sense of the world which is based on our own unique reservoir of sign triads. Abductions are the initial hypotheses that direct further investigation. Anomalies and the abductions they generate are the spark that initiates a cycle of inquiry which also includes deduction and induction. The three theoretical memos highlight these various aspects of the inquiry cycle as they parallel scientific discovery.

Theoretical Memo One: Life Texts for Learning

This theoretical memo addressed question number one concerning the role of experience in conceptualization. Throughout this memo, experience was seen as an important dynamic in conceptualization that can be primarily associated with the discovery of anomaly and the formation of abductions. This mysterious force has been misunderstood or ignored in both science instruction and public aspects of the science discovery process.

If one looks beyond the external aspects of scientific discovery, experience can be found to play a central role in the nascent moment (Holton, 1973) of discovery. This was bothersome to scientists such as Newton who, although he publicly subscribed to the position that theories could only be developed as they logically followed from empirical
observation, was fully aware that hypotheses present themselves that cannot be derived from a reasoned accounting of the phenomenon (Holton, 1973). It is this something more that is born from experience and called "themata" by Holton (1973) often just beyond the tangible that is the mystery of discovery that can be termed signification.

From a semiotic theoretical stance, the data presented in this memo suggests that experience is the resource of "themata" through which conceptualization occurs. In this way experience can be seen as a multifaceted dynamic, which includes affect and narrative experiences and is embedded in interpersonal and sociocultural contexts. Learners were seen to tap into their experiences in order to orient themselves to a problem and as a resource for constructing new conceptualizations.

This process parallels scientific discovery as it occurs in the "real world", where the effects of experience as it is embedded in the sociocultural context of the time exerts a subtle force on the working scientist. This was seen in Holton's (1973) notion of private science, where the actual process of discovery is grounded in experience and does not necessarily follow a step-by-step path. Science is not a cut and dried enterprise, but one that is fraught with emotion and beliefs. By including experience in conceptualization, alternative ways of knowing such as beliefs and affect can become an aspect of the process. These alternative ways of knowing are operating whether we acknowledge them or not. However, by including them a powerful resource for conceptualization can be realized.

Theoretical Memo Two: Narrative, Analogy and Science Conceptualization
This theoretical memo addressed questions two and three and highlights the role of intertextuality, analogy and narrative in conceptualization. Intertextuality was explored as a connective process generic to conceptualization and synonymous with semiosis or sign action. Analogy was considered as a special kind of sign through which learners conceptualized by making connections between new concepts and their own unique narrative experiences as an avenue for the expression and extension of science conceptualization. The semiotic nature of cognition can be seen through analogies which are generated when connections between signs are made, establishing new relationships. These signs were not constructed in isolation, but arose and were extended through literature discussion discourse.

An analysis of literature discussion discourse showed that students construct analogies as a way of discovering and explicating science concepts. Unlike metaphoric processes where new symbolic representations are forged, analogy is primarily a process of discovering relationships. The discovery aspect of analogies is abductive and connected to experience; the explicative aspect of analogy is deductive in that analogies can express the logical consequences of initial tentative hypotheses. This process was seen repeatedly as discussions began with the suggestion of an analogy as a tentative explanation, which was then built on by the group through discussion.

In this way, science conceptualization cannot be associated with only the gathering of information, but with the dynamics that take place through sign action, where meaning is constructed in the intersections of signs derived from experience with a variety of text
types. This suggests a rich potential for narrative in science conceptualization. Resources for conceptualization are not only found in empirical information or mathematical theory, but are discovered through story. It is in narrative that concepts come alive with the ambiguity that is generic to language, but that also creates the tension that makes new conceptualization possible.

The discourse that occurs in literature discussion groups supports the social nature of knowing and parallels the process of scientific discovery. Science discovery comes about through the transactions of communities of individuals attempting to discover truth; it is from these transactions that the possibility of new knowledge exists (Sutton, 1993; Holton, 1973). Therefore, literature discussion groups where conceptualizations are constructed in the transactions of the participants provide a powerful context for conceptualization that is a kind of microcosm of the process of scientific discovery.

**Theoretical Memo Three: "Storying", Metaphor and Conceptualization**

Theoretical memo three addresses questions four and five and deals with the role of transmediation as an instance of intertextuality, metaphor and "storying" in conceptualization. Metaphor, as highlighted in theoretical memo three, came to be seen in terms of the inductive/synthetic aspect of conceptualization, where learners engaged in "storying" or conceptualization through the construction of a configuration of signs that came to represent new understanding. In this way, metaphor was associated with the process of trans-literation where the "factual" world of science concepts was mediated through the construction of narrative. Metaphor was defined as a process of reasoning
where learners "bent the field of meaning" (Gerhart & Russell, 1984) through the novel juxtaposition of sign configurations that were both privately and publicly derived. This process is also paralleled in scientific discovery.

Throughout history, metaphors have been constructed as symbols of how we view our world. Newton's machine metaphor held sway for three centuries and represented the "intellectual horizon" of that era only to be replaced by relativity and a view of the universe as an ever-changing web of relationships. This metaphor was not constructed in isolation, but emerged from a community of inquirers operating within the limits of the sociocultural context. Therefore science is also a social enterprise that is embedded in the stories and lives of the participants.

From the early Greeks whose explanations of physical phenomenon blended science and metaphysics into a mythology of knowledge, humankind has always narratized experience and thus constructed meaning through what Bruner (1990) calls a kind of folk psychology. Or as Meek (1988) has suggested, when a new explanation is needed then we turn to metaphor. In stories can be found a kind of history of ideas developed as explanations that symbolize both the unique context in which they were constructed as well as the meanings they were intended to evoke.

This can be seen in the narratives constructed by the study participants, which were unique symbols of their knowing, as well as reflecting who they were as learners. The "facts" are there, but what makes them have meaning is their configuration as part of a story that communicates the learner's understanding of interdependence. Therefore, this
was not necessarily an efferent enterprise, but one that blended aesthetic and efferent ways of knowing.

This blending of ways of knowing can be seen through a process of intertextuality. as a kind of transmediational process, where conceptualization is multi-dimensional rather than limited to "factual" language. Trans-literation or "storying" is a process of conceptualization that opens up new avenues of knowing within the linguistic sign system, including nonlinguistic aspects of knowing.

Curricular Implications

Throughout the three theoretical memos presented in this section, I have argued that science conceptualization is a generative process that is grounded in the experiences of individuals and the sociocultural context, and constructed and expressed through sign action or semiosis. This generally runs contrary to instructional practices. Learning in this century has been characterized in terms of efficient information processing, with little regard for the inquiry process.

The scientific community, as well as economic and political considerations, has contributed to these notions of learning. The scientific community, by maintaining a dualistic model and masking the private aspects of discovery, has made conceptualization appear as an orderly process that moves between the two points of deduction and induction.

Industrialization, in striving for efficiency, conceptualized learning in terms of a series of small discreet tasks. The production of goods or in the case of education, the
attainment of knowledge, came to be perceived as a process of moving from one small task to another. With socio-political considerations, the issue became the control of large populations of people or in terms of educational practice, unitary standards for what was to be learned and how.

All these factors work against the process of science conceptualization as it actually occurs. This is highlighted in a comprehensive study of American schools conducted by John Goodlad (1984), which indicated that:

1. Science curriculum was arranged according to topics such as plants, seasons, light, color which were repeated throughout the school years.

2. Science instruction primarily involved the imparting of information about topics and scientific method, rather than engaging in science.

3. Science instruction was limited primarily to textbook materials.

4. What lab experiences were available were tightly controlled experiences where all learners were expected to reach the same conclusion.

5. The lives of great scientists or mention of science as a career was absent.

6. Testing emphasized the recall of information, rather than reasoning through problems.

What is indicated by these findings is that although teachers verbalized science learning in terms of the reasoning and critical thinking involved in doing science, science instruction in no way resembles scientific inquiry.

Missing from science instruction are the experience, the questions, and the
reasoning processes of the learners. It can be argued that in general, the curricular implications for the findings of this study suggest that in order for science instruction to be science learning, it needs to closely parallel scientific inquiry. This can only be accomplished through the use of what Siegel (1994) calls inquiry models of learning which "...invite learners to see themselves as knowledge makers who find and frame problems worth pursuing, negotiate interpretations, forge new connections and represent meanings in new ways" (p. 3).

This is certainly not a new notion for science learning. Eleanor Duckworth (1978), who for the last three decades has investigated the process through which we come to know the material world, characterizes intellectual growth as "the having of wonderful ideas", where children are allowed "...to accept their own ideas and work through them" (p.27). Duckworth has based her investigations on the notion that intellectual growth does not occur by providing students with a "...contentless set of tools that they can go about applying" to learn about the material world, but that "...tools cannot help developing once children have something real to think about" (1978, p.27). Duckworth describes these intellectual tools as:

...a person's own repertoire of thoughts, actions, connections, predictions and feelings. Some of these may have as their source something he has read or heard. But he has done the work of putting them together for himself, and they give rise to new ways for him to put them together. (p. 27)

At the heart of inquiry is also the process of critical thinking. Because
conceptualization is the construction of meaning, rather than the processing of information, contexts for science learning need to be organized in such a way that learners are encouraged to engage in critical thinking. This does not mean that subskills identified with critical thinking need to be taught but that a situation needs to be created that maximizes the opportunity for learners to engage in critical thinking. Based on a definition of critical thinking partly derived from Peirce by Short (1986, 1990), critical thinking begins with the discovery of an anomaly or problem. But because anomalies can only come from the unique experiences of the individual in contrast to a current experience of the material world, learning environments need to encourage learners to discover their own questions.

In their book *Creating Curriculum*, Short and Burke (1991) suggest that in order to foster learning, contexts need to be constructed in a way that takes advantage of the natural tendencies or attributes of learners, which they identify as curiosity, intentionality and sociability. Critical thinking can also be considered as a human intellectual attribute that can either be encouraged or limited by the educational context.

A context that builds on the critical thinking processes generic to all learners, is one where learners are allowed to engage in solving problems and exploring self-generated questions. This process must begin with the abductions or working hypotheses of the learner. In this scenario, there are no right answers, just speculations to be explored. Therefore, rather than assuming that the current knowledge of the learner is a misconception to be eliminated, that knowledge in process can be the starting point from
which to grow. We can only do this by engaging in inquiry and through open-ended discourse where the goal is discovering rather than changing the thinking of the participants to reflect curricular goals and objectives.

Three central notions about science conceptualization that can be implied from an inquiry approach to learning as described by Duckworth and Siegel, and learning as critical thinking as described by Short and Burke are: (a) Science conceptualization begins with the discovery of a problem or question the learner is interested in; (b) inquiry that generates new conceptualization is a process of making connections; (c) the intellectual reservoir available for intellectual growth include a variety of possible sign systems.

Discovery of a Question

Curriculum can not be seen in terms of textbooks or goals and objectives, but as a process that evolves through negotiation that begins by the discovery of a question. This takes place when learners are allowed the opportunity to engage in explorations of the material world that are not structured for a particular outcome, but that encourage learners to engage in the process of scientific investigation. Only in this way are learners able to recognize the anomalies, those surprising occurrences that challenge their thinking, that spark the inquiry process.

Anomalies arise when learners are allowed to engage their experiential repertoire to learn about the material world. As with the historic scientific discoveries, the "themata" of the inquirer provides unspoken resources for new conceptualization. If these themata are acknowledged as part of the process, learning has more meaning for students as well
as being a source of surprising discoveries. These surprising discoveries do not have to be
"new", they only need to be new to the learner; concept development is an individual
process that is encouraged through reflection on physical phenomenon in light of our own
experience and state of knowledge.

Science discovery progresses because of the very ambiguity that schools are
attempting to eliminate from curriculum. If science instruction is to become science
discovery, it is necessary to "live with our questions" (Greene, 1988). This means a trade­
off between predictable curriculum goals and objectives and allowing learners to actually
engage in the process of inquiry.

Making Connections

Intertextuality, or the making of connections, is a generic process of
contceptualization. The possibilities for connections are myriad if learners are provided
with experiences that encourage rather than limit the potential of intertextuality.
Encouragement for intertextuality to occur can be found in conceptually focused literature
discussion groups that are tied to other content and the use of other sign systems.
However, even within the linguistic sign system there is great connection making potential
in literature, where science concepts are mediated through narrative. In this way, the
generative potential of trans­literation can also obtain in a more limited sense within the
linguistic sign system when narrative is included as an avenue for conceptualization.

Literature and student constructed narrative need to be considered as legitimate
avenues for science conceptualization. Literature holds great potential for science learning,
if conceptualization is viewed as a process of sign construction, rather than the processing of textbook information. Through engagement with literature, and literature discussion groups, analogical relationships can be discovered that lead to new conceptualization. Through the construction of narrative, learners create metaphorical symbols, that represent their current understanding, while at the same time leading to new conceptualizations.

Alternate Sign Systems—Transmediation

The inclusion of all sign systems in learning has been identified as transmediation by Siegel (1984, 1994). Siegel (1994) defines transmediation through a discussion of the model proposed by the concept's originator Charles Suhor and states that the process of transmediation is "...the idea that moving across sign systems is a generative process in which new meanings are produced" (p. 12). Transmediation is understood by Siegel "...as a special case of semiosis in the sense that learners use one sign system to mediate another" (p. 12). A similar transformational process, trans-literation, was seen through engagement with narrative. The potential for this to happen exists with literature discussion groups, and the construction of narrative. While science concepts cannot be constructed solely through engagement with narrative, literature discussion and "storying" can broaden the possibilities for conceptualization by providing avenues for understanding science concepts through the underlying relationships in which they obtain.

Through discourse that is focused on discovery, meaning is negotiated, rather than transmitted and in this way learners "forge new connections" as they transact with other
learners. Those new connections can also be found when learners are allowed to explore concepts through other sign systems. Textbooks provide the primary materials for science instruction. However, if cognition is considered to be a universal process of sign action, where signs can be combinations of any mode and content, science conceptualization cannot be necessarily restricted to a particular sign system or a particular aspect of a sign system. This opens up possibilities for the inclusion of other sign systems such as music and art as avenues for "content" curriculum.

However, more importantly, it is the process of moving between and within sign systems that indicates a powerful potential for transmediation and trans-literation. When learners begin to make a shift in the conventional relationship between content and expressive planes, the possibilities for sign formations increase, broadening and deepening the potential for conceptualization.

In conclusion, in order for learners to tap their potential for conceptualization, the overall structure of the classroom context must change. Unless concept development takes place within a context focused on explorations of self-generated questions, through a variety of means, the potential for real learning and discovery is limited. This means that attention has to be shifted away from the teaching of representational structures such as language and math, to the engagement of all sign systems for inquiry. This does not mean that learners should not engage in whatever process is necessary to obtain these tools, but that the central focus for learning needs to be shifted to inquiry.

This means a shift in control from the "expert" to the learner, where all participants
become learners and knowledge is always in process. This is difficult to achieve in that it
cannot be understood in terms of curriculum guidelines, but develops by making changes
in outlook that occur when educators begin to reflect on themselves as learners in
relationship to their own unique experiences.

Implications for Teacher Education

To enable teachers to create learning environments that encourage students to use
their cognitive potentials to the fullest, practicing educators need to live through learning
experiences that encourage them to engage in critical thinking. This is especially true in
the area of science, where many teachers feel inadequate to the task of teaching science
and therefore tend to depend on textbook materials, rather than actually engaging students
in the exploration of science concepts.

In the introduction to her report on the African Primary Science Program, Eleanor
Duckworth (1978) describes an experience through which she began to understand for
herself the process of science conceptualization. During a conference of scientists from
various disciplines, which focused on the development of science curriculum, Duckworth
had the opportunity to explore scientific phenomenon as presented through hands-on
activities developed by various groups of science experts. This involved interacting with
materials, making predictions, and developing a rule only to have it challenged. It became
very clear to Duckworth that having the right answer was not as interesting or productive
as all the wrong turns and unpredictable occurrences associated with the study of physical
phenomenon. This initial experience and consequent investigations eventually led her to
observe that, "...after getting caught up in many phenomena for their own sakes, I began to see how this groundwork was indeed leading to intellectual understanding, in quite unpredictable ways" (p.31).

Engagement with physical phenomena, the discovery of a question and the usefulness of not knowing the answer are what characterizes Duckworth's (1987) approach to teacher education. In order for what Duckworth calls "instructors" to actually become "teachers", it is necessary to: (a) engage in the process of coming to understand one's own conceptualization process and; (b) make an attempt to understand the conceptualization process of children, rather than to stamp it with curricular objectives.

To summarize Duckworth's work, to meet the first goal some content would need to be sacrificed for process, with education classes structured more like think-tank sessions. These sessions would allow learners to really explore and reflect on how they think about physical phenomenon. This would not necessarily mean finding the right answer as much as it would involve surprises, confusion and the "productive wrong ideas" that drive the learning process.

Teachers would then develop a learners stance, making it comfortable to not necessarily have the "right" answer and also making it possible to meet the second goal mentioned above. Rather than organizing classroom experiences by focusing on arbitrary curricular objectives, teaching would center on a process of trying to understand the thinking of the learner:
To the extent that one carries on a conversation with a child, as a way of trying to understand a child's understanding, the child's understanding increases 'in the very process.' The questions the interlocutor asks, in an attempt to clarify for herself what the child is thinking, oblige the child to think a little further. (Duckworth, 1987, p.96)

In this way, school experiences can begin to parallel how humans make meaning through a process of making connections between experiences and our sense of those experiences.

These are not new ideas, they are central tenets of John Dewey's progressive education movement and Duckworth herself has been developing these notions through research since 1962 to name only two. However, the nature of institutionalized education, driven by standardized testing which consequently places arbitrary demands for accountability on teachers, consistently works against the possibility for learners to actually engage in the critical thinking. This leaves teachers and teacher educators with the almost overwhelming task of re-educating themselves and taking the incredible risks involved in going against the conventions established within the schools. If schools are to be an agent of change in a world full of challenges to our very survival, and the need for solutions to those challenges, creating the environment that fosters the "having of wonderful ideas" is the task at hand. In the words of Duckworth (1978):

The more we help children to have their wonderful ideas and to feel good about themselves for having them, the more likely it is that they will some day happen upon wonderful ideas that no one else has happened upon before. (p.28)
This cannot happen though if teachers are not given the same opportunity.

Conclusion

This study was only a glimpse into the incredible cognitive potential to be developed when learners are encouraged to explore conceptualizations through alternate avenues and to think through and reflect on those explorations. While most educators would probably say that learning does not involve the filling of an empty vessel, much of the structure of institutionalized education seems to be based on this viewpoint. The standardized testing and curriculum that drives what happens in classrooms represents an attempt to impose cognition from the outside that focuses on the learning of representational structures, rather than the meaning that can be made through those structures. This has added to our knowledge of cognition in only very limited ways. In order to further knowledge of cognition, future research needs to be focused on discovering what and how learners are actually thinking. This needs to be done in environments where multiple avenues and sign systems are made available allowing concept development to take place through a myriad of possible sign relations.

This does not mean the abandonment of the learning of the representational structures of sign systems through which we communicate meaning, but a change in balance. The relationship between sign systems or the "expression" planes and meaning or the "content" plane is a symbiotic one that drives the learning process forward. This relationship exists throughout the learning process, making it almost impossible to separate the two into discrete components where the "basics" are to be learned in
preparation for the learning of content.

In conclusion, if learning is considered, as suggested by semiotics, the discovery of ourselves in relationship to our world, then the previous implications follow naturally. Semiosis is synonymous with conceptualization and as such occurs regardless of the context. However if learning contexts build on instead of limit the semiotic potential of learners, individuals will emerge who have the self-knowledge and imagination to conceptualize beyond themselves and make a real contribution to the world community.
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