SEA OF IMAGES: A STUDY OF THE RELATIONSHIPS AMONGST STUDENTS' ORIENTATIONS, BELIEFS, AND SCIENCE INSTRUCTION

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Recent research in education has established that students at quite young ages bring to instruction beliefs which they construct from their own experiences, and that such beliefs are remarkably resistant to change. Although a growing body of research focuses on the nature of these beliefs, little attention has been given to the values underlying these beliefs and the way in which students' beliefs and values may have an impact upon the ways in which they respond to and interpret instruction in science.

One way of describing a set of beliefs and its underlying values is through the construct of an "orientation". In this study, an orientation referred to a tendency for an individual to understand and experience the world through an interpretive framework, embodying a coherent set of beliefs and values.

The purpose of this study was to explore the relationships between the students' orientations towards the seashore, their beliefs about specific seashore relationships, and their experiences during science instruction. The study involved the collection and analysis, by metaphor and literal interviews, of students' orientations and beliefs before and after instruction. By looking for patterns in the students' responses, six different orientations were identified (scientific, aesthetic, utilitarian, spiritual, recreational, and health and safety), as well as a diversity of beliefs about specific seashore relationships (tidal cycle, habitat,
predator-prey, food chain, community, pollution, conservation, etc.). In addition, observations were made during classroom instruction and interviews with individuals in the school and the community were conducted to aid in the analysis of the students' orientations and beliefs.

The primary focus of instruction was to introduce a basic set of ecological concepts focused around seashore relationships. In order to increase a students' knowledge of beach ecology, the teacher attempted to use instructional metaphors which were sensitive to the student's preferred orientation identified prior to instruction. A second purpose of instruction was to enhance the student's ability to view the seashore from a variety of orientations.

Results of the pre-instructional interviews showed that while all of the students used several orientations to describe the seashore, some students used one orientation predominantly. Only a few students held beliefs which were quite similar to accepted science ideas; most students held beliefs which were quite different. For most students, there was a reasonably strong relationship between their orientations and the nature of their beliefs about specific seashore relationships.

Results of the post-instructional interviews show that for all of the students there was an increase in knowledge about basic seashore relationships, and a decrease of beliefs inconsistent with accepted science ideas. This increased knowledge was accompanied in most students by a willingness to use more frequently a scientific orientation. This new knowledge appeared to be relatively stable six months after
instruction, implying that it was firmly integrated into the students' cognitive system. The fact that many students still used orientations which they possessed prior to instruction, and that for some students these orientations were more elaborated, provides evidence that they were willing and able to view the seashore from a variety of orientations. Implications for science instruction and research are discussed.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF ILLUSTRATIONS</td>
<td>vii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ix</td>
</tr>
<tr>
<td><strong>CHAPTER 1 STATEMENT OF THE PROBLEM</strong></td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Background to the Study</td>
<td>3</td>
</tr>
<tr>
<td>The Problem</td>
<td>4</td>
</tr>
<tr>
<td>The Major Research Questions</td>
<td>5</td>
</tr>
<tr>
<td>Brief Overview of the Study</td>
<td>6</td>
</tr>
<tr>
<td>Organization of the Report</td>
<td>8</td>
</tr>
<tr>
<td><strong>Chapter 2 REVIEW OF RELATED RESEARCH</strong></td>
<td>11</td>
</tr>
<tr>
<td>Children's Views and Classroom Experience</td>
<td>11</td>
</tr>
<tr>
<td>Children's Prior Beliefs about Science Concepts</td>
<td>11</td>
</tr>
<tr>
<td>Children's Prior Beliefs and Science Instruction</td>
<td>13</td>
</tr>
<tr>
<td>Children's Prior Beliefs, Cultural Values, and Science Instruction</td>
<td>20</td>
</tr>
<tr>
<td>Summary</td>
<td>22</td>
</tr>
<tr>
<td>Language, Metaphor, and Meaning</td>
<td>24</td>
</tr>
<tr>
<td>The Use of Metaphor to Give Meaning</td>
<td>24</td>
</tr>
<tr>
<td>The Use of Metaphor to Create New Meaning</td>
<td>28</td>
</tr>
<tr>
<td>The Use of Metaphor to Uncover Meaning</td>
<td>32</td>
</tr>
<tr>
<td>Summary</td>
<td>36</td>
</tr>
<tr>
<td><strong>Chapter 3 RESEARCH METHODS AND STRATEGY OF INSTRUCTION</strong></td>
<td>37</td>
</tr>
<tr>
<td>The Case Study</td>
<td>38</td>
</tr>
<tr>
<td>The Six Research Phases</td>
<td>40</td>
</tr>
<tr>
<td><strong>Phase 1 The Pilot Studies and Selection of the Setting</strong></td>
<td>40</td>
</tr>
<tr>
<td>The Five Pilot Studies</td>
<td>40</td>
</tr>
<tr>
<td>Selection of the Case Setting</td>
<td>45</td>
</tr>
<tr>
<td><strong>Phase II The Pre-instructional Study</strong></td>
<td>47</td>
</tr>
<tr>
<td>The Metaphor Interviews</td>
<td>47</td>
</tr>
<tr>
<td>Identifying the Students' Orientations</td>
<td>56</td>
</tr>
<tr>
<td>Identifying the Students' Beliefs</td>
<td>64</td>
</tr>
<tr>
<td>The Literal Interviews</td>
<td>68</td>
</tr>
<tr>
<td>The Target Students</td>
<td>74</td>
</tr>
<tr>
<td><strong>Phase III The Classroom Interaction Study</strong></td>
<td>75</td>
</tr>
<tr>
<td>The Strategies of Instruction</td>
<td>75</td>
</tr>
<tr>
<td>The Use of Verbal Metaphors to Create New Meaning</td>
<td>76</td>
</tr>
<tr>
<td>The Use of Non-verbal Metaphors to Create New Meaning</td>
<td>80</td>
</tr>
<tr>
<td>Classroom Observations</td>
<td>83</td>
</tr>
<tr>
<td><strong>Phase IV Post-instructional Interviews and Community Inquiries</strong></td>
<td>83</td>
</tr>
<tr>
<td><strong>Phase V Long-term Post-instructional Interviews and Community Inquiries</strong></td>
<td>84</td>
</tr>
<tr>
<td><strong>Phase VI Analysis of the Data</strong></td>
<td>85</td>
</tr>
</tbody>
</table>
Validity ................................................. 86
Limitations of the Study ................................ 90

Chapter 4 THE RELATIONSHIP BETWEEN THE STUDENTS' ORIENTATIONS
AND BELIEFS PRIOR TO INSTRUCTION ......................... 95
The Students' Orientations Towards the Seashore
Prior to Instruction ........................................ 96
Sets of Orientations ......................................... 103
The Experiential Bases of the
Students' Orientations ....................................... 114
Internal Coherence ........................................... 116
Summary ....................................................... 117
The Relationship Between the Students' Orientations
and Their Social and Cultural Backgrounds ............... 119
External Coherence .......................................... 131
Summary ....................................................... 139
The Students' Beliefs Prior to Instruction .................. 140
The Students' Awareness of Seashore Phenomena ........... 140
The Students' Beliefs About Seashore Relationships ...... 143
Summary ....................................................... 145
The Relationship Between the Students' Orientations
and Beliefs Prior to Instruction .................. 146
The Students' Orientations and their Awareness
of Seashore Phenomena ..................................... 147
The Students' Orientations and their Beliefs
about Seashore Relationships ............................... 150
Internal Coherences Across Orientations and Beliefs .... 164
Summary ....................................................... 166

Chapter 5 THE RELATIONSHIP BETWEEN THE STUDENTS' ORIENTATIONS
AND BELIEFS, AND EXPERIENCES DURING INSTRUCTION . 168
The Science Concepts and Activities ....................... 169
Taking Into Account the Students' Orientations
During Instruction ........................................... 173
On the Process of Generating Metaphors ................. 173
Individual Styles of Metaphorical Thinking ................ 176
Incorporating the Students' Own Metaphors
Into Instruction ............................................. 184
Metaphors as Rich Instructional Devices ................. 188
Aesthetic Metaphors to Teach Science Concepts ............ 191
Spiritual Metaphors to Teach Science Concept ............. 193
Utilitarian Metaphors to Teach Science Concepts ....... 196
Health and Safety Activities to Teach Science Concepts .. 197

The Relationship Between the Students' Orientations
and Beliefs, and Their Behavior During Instruction .... 199
The Students' Behavior During Science Activities ....... 199
Fieldtrips to the Seashore ................................ 199
The Science Projects ..................................... 202
Preferred Animals .......................................... 204
Pollution Study ............................................. 207
The Students' Behavior During Aesthetic Activities .... 209
The Students' Behavior During Spiritual Activities .... 212
Summary ....................................................... 215
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Luke's Awareness of Seashore Phenomena</td>
<td>69</td>
</tr>
<tr>
<td>Table 2</td>
<td>Luke's Category System Prior to Instruction</td>
<td>70</td>
</tr>
<tr>
<td>Table 3</td>
<td>Luke's List of Predator-prey Relationships</td>
<td>73</td>
</tr>
<tr>
<td>Table 4</td>
<td>The Students' Awareness of Seashore Phenomena</td>
<td>141</td>
</tr>
<tr>
<td>Table 5</td>
<td>Jimmy's Category System Prior to Instruction</td>
<td>152</td>
</tr>
<tr>
<td>Table 6</td>
<td>Mary's List of Predator-prey Relationships</td>
<td>156</td>
</tr>
<tr>
<td>Table 7</td>
<td>Dan's Category System After Instruction</td>
<td>240</td>
</tr>
<tr>
<td>Table 8</td>
<td>Jimmy's Category System After Instruction</td>
<td>243</td>
</tr>
<tr>
<td>Figure 1</td>
<td>Luke's Barnacles</td>
<td>70</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Dan's &quot;The Seashore is a Neighborhood&quot;</td>
<td>255</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Mary's &quot;The Seashore is a Bracelet&quot;</td>
<td>260</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Anna's &quot;The Seashore is a Garden&quot;</td>
<td>266</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Luke's &quot;The Seashore is a Happy Song&quot;</td>
<td>276</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Jimmy's &quot;A Fishing Boat&quot;</td>
<td>289</td>
</tr>
</tbody>
</table>
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Chapter 1

STATEMENT OF THE PROBLEM

Introduction

A few years ago while walking along a sandy beach, I became fascinated with watching children play. At first, the various children seemed to be playing in similar ways, but as I watched, I became impressed with how the individual children responded to and interpreted their experiences in diverse ways. I watched as some children drew pictures in the sand with kelp, sticks and seashells. Some drew pictures of mom, dad, and little brother; others drew pictures of dogs, cats, eagles, or fishing boats. Other children busily built intricate roadways or castles or forts. Some imagined themselves to be road-graders, dump-trucks, or fork-lifts and made power sounds as they collected and shaped the sand and mud. I was particularly amused to watch how some children imagined themselves to be graceful seagulls or jet planes and would run up and down the beach making wonderful loops and dives with outstretched wings. One little boy imagined himself a thunderbird and with eyes staring out of his head, breathed thunder and lightning from his eyes. Others must have imagined themselves killer whales, seals, or salmon, for they ran with marvelous undulating movements, swimming upside down and jumping out of the water. Others became tiny worms or snails,
as they wiggled and squiggled and slithered and slid through the sand and mud—a fascinating activity that left strange looking tracks they later came back to giggle over and admire.

When one looks around in such a mood, one becomes aware of the use of metaphor as fundamental to human communication. These children drew upon the materials around them to become something else. This "becoming" a graceful seagull, a soaring jet plane, a splashing killer whale, a magnificent thunderbird, is a process whereby children understand their experiences through metaphor.

By reference to the children's dramas, educators can explore how children conceptualize their experiences at the seashore through metaphor. How does the childrens' choice of metaphor relate to their values and feelings about the seashore? How does the childrens' choice of metaphor relate to their beliefs about how seashore plants, animals, objects, events, and conditions interact? And finally, do these preferred metaphors act either as a "barrier" or "bridge" to gaining knowledge through science instruction?

I had been exploring the use of metaphor as an instructional device for many years. In writing the curriculum Once Upon a Seashore (Snively, n.d.), I used metaphors as a means of increasing the students' understanding of beach ecology. This study describes the use of metaphors to identify and analyze how the knowledge of students' prior beliefs and values can be used to understand their experiences during
science instruction, and their subsequent understanding of seashore ecology. Instruction was based on a modified version of *Once Upon a Seashore*.

Background to the Study

Students bring to the classroom ideas based on prior experiences. These ideas or beliefs have an impact upon the ways in which they respond to and interpret instruction in science. The notion that students approach the world with some degree of mental organization, not a blank mind, is not new (Ausubel, 1963; Driver & Easley, 1978; Driver & Erickson, 1983). Not only have researchers been able to identify and describe such intuitive views for a range of specific phenomena, but they have also established that such views can be remarkably persistent.

Typically, researchers in science education have addressed the notion of constructed meaning by analyzing students' cognitive beliefs about a narrow set of concepts or topic area. Little work has been done on describing a set of beliefs and its underlying values. Researchers try to distinguish between cognitive and affective domains, but in fact, they can't be separated. One way of attempting to capture some of the complex interplay between cognition and affect is by the construct of an orientation. In this study, an orientation means a tendency for an individual to understand and experience the world through an interpretive framework,
embodying a coherent set of beliefs and values.

These orientations are thought to be deeply rooted aspects of our conceptual system and not easily accessible with normal probing techniques such as pencil and paper tests or even conventional interview techniques. One of the ways of understanding these broad intellectual commitments is to look more carefully at the nature of metaphorical thinking in children.

The Problem

The fact that students clearly have ideas and feelings about nature prior to specific instruction suggests that teachers need to know more about the nature and variability of students' ideas and feelings, as expressed in their orientations and beliefs. Variations in the students' orientations and beliefs may influence their understanding and acceptance of new science concepts. There may be conflicts between the students' prior orientations and beliefs and the instruction as presented. If a student interprets science concepts as being in harmony with his or her own orientations and beliefs, then learning these concepts may be a fairly straightforward task. But if a conflict exists between the orientations and beliefs held by a student and those presented by the instruction, then learning the accepted scientific concepts may be quite difficult. The fact that students bring to the classroom prior orientations and beliefs suggests also that teachers need to take the students' beliefs and values
seriously and incorporate these into the instructional process.

In this study, the students' initial orientations were taken into account during instruction. It was hoped that the interaction between the students' orientations and school science presentations would result in increased knowledge about seashore ecological concepts that would be sufficiently stable to persist for a significant time after instruction had ended.

The Major Research Questions

This study explored the following research questions:

1. What is the nature of the students' orientations towards the seashore prior to instruction?
   1.1 What is the nature of the students' beliefs about specific seashore relationships prior to instruction?
   1.2 How are the students' beliefs about specific seashore relationships related to their orientations?

2. What interactions occur between the students' orientations and beliefs and their experiences during instruction?

3. How effective were the strategies of instruction?
   3.1 What is the nature of the students' beliefs about specific seashore relationships after instruction?
   3.2 To what extent are the students' able to view the seashore from a variety of orientations?
3.3 What is the relationship between instruction and the students' orientations and beliefs?

3.4 How stable are the students' post-instructional orientations and beliefs?

Brief Overview of the Study

This study was primarily concerned with describing the relationships between the students' orientations and beliefs and their experiences during science instruction. It involved the probing, by metaphor and literal interviews, of students' orientations and beliefs during pre- and post-instructional interviews. During the metaphor interviews I asked the students to select metaphors from a range suggested and to explain why they selected the metaphors indicated. For example, the students were asked the question: If the seashore were one of the following (painting, community, church, playground, factory, pin cushion), which one or ones would it be, and why? The students' full verbal responses were recorded on audiotape. By looking for patterns in the students' responses I was able to identify six different orientations in the respondents' answers (aesthetic, scientific, utilitarian, spiritual, recreational, health and safety), and a great diversity of beliefs about specific seashore relationships (tidal cycle, habitat, predator-prey, food chain, etc.).

The primary purpose of the three-week instructional
unit was to teach such basic ecological concepts of seashore relationships as: tidal cycle, habitat, desiccation, predator-prey, protection, recycle, food chain, interdependence, community, zonation, pollution, conservation, etc. In order to increase the students' knowledge of beach ecology, the teacher attempted to use instructional metaphors consistent with the students' own orientations. A second purpose of instruction was to enhance the students' ability to view the seashore from a variety of orientations through the use of instructional metaphors representative of different orientations. During this phase I collected data through the use of field notes of selected class discussions and activities.

The participants in this study (n=20) consisted of a class of grade 6 students in a small coastal town in British Columbia, which will be given the pseudonym "Salmon Cove". A native Indian community is located at one end of the cove and a community largely of European extraction is located at the other end of the cove. It was expected that the presence of both native and non-native students in this study would result in the presentation of a wide range of orientations towards the seashore, and a diversity of beliefs about specific seashore relationships. The main criterion used in the selection of a grade 6 class was the ability of students at that age level to express their ideas in the metaphor interviews. Within the class, six target students were selected for intensive study: the student with a preferred
scientific orientation (Dan), the student with a preferred utilitarian orientation (Jimmy), the student with a preferred aesthetic orientation (Mary), the student with a preferred spiritual orientation (Luke), the student with a preferred recreational orientation (Anna), and a student with no preferred orientation (Sharon).

Organization of the Report

Seven chapters reflect the questions addressed in this study.

In the second chapter, the review of the literature, I outline recent research in education that has analyzed students' beliefs about science phenomena. The literature on how metaphors play a role in the fine tuning of the concepts that govern everyday life is also discussed. The underpinnings of the metaphor interview, together with related research, are outlined to substantiate how metaphors can be elaborated to identify and analyze beliefs and values. In so doing, I show how metaphors give meaning to everyday reality, how they can be used to uncover meaning, and how new meaning may be created from them.

The third chapter describes the collection and analysis of the data. It outlines the six research phases and the tasks involved in each phase. In so doing, it describes the five pilot studies and includes the metaphor interviews I constructed for the analysis of the students'
orientations and beliefs. It describes the pedagogical strategy which was developed to take into account the students' orientations and beliefs during instruction. Last, it outlines how I analyzed the data using multiple methods and addresses the issues of validity and limitations of the study.

The fourth chapter describes and analyzes the organization of the orientations and beliefs that the students in the Salmon Cove study brought to instruction. In so doing, it describes in detail how some of the students' ideas and beliefs about specific seashore relationships were quite similar to accepted science concepts, whereas others were quite different. Then, by analyzing the interviews with school officials and elders in the community, I describe how the students' orientations and beliefs may be influenced in part by socio-cultural factors, and in part by their previous physical experiences at the seashore.

The fifth chapter describes the students' experiences during instruction. It describes the type of activities that were designed to teach about specific science concepts, and describes how the teacher attempted to take into account variations in the students' orientations and beliefs. Finally, it describes the relationships between the students' orientations and beliefs, and their experiences during instruction.

The sixth chapter begins by documenting the use that each student made of various orientations to describe the
seashore after instruction. In so doing, it describes a relationship between the students' preferred orientations towards the seashore prior to instruction, the instructional input, and changes in their specific beliefs about seashore relationships. Also, it describes and analyses the stability of the students' orientations and beliefs six months after instruction, and relates the findings to the type of instruction that occurred.

The seventh chapter provides a summary of the study and conclusions. The implications of the research for learning and instruction are discussed, as well as issues that this work leaves unanswered and possibilities for future research.
Chapter 2

REVIEW OF RELATED RESEARCH

This chapter is organized around two major themes: 1) the importance of recognizing the learners' prior knowledge and the implications of this for classroom instruction, and 2) the relevance of work on how metaphors can be used to give meaning, to create new meaning, and to uncover meaning in an instructional setting.

Children's Prior Knowledge and Classroom Experiences

This first section addresses issues for science instruction which are pertinent to this study. What is known about children's beliefs about science concepts prior to instruction? How do these prior beliefs influence the learning of science concepts in an instructional setting? What is known about how the values of a culture influence children's beliefs about science concepts?

Children's Prior Beliefs About Science Concepts

Recent research in education has emphasized that children at quite a young age, and before they are taught science, construct out of their everyday experiences views which they use to explain their world (Ausubel, 1968; Driver &
Easley, 1978; Driver & Erickson, 1983; Karplus & Stage, 1981; Magoon, 1977). Not only have researchers been able to identify and describe such intuitive views for a range of specific phenomena, but also they have established that such views can be remarkably persistent. Ausubel in his work uses the term "preconception" to describe children's views which are amazingly tenacious and resistant to change.

Studies of children's conceptions have a long history, mostly in clinical settings. One of the earliest systematic attempts to examine conceptions of the physical world was carried out by Piaget (1929, 1930). Children's ideas about science concepts are becoming widely recognized as an important area of research. For example, children (ages 8-10) have been observed to say the following: "temperature is a measure of the hotness of an object and is a result of the amount of heat that is added to it" (Erickson, 1975), "a seed grows when the weight of the soil causes the seed to crack and lets the little tree inside out" (Luyten, 1985), "gravity requires the presence of air" (Osborne & Cosgrove, 1982), "light from a candle goes further at night" (Stead & Osborne, 1980), and "electric current is used up in a lightbulb" (Osborne, 1981). All of these ideas are quite different from those of scientists and they support the notion (Ausubel, 1968; Kelly, 1969) that children acquire considerable knowledge about the world from their previous experiences with the physical environment, and with other people in their social and physical milieu. Furthermore, the nature of the views children have supports the
comments of Champagne, Klopfer, and Anderson (1979) that children do not have isolated ideas, but rather the ideas are parts of conceptual structures which provide a coherent understanding of the world from the child's point of view.

Evidence for the claim that students have intuitive ideas about natural phenomena is now extensive in the research journals. Virtually all of this empirical work stems from a constructivist epistemology in which it is assumed that learners actively generate meaning from experience. As Driver and Erickson (1983) have indicated, "There is growing interest in the notion that students do possess invented ideas based upon their interpretation of sensory impressions which influence the ways in which they respond to and understand this disciplinary knowledge in science."

Students' Prior Beliefs and Science Instruction

Although the importance of children's beliefs about science concepts is becoming widely accepted as an important area of research, less is known about the effect of alternative beliefs on a child's capacity to learn the scientifically accepted concepts. Driver and Easley (1978) refer to sets of ideas that are based upon a perspective different from that of the current scientific descriptions as "alternative frameworks" while Hewson and Hewson (1981) use the term "alternative conceptions." The role played by these alternative frameworks in an instructional setting, however, is not clear. Novak
(1977), in a summary of Ausubel's theory, stated that the central idea in that theory was simply that the "most important single factor influencing learning is what the learner already knows."

Of the work that has addressed the instructional implications of this perspective the findings suggest that when students' ideas are changed by science teaching the changes are sometimes quite different from those intended. For example, Lebouerter (1976) identified misconceptions related to ideas of force and motion which often persisted in spite of instruction. Rowell and Dawson (1982) report a study with 12-15 year old pupils in which the instruction allowed pupils opportunities to reject irrelevant factors in understanding the principle of flotation, but some alternate beliefs persisted. A study of fourth grade children (Stavy and Berkowitz, 1980) revealed that completion of an intensive unit on temperature did not result in the children modifying all the ideas they held prior to instruction, although some changes were evident. Osborne (1980) and Osborne and Gilbert (1980) found that views of force held by some first-year university students remained essentially the same as those of much younger children, rather than those of a scientist, in spite of a background of experiences which included five years of apparently successful involvement in secondary school science. The persistence of alternate beliefs about the concepts of heat and temperature in school-age children has been studied by several investigators and is relatively well-known (Albert, 1974, 1978; Erickson,
1975, 1979, 1980; Haggerty, 1985; Hewson & Hamlyn, 1984; Triplett, 1973). The data indicate that these intuitive ideas are not necessarily reorganized as a result of instruction; the prior ideas may remain with 'classroom words' imposed, or the new and old ideas may co-exist. White (1982) suggests that the above findings show problems in the teaching of science on a scale not previously imagined.

The work of Tasker (1981) shows that there are considerable discrepancies between the expectations of the teacher for pupils—even the teacher's assumptions about what the pupils had attained from a learning experience—and the reality as described by the observer. Often pupils' perceptions arising from a classroom task are not clearly identified by the teacher who checks by means of a simple written or verbal response to see if the scientific viewpoint is held. According to Tasker, what became apparent was how this practice has encouraged a spectrum of assumptions regarding the learner's response that may be unjustified. One such assumption, described by Fensham (1980), is that the learner has no knowledge of a topic before instruction, and that the learner's 'blank mind' can be 'filled' with the teacher's science. Thus, Tasker and Fensham conclude that teachers and curriculum developers have tended to view investigative tasks largely from their own perspective.

If one accepts a constructivist epistemology, as advocated by Driver and Erickson (1983) and Magoon (1977), it should be no surprise that new information, in and of itself in
the form of counter examples, is not sufficient to enable pupils to change their thinking. "Pupils have to comprehend the new theory and integrate previous experiences into it. As with science itself, perhaps learning science proceeds not by the testing of one theory against the data, but by first making an imaginative leap which enables a new way of thinking about a problem to take place" (Driver & Easley, 1978). Then, a selection between rival theories can be made in the light of data (Koertje, 1970). In modern science teaching, the place for imagination and critical thinking has been minimized, and little attention has been given to the accommodation process amounting at times to a paradigm shift in pupils' thinking, or to the conditions which facilitate it (Driver & Easley, 1978).

As Posner, Strike, Hewson, and Gertzog (1982) have indicated, "Identifying alternative frameworks, and understanding some reasons for their persistence, falls short of developing a reasonable view of how students' current ideas interact with new, incompatible ideas." Much of the past research and curriculum design has been modeled on the notion that if a well developed model of a science topic can be obtained, then one needs only to determine the specific differences with the students' knowledge and teach accordingly. Fensham (1980), suggests that in this process the existence of students' viewpoints and meanings for words have usually been ignored or inadequately considered. As Tasker (1981) has indicated, often the students' perceptions arising from a classroom task are not clearly identified by the teacher who
simply checks to see if the scientific viewpoint can be stated. The importance of recognizing the students' response, and the careful distinction of that answer from the scientific answer, is often overlooked.

Hawkins (1978) has suggested that the incongruence between the child's prior beliefs and accepted science concepts may result in "critical barriers" that interfere with the child's learning. It seems evident to Hawkins, that in considering these critical barriers we must get beyond an approach that conceives of instructional problems in terms of limitations in the child's thinking abilities—such as that which simply classifies students in terms of stages in the Piagetian taxonomy. Rather, he argues, one should distinguish between learning conceived of as the reception, retention, and recalling of verbally coded and transmitted information, and learning understood as transforming sensory or verbal information so as to bring into congruence or conflict with prior general knowledge or belief. He suggests that it is this latter kind of learning which has failed to take place in science classrooms. If science concepts have been taught in a superficial way—verbally transmitted, momentarily understood, and retrievable as fact—then true conceptual understanding is unlikely and loss is unavoidable.

In most studies of instructional impact upon students' prior beliefs students have been exposed to the formal models or theories of school science, yet they have not been able to relate them meaningfully to their own beliefs. Some
researchers have put Ausubel's theory forward as a means of interpreting these data. This theory suggests that pupils in attempting to relate new knowledge to existing knowledge are often in a position of either making inappropriate connections (false assimilation) or, failing to see any connection at all, are forced to rote memorize the new materials. In addition, as Freyberg and Osborne (1981) point out, pupils in classrooms often unknowingly misinterpret what they are taught so that the new information is not in conflict with their earlier ideas. While pupils frequently pass formal assessment tests, the present studies clearly suggest that pupils often do not really change their ideas of how and why things behave as they do as a consequence of science teaching.

Knowledge of pupils' alternate frameworks has been used in designing instructional sequences in science. One approach is to develop teaching materials based upon a model of conceptual change posed by Posner, Strike, Hewson, and Gertzog (1982). These authors recommend that science teaching build on students' prior knowledge and beliefs by showing them the inadequacies of their existing beliefs, and by helping them recognize the validity and usefulness of the scientific view. The central commitment in these studies is that learning is a rational activity. Learning is fundamentally coming to comprehend and accept ideas because they are seen as intelligible and rational.

Minstrell (1982) has documented in his high school physics class the use of guided observations and
common-experience analogies specifically designed to point out the inadequacy of the students' existing conceptions. By using instructional strategies which require students to organize their observations into consistent patterns, to justify and clarify their existing ideas, he argues that they are able to rationally develop a new more encompassing framework without the use of the authority of teacher or textbook.

Osborne and Wittrock (1983) support the contention that what is required is a theory or model of learning which places full recognition on the importance of what pupils bring with them to any learning experience in any setting. The essence of their "generative learning model" is that the brain is not a passive consumer of information. According to their model, if children are to comprehend what they are taught then they must retrieve information from long-term memory and use their information processing strategies to generate meaning from incoming information, to organize it, to code it, and store it once again in long-term memory. In their view, the pathway to the construction of meaning from any experience does not begin with that experience. Rather, it begins with selective attention that is influenced by a variety of aspects of long-term memory and cognitive processes.

Sutton (1980) argues that terms such as cognitive structure and concept map do not adequately represent the fluidity of thought in which changes in students' beliefs occur. Any useful conceptualization of how a learner's thought is organized must include some picture of its dynamics as well
The idea of fixed mental structure could even be dangerous if teachers become preoccupied in building up one 'expected' structure rather than encouraging flexibility." Sutton criticizes Ausubel for having undervalued this feature when he asserted (1963) that what matters in the learning of new material is the "stability", clarity and organization of the learners' existing knowledge. To Sutton, stability can be a hindrance, and having many different starting points makes knowledge more accessible. The fluent learner may succeed by bringing to the learning task not just one stable set of subsumers, but a range of possible ones.

Although the learning models cited here place central importance on the knowledge and experience that pupils bring with them to the classroom, and the active involvement of the learner in his or her own learning, they do not provide teachers with strategies which give them some appreciation of how to assess the likely knowledge structures that pupils will bring with them to the learning of specific topics, nor do they provide teachers with specific instructional strategies which take into account the students' beliefs, as well as their values.

Children's Prior Beliefs, Cultural Values, and Science Instruction

Researchers in science education have been hesitant to study the relationships between students' beliefs about science
concepts, and the students' social and cultural backgrounds. Instead they have been more interested in understanding the beliefs of students in "main stream" society. However, one study of particular interest involved the development of instructional materials for black high school students in South Africa, using their previously identified knowledge (conceptions and alternate conceptions) and incorporating principles for conceptual change. In this study Hewson and Hamlyn (1985) analyzed the external cultural factors influencing the students' conceptions of heat. The results showed a significant improvement in acquisition of scientific conceptions as a result of the instructional strategies and materials which explicitly dealt with students' alternate conceptions. The researchers conclude that if prior knowledge exists as a consequence of cultural and personal beliefs and theories, then different groups will likely have different prior knowledge and alternative conceptions which need to be discussed during instruction. While it is likely that inter-cultural differences exist, it is also likely that intra-cultural differences exist, and that students within the same cultural group hold a wide range of prior conceptions.

In considering the possible interactions between students' views and science instruction, researchers have generally addressed the notion of constructed meaning by analyzing children's cognitive beliefs and focusing their attention upon a narrow set of concepts. However, an important additional consideration which may determine whether or not a
given student accepts or understands a given concept is the set of values which the student brings to the instructional setting. Because students have experienced and thought about the world, they come to class with a complex cluster of ideas, beliefs, values, and emotions which they use to understand the world. When the accepted scientific view is presented in a classroom setting, this cluster of ideas, beliefs, values and emotions serves as the initial set of interpretive categories and it is the potential match between these existing cognitive commitments and the new information which determines how the student will respond to the instructional inputs.

What became apparent from reviewing the literature is that many factors operate to influence what pupils recognize as the significant outcomes from their involvement with a learning task. What makes science teaching difficult is the fact that any one factor may be sufficient to prevent pupils from learning the accepted science concepts. With a growing interest in this field of inquiry, researchers are developing an awareness of the complex issues involved in science teaching.

Summary

There is widespread support for the idea that students bring to the classroom views which they have constructed to explain their world. Researchers have been able to identify and describe such intuitive views for a wide range of natural
phenomena; they have also established that such views are difficult to change. Teachers and curriculum developers appear to assume that presenting evidence of the accepted view will result in the student embracing that view. Recent studies suggest that this assumption may not be valid.

There is a wide range of studies which focuses on the learners' beliefs about specific science concepts, and some recent studies which focus on how these beliefs interact with learners' experiences during instruction. However, studies of the relationships between the students' beliefs and values and how they interact during science instruction are few—and studies of students' beliefs about seashore ecology are non-existent.

Although the various intervention programs reported in this review of the literature derive from somewhat different research traditions, there is much commonality in terms of the strategies of instruction employed. These conclusions imply a somewhat different conception of science education than those which have traditionally or even recently prevailed: one which gives time and attention to the students' prior social and cultural knowledge. This conception requires consideration about the kinds of bridges which can and should be built between a learner's social and cultural background, and a classroom science task. There is a need for developing strategies of instruction which take into account the students' beliefs, as well as their values, and which allow for the possibility of different views of the world. One possible way
to illuminate the ways in which this interaction occurs is to look more carefully at the nature of metaphorical thinking in children.

Language, Metaphor, and Meaning

In reviewing the literature I looked for a method of data collection and analysis which was consistent with the metaphorical teaching strategies in Once Upon a Seashore. Within weeks, I found that most traditional views permit metaphor little, if any, role in understanding our world and ourselves. I discovered that I shared Lakoff and Johnson's (1980) position that metaphor is a matter of central concern, perhaps a key to giving an adequate account of understanding. I also discovered the pioneering work of Brenda Beck (1981, 1982, 1983) in developing a metaphor interview technique which could be used to identify cultural beliefs and values.

In this section I outline in some detail the theoretical and methodological issues raised by these researchers, and explore implications for my own study.

The Use of Metaphor to Give Meaning

Only recently have metaphors been viewed as a fundamental aspect of the human communication process that affects the ways in which we perceive, think, and act. In the book Metaphors We Live By, Lakoff and Johnson (1980)
claim that metaphor is pervasive in everyday life: "Our ordinary conceptual system in terms of which we both think and act, is fundamentally metaphorical in nature" (p. 3). As such, what we experience and do is very much a matter of metaphor. But our conceptual system is not something we are normally aware of. We simply think and act more or less automatically along certain lines. Just what these lines are is by no means obvious. One way to find out is by looking at language. "Since communication is based on the same conceptual system that we use in thinking and acting, language is an important source of evidence for what that system is like" (Lakoff & Johnson, 1980, p. 3).

On the basis of linguistic evidence, Lakoff and Johnson claim that our ordinary conceptual system is metaphorical in nature. For example, they show how the conceptual metaphor "Argument is war" is reflected in our everyday language:

Your claims are "indefensible."
He "attacked every weak point" in my argument.
His criticisms were "right on target".
I "demolished" his argument.
I've never "won" an argument with him.
You disagree? Okay, "shoot!"
If you use that "strategy," he'll "wipe you out."
He "shot" down all my arguments. (p. 4)

We don't just "talk" about arguments in terms of war, claim Lakoff and Johnson. We can actually win or lose arguments. We see the person we are arguing with as an opponent. We attack his positions and defend our own. This is what it means for a metaphorical concept, "Argument is war," to
structure (at least in part) what we do and how we understand what we are doing when we argue. "The essence of metaphor is understanding and experiencing one kind of thing in terms of another" (p. 5).

The very "systematicity" that allows us to comprehend one aspect of a concept in terms of another (e.g., comprehending an aspect of arguing in terms of a battle) will necessarily "hide" other aspects of the concept. In allowing us to focus on one aspect of a concept (e.g., the battling aspects of arguing), this metaphorical construction can keep us from focusing on other aspects of the concept that are inconsistent with that metaphor. For example, when we are preoccupied with the battle aspects of an argument, we often lose sight of the cooperative aspects. "So when we say that a concept is structured by metaphor, we mean that it is partially structured and that it can be extended in some ways but not others" (p. 13).

The fact that we have been led to hypothesize metaphors like "Argument is war," "Time is money," and "Love is a journey" suggests to Lakoff and Johnson that the focus of definition is at the level of "basic domains of experience" like argument, time, and love. These experiences are then conceptualized and defined in terms of other basic domains of experience like war, money, and journeys. Each such domain is a "structured whole" within our experience and represents a coherent organization of our experience in terms of dimensions which seem to be "natural kinds of experience."
They are natural in the following sense:

They are products of:

Our bodies (perceptual and motor apparatus, mental capacities, emotional makeup, etc.)

Our interactions with our physical environment (moving, manipulating objects, eating, etc.)

Our interaction with other people within our culture (in terms of social, political, economic, and religious institutions). (p. 117)

In other words, "The kind of conceptual system we have is a product of the kind of beings we are and the way we interact with our physical and cultural environments" (p. 119).

Lakoff and Johnson's concern with the way we understand our experience has led them to an "interactional" view of categorization. Because defining concepts (war, time, money) emerges from our interaction with one another and with the world, the concepts they metaphorically define (e.g., love) will be understood in terms of "interactional properties." The concept "love" as people actually understand it, is at least partly defined by interactional properties having to do with perception, motor activity, culture, etc. Rather than being rigidly defined, concepts arising from our experience are open-ended. Lakoff and Johnson cite Rosch (1977, 1978) as having established that we categorize things in terms of prototypes and by types of relations to prototypes. Lakoff and Johnson are convinced that for human beings, categorization is primarily a means of comprehending the world, and as such it must serve that purpose in a flexible way (p. 122).
Lakoff and Johnson turn to metaphors that are capable of giving us new understanding of our experience. "New metaphors have the power to create a new reality. . . If a new metaphor enters the conceptual system that we base our actions on, it will alter that conceptual system and the perceptions and actions that the system gives rise to" (p. 145). As an example, Lakoff and Johnson consider some cultural values in our society that are coherent with "up-down metaphors" and whose opposite would not be:

"More is better" is coherent with MORE IS UP and GOOD IS UP.
"Less is better" is not coherent with them.

"Bigger is better" is coherent with MORE IS UP and GOOD IS UP.
"Smaller is better" is not coherent with them.

"The future will be better" is coherent with THE FUTURE IS UP and GOOD IS UP. "The future will be worse" is not.

"There will be more in the future" is coherent with MORE IS UP and THE FUTURE IS UP.

"Your status should be higher in the future" is coherent with HIGH STATUS IS UP and THE FUTURE IS UP. (p. 122).

These are values deeply embedded in the dominant culture. "The future will be better" is a statement of the concept of progress. "There will be more in the future" refers to the accumulation of goods, wage inflation, higher careers, and higher status. So it seems that many of our values form a
coherent system with the metaphorical concepts we live by. Lakoff and Johnson are not claiming that all values will be coherent with a metaphorical system. There are often conflicts among these values and hence conflicts among the metaphors associated with them.

Not all cultures give the priorities we do to up-down metaphors. There are cultures where balance and centrality plays a much more important role than it does in ours. For us "Active is up" and "Passive is down" in most matters. But there are cultures where passivity is valued more than activity. Lakoff and Johnson cite the Westernization of cultures throughout the world as partly a matter of introducing the "Time is money" metaphor into those cultures. "Much of cultural change," they postulate, "arises from the introduction of new metaphorical concepts and the loss of old ones" (p. 145). But it is by no means an easy matter to change the metaphors we live by. Because each person's view of "time" and "money" may be different, the metaphor may be grossly inappropriate. "Hence, the same metaphor that gives new meaning to one person's experiences will not give new meaning to another" (p. 22).

In taking an experiential view of metaphor, Lakoff and Johnson insist that personal perception, feeling, and encounter form the real ground that supports understanding. They argue that metaphor is not a peripheral and merely stylistic feature, but a central feature of human thought.

The work of Lakoff and Johnson has implications for
classroom instruction and learning. It suggests that metaphor is an important source of evidence for identifying and analyzing the students' prior conceptions. Since metaphor is fundamental to the human communication process, language is an important source of evidence for analyzing what their conceptions are like.

Lakoff and Johnson suggest possible sources of the students' prior conceptions. The experiential bases of metaphor suggests that the students' conceptions are products of their life experience, that is, their bodies, mental capacities, emotional makeup, and the way they interact with the physical and cultural environments. It suggests that science educators need to attend to themes that extend further than previously explored.

I agree with Lakoff and Johnson in their view that language involves "whole systems" of concepts rather than "individual words" or "individual concepts." My concern for how children comprehend their own experience at the seashore suggests that the students' conceptions about the seashore emerge from their interaction with one another and with the world, and must be understood in terms of "interactional properties" such as sensory experiences, emotions, and culture.

The work of Lakoff and Johnson suggests criteria for creating instructional metaphors that increase the students' comprehension of specific science concepts. If they are right about metaphorical systematicity, it should be possible
to elaborate metaphors in various ways to "highlight" specific concepts associated with beach ecology (habitat, food chain, community, etc.). In addition, it should be possible to design instructional metaphors that would be consistent with the students' orientations towards the seashore (aesthetic, scientific, spiritual, utilitarian, etc.). I assumed that such metaphors would be capable of giving new meaning to the students' beliefs about the seashore, and to what they say and do during instruction. I also assumed that the same metaphor that would give new meaning to one student's experience, may not give new meaning to another's.

Though I agree with Lakoff and Johnson on the fundamentals, and though their extensive use of examples are useful, there are weaknesses. The most obvious and important issue that Lakoff and Johnson only partially address, is how to identify conflicts between cultural values and hence conflicts between the metaphors associated with them. The book is almost completely lacking in cross-cultural comparisons. Lakoff and Johnson do not provide the tools for researchers to find the different priorities given to these cultural values and metaphors by the individuals that use them. I found the metaphor interview technique described below to be helpful in this regard.
The Use of Metaphor to Uncover Meaning

For several years Beck has been exploring the use of metaphor as an indicator of cultural values. More recently, she developed a metaphor interview technique which could be used to identify conceptual frameworks of a culture. A topic is explored through the use of images and interviewees are asked to explain and extend these metaphor images. For example, in a set of interviews conducted by Beck (Beck, 1978), 75 people were asked what the terms "ethnicity" and "ancestral identity" meant to them. Each person was given a number of metaphor questions about 1) social relationships within the family, 2) interaction between friends, 3) attitudes at work and related matters, and 4) ethnicity. By drawing her sample from five ethnic groups, Beck hoped to identify cultural variations in frameworks of metaphorical thought between Indian, Japanese, and Hungarian emigrants resident in Canada, and to contrast all three of these with the metaphor frameworks of Canadians of European ancestry. The stimulus questions consisted of the following: "Do you think a person's ethnic or ancestral identity is most like . . . a) buttons of a coat, b) the sleeve of a coat, c) a tie matching a coat, d) the style of cut of a coat, e) the cloth of a coat?" The interviewees were asked to select the image that best described the nature of ethnicity to them. Each was then asked to expand on his or her choice and to explain how a relationship could be seen between the image of
their choice and the larger, more abstract concept under discussion.

There was a great diversity in the respondent's metaphor choices: "Ethnicity relates a person to their family, like a tie is related to a coat." "Ethnicity is harmonious to a person, like a tie should be with a coat." "An ancestral community is like a brand name, it marks one community off from another. Similarly, the style of a coat marks it off from others." By looking for patterns in the metaphor responses, Beck was able to gain insights into cultural differences in family values and dynamics, and community and national values.

Beck (1979) suggests how metaphors could be used in classroom situations as a way of helping students understand and deal with cultural differences. For example, family expectations in India and Canada could be explored in classroom discussions as a way of helping students understand and deal with differences. In particular, some of the specific metaphors suggested by respondents could be used as a teaching device to clarify the nature of such differences.

In a second study, Beck and Moore (1981) used a metaphor interview to focus on the dimensions of human relationships. Specifically, they were interested in ethnicity and work hierarchies, and turned to bank management and work relationships in branch bank offices. Beck and Moore designed metaphor questions based on Kluckholn and Strodtbeck's (1961) theory around three possible value
orientations to human relationships: lineal or hierarchical, collateral or horizontal, and individualistic or person-specific. They interviewed bank managers using questions that asked how one solved specific day-to-day problems. They then probed the popular images these bankers used in thinking about such situations by asking them to discuss their choices using a variety of metaphors. The respondents' answers clearly reinforced Beck and Moore's findings on other questions, that is: the Germans tended towards centralized power, the French towards dispersed power, and the Japanese towards personalized power.

In a third study, Beck and Moore (in press) went on to explore the style of the bank manager in Canada. Given the popularity of the sport team image of management in Canada, they expected and found that Kluckholm's "collateral" orientation dominated Canadian bankers' responses.

Overall, Beck and Moore gained considerable insight into how a variety of metaphors play a role in bankers' value orientations. They also found some variation in value orientations, depending on the nature of the incident described. Local office problems invoked more "collateral" responses, while changes in policy originating outside the branch often activated "lineal" or "hierarchical" responses.

The Beck interviews—designed to explore family-community relationships, parent-child relationships, or even bank teller and bank management relationships—suggested a way to identify and analyze
student-seashore relationships, student-instructional relationships, and student-science relationships in an instructional setting. Here was a research methodology consistent with the teaching strategies of a metaphor curriculum and, in addition, one which would allow an analysis of the students' reactions to instruction without separating the affective and cognitive components. Here was a research methodology which would allow an analysis of the students' values, and hence conflicts between the metaphors associated with them. However, Beck emphasized the orientations of people towards family relationships and banking, paying less attention to the implications of the orientations for specific beliefs and practices. I needed to understand how the students' orientations and beliefs were related. The problem then, was one of developing a set of metaphor interviews which would allow me to identify and analyze the relationships between the students' orientations towards the seashore and their beliefs about specific seashore relationships, the instructional input, and their beliefs after instruction.
Summary

Relying on the work of Lakoff and Johnson (1980), and Beck (1979, 1980, 1982, 1983), I suggest the following conclusions about metaphors and the students' beliefs and values:

1. Metaphors are a part of everyday reality that affects the ways in which students perceive, think, and act.

2. The meaning of a metaphor will be partly determined by physical experience, and partly determined by social and cultural experience.

3. The beliefs and values that students bring to instruction are not independent, but form coherent systems.

4. If a new metaphor enters the conceptual system that a student bases his or her actions on, it will alter that conceptual system and the perceptions and actions that the system gives rise to.

5. The same instructional metaphor that gives new meaning to one student's school experience, may or may not give new meaning to another.
Chapter 3

RESEARCH METHODS AND STRATEGY OF INSTRUCTION

An assumption of this research is that teachers can make more effective use of learning situations if they understand students' orientations. The research questions I asked were with reference to the nature of the beliefs and orientations of the students. What is the nature of their beliefs about seashore relationships? What types of orientations do they hold regarding the seashore, and how do these orientations influence their understanding of ecological relationships? How can teachers take into account the students' orientations and beliefs during science instruction? These questions were directed at the experience of the students, at their understanding of situations, and at the nature and variety of complex transactions which characterize the learning milieu of the classroom.

Chapter II described how metaphors are tools for constructing meaning. In this chapter, I describe a method for using metaphors as a tool for uncovering the meaning students give to their experiences at the seashore. I also describe how metaphors can be used in an instructional setting to give new meaning to the students' understanding of seashore life.

The chapter begins with a brief rationale for conducting a case study to address the research questions. Then I describe in detail the six research phases and the tasks
involved in each phase. The chapter closes with a discussion of the issues of validity and limitations as they relate to this particular study.

The Case Study

This case study focuses on the experiences of a specific group of students in one setting. The use of a case study allows a concern with the meanings of actions and events to the students. The situation is seen as the students see it; the meanings of objects and events are determined in terms of the students' meanings; and the organization of the students' orientations is understood as the students organize them. By taking the students' beliefs seriously, I did not eliminate an interest in behavior, objects, or emotions. I merely shifted the emphasis from these phenomena to their meaning. I observed behavior, but went beyond it to inquire about the meaning of the behavior. I saw the students interacting with the animals, objects, and events in the classroom and at the seashore, but went beyond those interactions to interpret the meanings the students assigned to their experiences. I observed and recorded emotions, but went beyond them to explore the meaning of joy, fear, anxiety, pain, and other feelings.

Because the classroom teacher attempted to take into account the students' orientations and beliefs during instruction, there had to be flexibility in adjusting the strategies of instruction to changes occurring in the setting.
itself and, more importantly, to changes in the constructs being used to frame and interpret the events occurring in the setting. Additionally, there had to be changes in some of the analytical procedures used.

I made use of the "cumulative" or "triangulated" attack (Smith, L. 1977; Smith, L.M., 1979; Wilson, 1979). As much as possible, I had to understand the total situation in order to interpret the students' metaphor responses. For instance, the analysis of data depended on an understanding of the respondent's physical, social and cultural experiences, the curriculum as presented, and so on. In this study, I used literal interviews, metaphor interviews, class observations, and interviews with individuals in the school and community to describe several aspects of the same phenomenon, make comparisons, and formulate new questions.

An important feature of the case study is that the data-gathering process is intimate and the product consequential for those involved (MacDonald & Walker, 1977). In this study, I provide accounts of six individual students and their experiences during science instruction, each with a different set of orientations and beliefs about the seashore. The descriptive aspect of the classroom observations and interviews with individuals in the community provide an account of the qualities of the instructional setting, and offer the reader an informed opinion as to the educational significance of the individual cases presented.
The Six Research Phases

The method of data collection and analysis evolved over a long period of time and involved six research phases. These phases are:

Phase I  The Pilot Studies and Selection of the Setting
Phase II Pre-instructional Interviews and Selection of Target Students
Phase III The Classroom Interaction Study
Phase IV Post-instructional Interviews and Community Inquiries
Phase V Long-term Post-instructional Interviews and Community Inquiries
Phase VI Analysis of the Data

Phase I  The Pilot Studies and Selection of the Setting

During Phase I (May 1980 to October 1981), I conducted a series of five small pilot studies to develop the metaphor interviews and to gather general information on students' orientations and beliefs. Then, from the data collected, I selected the setting for the cases under study.

The Five Pilot Studies

In the early stages of formulating the research
questions, I explored different means of analyzing the relationships between the students' prior knowledge of ecological relationships, and the concepts presented in *Once Upon a Seashore* (Snively, n.d.). In the spring of 1980 I began exploring the students' ideas and beliefs about the seashore by using semantic differential scales and interviews. I had no specific objective in mind, other than to explore different methodologies, and to speculate from the data obtained. For this first study, I attempted to elicit the students' ideas, beliefs and attitudes about the seashore, and about specific seashore organisms: crabs, starfish, snails, barnacles, seaweeds, seagulls, etc. The interviews contained two types of questions. The first question asked the students to rate "barnacles," for example, against a series of bi-polar adjectives; good/bad, big/little, important/not important, fast/slow, beautiful/ugly, boring/interesting, etc. The second question asked the respondent to explain "WHY?" The answer was intended to indicate the respondent's reasoning for rating animals in a particular way.

After interviewing the students, I looked for individual patterns of thinking in their responses. Although there was great diversity, certain patterns began to emerge. For example, some responses appeared to be grounded in the physical aspects of an experience at the seashore: "When they're underwater they move, but at low tide they don't move." Some responses expressed feelings and emotion, but gave little evidence of the students' thinking: "I just don't like them. I
don't know why." Some responses appeared to be grounded in the social or cultural aspects of an experience: "God made them. God made everything." Other responses expressed certain judgements or viewpoints: "They're pretty. I like all their colors." Or, "I don't like them, they're ugly. Just gray." Some responses expressed beliefs about ecological relationships: "They're fast when they fight other animals for food." These latter responses to the "Why?" question proved to be the most fruitful, because they provided clues to the students' thinking about ecology. By looking specifically for patterns in such responses, I identified certain broad types of preferred viewpoints. For example, some responses expressed a utilitarian viewpoint: "You can catch them and eat them," or "You can't eat them." Some responses expressed a spiritual viewpoint: "God made them." Some expressed an aesthetic viewpoint: "They're pretty." Still other responses expressed a health and safety viewpoint: "They're fast, the way they pinch, it hurts," or "They scare you." Although there was great variation within each type of viewpoint, it soon became evident that some students tended to stress the utilitarian aspects of an experience, while others tended to stress the spiritual, or aesthetic, or scientific, or health and safety aspects of an experience. These broad viewpoints were subsequently articulated as "orientations" towards the seashore.

Although I was able to revise and improve this first interview format by identifying those bi-polar adjectives which tended to generate responses more easily categorized into
orientations, the interviews continued to pose two major problems:

1. a large proportion of responses could not be identified with a given orientation, and
2. responses were monotonously repetitive, as in "You can eat it," "You can't eat it." Or "God made it." "God made everything."

Hence, the typology of orientations (scientific, aesthetic, spiritual, utilitarian, and health and safety) emerged early in the study, but it was apparent that a better interview technique would have to be developed which would more consistently generate responses identified with orientations.

It was also apparent that a more complete understanding of the sources and dynamics of the students' orientations towards the seashore would require an extensive data base.

Shortly after this first pilot study then, I decided to look for another interview method which would allow for an analysis of the students' orientations towards the seashore. In reviewing the literature, I discovered the Beck interviews and the work of Lakoff and Johnson on metaphorical systematicity. The problem was not one of extending or adapting some existing metaphor interview, but of developing a metaphor interview which could be used with elementary students. This meant developing my own set of metaphor interviews in which the analysis of the students' orientations was the central purpose.

The next series of interviews was designed to pilot
different formats for the metaphor interviews, to find an appropriate grade level for interviews, and to gather information on the students' orientations and beliefs. I interviewed individual students in grades 2, 3, 4, 5, and 6 in three different coastal communities in British Columbia.

In piloting the metaphor interviews, I soon learned that many of the metaphor constructions developed by Beck were far too difficult for grade 3 and 4 students, the students I had originally intended for this study. This difficulty was especially true for questions which represented contrasting domains, or double metaphors. With this in mind, four different metaphor formats were developed ranging from a simple format using a single metaphor construction ("The seashore is a painting"), to questions which represented contrasting domains, or double metaphor constructions ("I am to the seashore as: a driver is to a car, a passenger is to a car, a mechanic is to a car").

Finally, I conducted a fifth pilot study in Salmon Cove which provided a preliminary view of the students' orientations and beliefs in that community. By talking to various native elders and interviewing students in grades 3, 4, and 5, and by interviewing students in a grade 6 class other than the one I would eventually study, I was able to construct metaphor questions grounded in the physical and cultural backgrounds of both native and non-native students living in a small community in British Columbia.
Selection of the Case Setting

The main criterion used in the selection of the site was that the students should possess a wide range of beliefs and values towards the seashore. After investigating several locations and grade levels, I determined that the best setting consisted of a class of grade 6 students in a coastal town in British Columbia, which will be given the pseudonym "Salmon Cove." A native Indian community is located at one end of the cove and a community of largely European extraction is located at the opposite end of the cove. Commercial fishing is the main source of income for both groups. Salmon Cove has 1800 inhabitants.

Salmon Cove is situated on an island, and has a long history of human habitation. It was used as a winter dwelling place by the native people who realized the protection offered against winter gales by the peculiar shape of the cove.

The arrival of the Europeans and the realization of abundant fish stocks in the area brought about the establishment of fish salteries, and the church mission. Gradually Salmon Cove became the center of the whole area and schools, a hospital, cannery, shipyard, seaplane dock, hotels, and stores sprang up. The native Indian people practice many traditional customs and ceremonies and maintain a strong presence with their Indian Band Office, Museum of Anthropology, bighouse, and cemetery with some of the finest
totem poles on the coast.

Salmon Cove School is part of the provincial school district, with a primary school (n=80) and an intermediate-junior high school (n=130). Four native Indian cultural teachers offer Indian language and dance classes, and Indian art and fish-net mending are a regular part of the curriculum. An elementary native Indian band school (n=75) is located on the reserve.

Salmon Cove School was selected on the basis of three criteria: (1) the presence of both native Indian and non-Indian students, (2) the presence of students born and raised in a community surrounded by the seashore, and (3) the willingness of the school and the native Indian band to participate. It was expected that the presence of both native Indian and non-Indian students living in a coastal community would uncover a wide range of orientations towards the seashore and, also, would provide a rich mix of metaphor responses imbedded in sensory-based experiences on the one hand, and social and cultural experiences on the other. The grade 6 teacher was new to Salmon Cove, having moved from the prairie provinces, and was in his second year of teaching.
Phase II  The Pre-instructional Study

During Phase II (April 19 to May 4, 1982), I collected interview data on all the students in the grade 6 class in Salmon Cove. The purpose of the pre-instructional interviews was to collect data concerning the following questions:

- What is the nature of the students' orientations towards the seashore prior to instruction?
- What is the nature of the students' beliefs about specific seashore relationships prior to instruction?
- What is the relationship between the students' orientations and beliefs prior to instruction?

The Metaphor Interviews

In attempting to use metaphor interviews, I had to solve three problems: the interviews had to be designed to 1) explore the students' orientations towards the seashore, 2) explore the students' beliefs about specific seashore relationships, and 3) be appropriate to the language development of young children.

I followed Beck's basic interview techniques, but incorporated ideas from Lakoff and Johnson about "metaphorical systematicity" to construct the interview questions. Recall that the very systematicity which allowed the students to comprehend one aspect of a concept in terms of another will necessarily hide other aspects of the concept. In the "Seashore is a playground" metaphor, the students were encouraged to focus
on some aspects of a concept (the recreational aspects of the
seashore), and encouraged not to focus on other aspects of the
concept (the aesthetic, or utilitarian, or spiritual, etc.
aspects of the seashore). I designed interview questions which
would "highlight" and "hide" a range of orientations towards the
seashore: e.g., the image "painting" was selected to highlight
an aesthetic orientation, a "town" to highlight a scientific
orientation, a "church" to highlight a spiritual orientation, a
"playground" to highlight a recreational orientation, and a "pin
cushion" to highlight a health and safety orientation. For
example, the respondent was asked the following question:

If the seashore were one or more of the following,
which one or ones would it be:

factory church
painting playground
town pin cushion

WHY?

At every point the student was asked to explain "WHY?" he or
she had selected a particular metaphor over others. THE
QUESTION "WHY?" WAS ESSENTIAL, as this procedure generated the
most interesting and useful information. Although the actual
type of metaphor chosen was noted, and for some students did
yield some interesting patterns, the "WHY?" query was the key
to the technique's success since it indicated the respondent's
reasoning for choosing a particular metaphor.

During the interviews I asked the students to select the
best metaphors from amongst a range suggested. Since it is
difficult to keep several images in mind at once, the options provided were written on three-by-five-inch white cards. In some of the interviews involving seashore animals a pictorial black-and-white line-print was developed for the card. When possible, the native Indian word for the animal, object or event was printed inside parentheses beside the English word.

Since metaphors are often sophisticated, it could be argued that children would have great difficulty in using language metaphors when interviewed, especially children of different cultural backgrounds. In the present study, however, all the metaphors were formed from common nouns, and the imagery was not difficult for elementary students to grasp. Most of the imagery was taken from a range of familiar household or community objects: e.g., painting, bicycle, pin cushion, jewel, curtain, door, house. But also, I added a few "atypical" metaphors to probe for variations in metaphor style: e.g., spaceship, robot, submarine.

Also, it should be acknowledged that simple metaphors frequently become imbedded in sea lore and everyday conversation—"cranky as a crab," "crusty as a barnacle," "smells fishy," "clam-up," "ship-off." This kind of trite expression was avoided. Following Beck (1978), the interest in choosing metaphors for use in an interview was in stimulating the respondents to project "deep-set" concepts onto exterior forms in an imaginative way.

By talking to various students and native elders in Salmon Cove, and by exploring the community and noting its
special features, I was able to construct metaphor questions grounded in the physical and cultural backgrounds of students living in a small native Indian and non-native coastal community in British Columbia. For example, the metaphors "pot-luck dinner" and "potlatch" were seen to be better utilitarian metaphors than the metaphors "dinner" or "supper" or "feast." The metaphor "cannery" was seen to be a better utilitarian metaphor than "factory," since a fish cannery was an integral part of everyday life in Salmon Cove. The metaphors "totem pole" and "legend" were viewed as appropriate spiritual metaphors, and the metaphors "blackberry bush" and "pin cushion" were viewed as appropriate health and safety metaphors, and so on.

The metaphor formats contained four types of questions that depended on metaphorical thinking. The first set of questions asked each student to explore twelve different imaginary questions. For example:

If you were a bird, would you be a:

- raven
- seagull
- eagle

WHY?
Or

If you were a boat, would you be a:

sail boat
ferry boat
fishing boat

WHY?

This interview generated some of the most imaginative and useful material. The students found the metaphor questions in this interview the easiest to elaborate. They appeared to enjoy discussing their metaphor choices, possibly because of the single metaphor construction, and because the questions resembled the children's play at the seashore where in they "became" a bird, or a fish, or a boat.

The second set of questions asked students to explore what the term "seashore" meant to them. I asked each respondent to choose between a set of images I had listed for them on separate cards. These contained four sets of six metaphors, or twenty-four metaphors. As an example:

If the seashore were one or more of the following, which one or ones would it be:

cannery

totem pole

song
blackberry bush
gift

WHY?
The response was intended to indicate the student's reasoning for choosing a particular image for the seashore. The third type of question asked each respondent to explore fifteen different seashore animals, objects, events and conditions. For example:

If a clam were one or more of the following, which one or ones would it be:
- vacuum cleaner
- legend
- potlatch necklace
- dance

**WHY?**

The response was intended to indicate the student's reasoning towards selected animals, objects, events and conditions at the seashore.

The fourth set of questions asked each respondent to explore nine metaphoric dyads. Each dyad contained two types of questions that depended on metaphoric thinking. The metaphors were chosen to represent contrasting relationships: story teller is to a story, or character is to a story, or listener is to a story. The respondents were asked to decide which of the three pre-selected images was best suited to symbolize his or her own relationship to the seashore: For example:

I am to the seashore, as a
- story teller is to a story
- character is to a story
- listener is to a story

**WHY?**
In addition, the students were asked to indicate directionality. If the students' relationship to the seashore was like a story teller to a story, which element of the dyad would the respondent call the story teller and which the story, and "WHY?" Some students found the metaphor questions in this interview to be difficult to think with, possibly because of the double metaphor. Nonetheless, all of the students gave some explanation for their choices. (See Appendix A for the complete set of metaphor questions.)

Also, during the pilot study interviews, students were asked to generate their own metaphors for the seashore. One might think that imagery generated by the students would be more revealing than those generated by the researcher. But this advantage was counterbalanced by the difficulty most students had thinking up metaphors for themselves. Most students could not give a metaphor, or gave partial explanations which could not be categorized into orientations. Even after completing the interviews and with coaching, most students gave back metaphors that had already been used during the interviews. Because generating their own metaphors was judged to be stressful, I decided to ask the students in the Salmon Cove study to generate their own metaphors for the seashore only in the post-instructional interviews.

When interviewing students, I frequently tried to extend the students' thinking without leading them in a given direction. Most responses were relatively complete, and could
be coded in relation to basic orientations, as for example, in the following interview with Luke:

R. If the seashore were one or more of the following, which one or ones would it be: factory, battleground, town, painting, gift, totem pole? Why?
L. A gift.
R. O.K. Why would you say it would be a gift?
L. Because if there's no beaches, you would have no place to build fires for cooking fish. There would be no place for the children to play.
R. O.K.

But some students left the questions unanswered, or only partially completed. Where they did not elaborate the metaphor, it was sometimes impossible to code in relation to the respondent's more basic orientation, for example, in the following interview with Jimmy:

R. If a crab were one or more of the following, which one or ones would it be: garbage collector, mobile house, robot, pair of pliers, feast? Why?
J. It's a robot.
R. Why would it be a robot?
J. They walk like a robot.
R. Anything else?
J. No.
R. Can you tell me anything about how it walks?
J. No. That's all.

Where necessary, I urged the students to give a sharper response: "Tell me more," or "Can you think of any other reason why a crab might be like a robot?"

Sometimes it was useful to ask extending questions to urge the students to elaborate a response so that I could gain a fuller understanding of the physical or social or cultural aspects of an orientation. For example, in the following interview with Dan:

R. O.K. Which one of the following best describes your own
relationship to the seashore: listener to a story, animal to a story, story teller to a story? Why?

D. I guess I'd be the story teller. Like, if I did something at the beach or something related with it, I'd tell my brother and my mom what happened.

R. Have you done that before?

D. Yes.

R. Can you tell me what kind of thing might happen?

D. Like that eagle taking the cage and tipping it over when we were trying to catch some seagulls with a cage and some bait. I told my mom and dad all about that.

R. What were you trying to catch the seagulls for?

D. Just to look at them.

This more elaborated response contains a richer imagery about the family's support role, and provides important insights into the nature and dynamics of Dan's use of a scientific orientation by providing data on his incessant curiosity and his ability to observe, infer, question, and investigate on his own.

And finally, after selected interview sets, I asked each student to choose the metaphor response which best described how he or she viewed the seashore. It was hoped that by comparing the students' preferred responses (their first, second, and third choice responses), and by noting their own metaphors for the seashore, that a distinction could be made between the students' preferred orientations prior to instruction, and the effect of instruction on the students' preferred orientations after instruction.
Identifying The Students' Orientations

By looking for patterns in the students' responses during the pilot studies, I was able to identify five different orientations or dimensions in the students' answers. Some students stressed the utilitarian aspects of the seashore, its products and uses. Some students stressed the aesthetic aspects of the seashore, its beauty and harmony. Some students stressed the scientific aspects of the seashore, the interdependence of living things. Some students stressed the spiritual aspects of the seashore, how animals and events in nature help humans. Still others stressed the health and safety aspects, how animals and events in nature may be harmful to humans.

After looking for patterns in the students' responses in the Salmon Cove Study, I was able to identify an additional orientation to the seashore. Some students stressed the recreational aspects of the seashore, the sports, adventure, and enjoyment.

The six orientations listed in the chart next page were those identified to be most useful in thinking about the responses students gave to my questions about the seashore. The phrases beside each orientation are not complete descriptions, but illustrate some of the broader ideas associated with the orientation:
<table>
<thead>
<tr>
<th>Orientation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Utilitarian</strong></td>
<td>Humans are the benefactors, directors, producers, developers, controllers. They harness nature for their own practical and necessary use.</td>
</tr>
<tr>
<td><strong>Aesthetic</strong></td>
<td>Humans are the admirers, reflectors, imitators, lovers, protectors. Humans are aware of the beauty or ugliness in nature. Pertaining to, an artistic interpretation of nature: art, music, poetry, drama, dance, etc.</td>
</tr>
<tr>
<td><strong>Scientific</strong></td>
<td>Humans are the observers, identifiers, quantifiers, predictors, theoreticians, experimenter, controllers. Humans and nature are interconnected and dependent on one another for survival.</td>
</tr>
<tr>
<td><strong>Spiritual</strong></td>
<td>Humans are aware of the sacred, or moral, or spiritual, or supernatural aspects of nature. Humans are part of nature, but nature runs itself. Humans may help and protect nature, and the plants, animals, objects and events in nature may even help humans. Of, or pertaining to, an organized religion, or an ability to &quot;indwell&quot; or &quot;become&quot; part of another living, or non-living thing.</td>
</tr>
<tr>
<td><strong>Recreational</strong></td>
<td>Humans are aware of nature as a source of refreshment for their own body and mind; for exercise, relaxation, entertainment, exploration, enjoyment.</td>
</tr>
<tr>
<td><strong>Health and Safety</strong></td>
<td>Humans are the fearful, endangered, injured, or lost. Humans may have little or no control over nature, and nature may even control humans in a detrimental sense.</td>
</tr>
</tbody>
</table>

The following illustrates a typical student response within each of the six orientations:

**Utilitarian**
The seashore is a factory.
It's got crabs, fish for canning.

**Scientific**
The seashore is a town.
All the animals that live at the seashore. They all grow up there. The rocks being for the animals to hide under.
Aesthetic
The seashore is a painting.
It just looks like a painting an artist would paint.

Recreational
The seashore is a playground.
You don't have to work. Do what you want. Could be a lot of fun; looking for animals, crabs, finding shells. It's peaceful.

Spiritual
The seashore is a legend.
There's a legend about this man who became wild and he could do things that the animals could do...

Health and Safety
The seashore is a pin cushion.
There's the barnacles and the sea urchins that could poke you if you were to fall on them.

A certain consistency in the reasons of students could be seen to persist across their particular choices of metaphor. For example, "The seashore is a painting" metaphor frequently resulted in an aesthetic response. "The seashore is a factory" metaphor frequently resulted in a utilitarian response. "The seashore is a pin cushion" metaphor usually elicited a health and safety response. However, the students with a preferred aesthetic orientation, for example, tended to stress the aesthetic aspects of the seashore regardless of the type of metaphor image selected. For illustration, notice how three different students stressed different orientations for the metaphor, "The seashore is a gift":
<table>
<thead>
<tr>
<th>Scientific</th>
<th>Aesthetic</th>
<th>Recreational</th>
</tr>
</thead>
<tbody>
<tr>
<td>The seashore is a gift. Because of the many things that live there.</td>
<td>The seashore is a gift. We can enjoy the water. The way it looks pretty.</td>
<td>The seashore is a gift. Because children can play on it, swim in the water, and throw rocks.</td>
</tr>
</tbody>
</table>

Some students, more than others, responded to a particular metaphor with a complex concept of the seashore. For example, in a single response notice how one student stressed a range of orientations for the gift metaphor:

It was given to us to use. And we use it! We're supposed to use it properly. It's like a special gift that was given to us to use. The way fishermen use it for fish. People use it to learn about the animals. And for fun too.

Notice the obvious utilitarian aspects: "We use it... The way the fishermen use it for fish." There are recreational aspects as well: "And for fun too." Also, notice the scientific or intellectual aspects: "People use it to learn about the animals." Perhaps there is even a concern for conservation: "We're supposed to use it properly." And overall, there are subtle spiritual or moral aspects that may not be immediately obvious: "It was given to us to use. We're supposed to use it properly. It's like a special gift that was given to us to use." Hence, a student's response depends upon the complexity of thought the metaphor stimulates and upon other characteristics of the students.

One detailed categorization is included to give some idea of how I attempted to comprehend and adequately represent the students' orientations towards the seashore:
If the seashore were one or more of the following, which one, or ones, would it be:

- painting
- factory
- playground
- community
- pin cushion
- church

"WHY?"

The focus of thinking in the above metaphors, the "seashore," has very different kinds of experiential bases to a child growing up in a large urban center such as Vancouver, a child growing up in an isolated coastal community in British Columbia, and a child growing up on a white sandy beach in the South Pacific. Similarly, the word "playground" has very different kinds of experiential bases to a child whose only space for recreation is a city street, a child who has access to a large vacant lot or an adventure playground, and a child who frequents Disneyland. It is not that there are many different "playgrounds," rather, the concept of playground enters the child's experience in many different ways and so gives rise to many different metaphor responses.

The metaphor interview has a kind of ambiguity in the context of an experience. The student is asked to compare two terms: The term "seashore," of which something is being asserted, and the term "painting," used metaphorically to form the basis of the comparison. Words have a range of meanings; some may have new or original meanings while others may have familiar meanings. The force of the metaphor depends on the
respondent's uncertainty as he or she wavers between the two meanings. The student's response should be viewed as the meaning, either consciously or unconsciously, that the respondent gives to the metaphor. The student's emerging response depends on the complexity of thought the metaphor stimulates and upon multiple characteristics of the student's thought.

The students' interpretation of the term "playground" may be based on different kinds of experiences, as shown in the responses of two different students, Jimmy and Dan:

**Jimmy**

The seashore is a playground. All the kids play on the beach. You find crabs, make stuff, teeter totter, make masks from wood, make sticks to hold fish.

The seashore is a playground. I play at the beach a lot; catching animals, looking at them. I fly my kite.

**Dan**

Some of the experiential bases of Jimmy's metaphor response is obvious. For example, "All the kids play on the beach . . . teeter totter" is an obvious statement of the recreational aspects of the seashore. "You find crabs, make stuff, make sticks to hold fish" is an obvious statement of the utilitarian aspects of the seashore. While some of the experiential bases of Jimmy's metaphor responses is obvious, some of the experiential bases is not obvious. In my view, "making masks from wood" is an implicit statement about the spiritual aspects of the seashore that is grounded in cultural experience. Stronger corroborating evidence comes from other examples of
attaching spiritual significance to the seashore. For illustration, during my field study research, I collected the following data from the Salmon Cove native Indian teachers:

Jimmy is a full-status native Indian living with his very traditional native Indian grandparents. The grandfather dances a lot in the bighouse. Jimmy was a good dancer in the primary grades.

From the above data I can infer that Jimmy's reference to "making masks from wood" is most likely a statement about the spiritual aspects of dancing in the bighouse and attending potlatches. This datum suggests that some metaphor responses can only be categorized and adequately represented when additional information concerning the student's social and cultural background is taken into consideration.

There is another way the students' metaphor responses illustrate why it is important to categorize in terms of entire domains of experience. In my view, Jimmy's reference to "you find crabs" is very different from Dan's reference to "catching animals and looking at them." At first, the two statements appear similar in their experiential bases. However, important experiential differences become clearer when additional information is taken into consideration. For example, from the metaphor interviews Jimmy makes numerous references to "finding crabs", "catching fish", "checking his crab traps", "eating them" and "making a lot of money". By sharp contrast, Dan makes numerous references to "finding crabs", "catching animals", "looking at them", "learning about them", and "letting them go". Also, when asked to draw a picture of a crab at high tide and at
low tide, Jimmy was the only student to draw an edible crab (Dungeness crab), while Dan drew the common purple shore crab. In my view Jimmy's reference to "finding crabs" is most likely a statement about the utilitarian aspects of an experience, while Dan's reference to "catching animals and looking at them" is most likely a statement about the scientific aspects of an experience. This is important, because many times I found clues to a student's own understanding of a reference when I related it to similar references in the student's entire set of metaphor and literal responses.
Identifying the Students' Beliefs

In attempting to identify and analyze the students' beliefs about seashore relationships before and after instruction, I had to 1) clearly define the basic set of seashore relationships which were judged to be appropriate for this grade level, and 2) design questions to explore the students' specific beliefs about those seashore relationships.

Since the primary focus of instruction was to teach concepts of beach ecology, I used accepted science concepts related to beach ecology as a standard to compare and contrast the students' ideas and beliefs. I simplified these concepts to suit the level of elementary school students. (See Appendix B for definitions of the basic set of science concepts).

Within the metaphor interview formats, I designed questions to explore the students' beliefs about specific seashore relationships. For example, I used the metaphor "The seashore is a hotel" to highlight the concept of habitat, "A seagull is a robber" to highlight the concept of predator-prey, "A crab is a garbage collector" to highlight the concept of recycle, "The sun is a factory" to highlight the concept of energy, "The seashore is a town" to highlight the concept of community, and so on. (See Appendix A for the complete set of metaphor questions.)

The students' responses were categorized according to the types of beliefs represented. After looking for patterns in the students' responses, I was able to identify a number of
specific beliefs which students held about seashore relationships.

The beliefs listed below illustrate the responses students gave to my metaphor questions:

**Death**
The seashore is a graveyard. Some whales go up on the beach when their time is up. They go up on the beach and die.

**Habitat**
A cobblestone is a hotel. Under the rocks there's all sorts of little things: crabs, sand fleas, eels.

**Predator-prey**
A starfish is a can opener. It can open clams, mussels, and many other shellfish.

**Recycle**
A crab is a garbage collector. It picks up anything that's dead to eat, because it's a scavenger.

**Energy**
The sun is a factory. It seems like a factory because it's producing things, like helping plants grow.

**Community**
The seashore is a town. It's like the little animals are all together in a community. Like under a rock it's just like there are different animals: shore crabs, limpets, hermit crabs, eels, snails, all living together.

When attempting to comprehend and adequately represent the students' beliefs, I categorized their metaphor responses according to the criteria that best described the concepts mentioned previously. While some of the students' responses are explicit statements about specific concepts and are reasonably easy to categorize, other responses are implicit statements and are more difficult to categorize.

One belief, which was particularly interesting to observe, involved the concept of zonation. Like everything in nature, zones are not simple patterns. The arrangement of plants and animals on a vertical rock face exposed to the
surf-swept ocean are close together and zonation patterns appear as distinct, horizontal color bands; but on a protected rocky, cobblestone, or muddy shore with a gentle slope the zones spread out and overlap. Though zones do occur, they are difficult to observe because so many of the animals live in the cracks and crevices and below the sediments.

To understand how I categorized the students' beliefs about the concept of zonation, it is helpful to briefly observe the following metaphor responses which were obtained during one of the pilot study interviews:

The seashore is a totem pole. When you go down to Wilson's Beach, there's a cave, then land, then grass on top. There's black, brown, then green grass. The beach just looks like a totem pole.

The seashore is a patchwork quilt. All the rocks are different; they're different shapes, and some are smooth and some are not. Then there's seaweeds that are different colors. The beach looks like a beautiful quilt from a distance.

Although this student was not aware of the "scientific" concept of zonation, she had at least an awareness of color patterns in nature. Interestingly, similar responses were obtained from other students living near Wilson's Beach, but not from students in any of the other four pilot studies (or from other students in Salmon Cove prior to instruction). Of all the beaches within walking distance from schools where interviews were conducted, Wilson's Beach has the only vertical rocky cliff located near the exposed open coast. In other words, Wilson's Beach is the only type of beach where color patterns or zonation patterns can be easily recognized. Therefore, it is unlikely
that students living near the comparatively protected beaches of Salmon Cove would have had a concept of "zonation" without previous instruction.

By contrast, the concept of zonation was clearly developed in some students after instruction, as evidenced by the following post-instructional response:

The seashore is a totem pole. It's a totem pole because of the tide zones. A totem pole has different animal designs going up and down the pole; like a bear, then an eagle, and a man. That's like low tide, middle tide, high tide and spray zone.

But even after instruction, some responses were difficult to categorize:

The seashore is a blackberry bush. A blackberry bush can have lots of berries. The animals can be the berries and the leaves of the blackberry bush can be the kelp. The blackberries are in a bunch, and a school of fish are in a bunch too. Starfish, urchins, all the different animals are in bunches at the seashore.

The same kinds of coherence found in the "totem pole" metaphor also occur in the "blackberry bush" metaphor. The concept of zonation is more or less explicit, and the life experiences through which the concept is interpreted are very different. Zonation, then, enters the conceptual system of students in many different ways, and so gives rise to different metaphor preferences, and many different metaphor responses.
The Literal Interviews

To see how the literal interviews served to triangulate the concepts identified in the metaphor interviews, I use Luke's case as a focus, and briefly compare and contrast data from both the literal and the metaphor interviews.

To begin, the literal interviews consisted of two sets of questions:

1. Set (A): The Students' Awareness of Seashore Plants, Animals, Objects, Events and Conditions.

2. Set (B): The Students' Beliefs About Specific Seashore Relationships.

For the first literal interview, I asked Luke (as well as all of the students) to list all the seashore plants, animals, objects, etc., that came to mind. As Luke spoke, I wrote the names (e.g., clams, crabs, rocks) and the order listed (1st, 2nd, 3rd, etc.) onto white cards. I then asked Luke to sort the cards in some way. As he explained his reasons for constructing groups, I recorded his explanations and the order of the groups into my notebook. Following the interviews, I looked for patterns in the list of phenomena, and patterns in the "WHY" explanations. The order was recorded to identify preferred types of animals, objects, events; and preferred reasons for constructing groups from a particular orientation (scientific, spiritual, utilitarian, etc.).

For illustration, in the pre-instructional interviews, Luke listed the plants, animals, etc., presented in Table 1:
Table 1

Luke’s Awareness of Seashore Phenomena

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1. rocks</td>
<td>10. old bikes</td>
<td>19. seagulls</td>
</tr>
<tr>
<td>2. eels</td>
<td>11. machine parts</td>
<td>21. pigeons</td>
</tr>
<tr>
<td>3. crabs</td>
<td>12. little shells</td>
<td>22. clams</td>
</tr>
<tr>
<td>4. seaweed</td>
<td>13. starfish</td>
<td>23. salmon</td>
</tr>
<tr>
<td>5. kelp</td>
<td>14. Chinese hats (a)</td>
<td>24. halibut</td>
</tr>
<tr>
<td>6. fish</td>
<td>15. barnacles</td>
<td>25. herring</td>
</tr>
<tr>
<td>7. killer whale</td>
<td>16. Chinese slipper (b)</td>
<td>26. cod</td>
</tr>
<tr>
<td>8. logs</td>
<td>17. chitons</td>
<td></td>
</tr>
<tr>
<td>9. water</td>
<td>18. eagles</td>
<td></td>
</tr>
</tbody>
</table>

(a) limpet
(b) different species of limpet

Compared to the other students, Luke expressed an average awareness of the existence of seashore plants, animals, objects and events. The fact that his list included such items as "Chinese hats," "Chinese slippers," and "chitons" suggests that he is aware of some of the less conspicuous seashore animals.

When asked to sort the cards into groups, Luke constructed the groups identified in Table 2, and gave the explanations indicated:
Table 2

<table>
<thead>
<tr>
<th>Luke's Category System Prior to Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. rocks</td>
</tr>
<tr>
<td>- eels</td>
</tr>
<tr>
<td>- crabs</td>
</tr>
<tr>
<td>- seaweeds</td>
</tr>
<tr>
<td>- kelp</td>
</tr>
<tr>
<td>- Chinese hats</td>
</tr>
<tr>
<td>- barnacles</td>
</tr>
<tr>
<td>- Chinese slippers</td>
</tr>
<tr>
<td>clams</td>
</tr>
<tr>
<td>- all stick to rocks</td>
</tr>
<tr>
<td>- seaweed sticks to rocks</td>
</tr>
<tr>
<td>- kelp ties itself to rocks</td>
</tr>
<tr>
<td>- clams attach to rocks with sticky stuff</td>
</tr>
<tr>
<td>- chitons stick to rocks</td>
</tr>
<tr>
<td>- I turn the rocks over and</td>
</tr>
<tr>
<td>eels and crabs crawl out</td>
</tr>
<tr>
<td>2. killer whales</td>
</tr>
<tr>
<td>- fish</td>
</tr>
<tr>
<td>- cod</td>
</tr>
<tr>
<td>- halibut</td>
</tr>
<tr>
<td>- herring</td>
</tr>
<tr>
<td>- salmon</td>
</tr>
<tr>
<td>starfish</td>
</tr>
<tr>
<td>- all swim</td>
</tr>
<tr>
<td>- some eat the same thing</td>
</tr>
<tr>
<td>- all fish</td>
</tr>
<tr>
<td>- the starfish sort of walks too</td>
</tr>
<tr>
<td>3. logs</td>
</tr>
<tr>
<td>- water</td>
</tr>
<tr>
<td>- sometimes the logs have pools of water</td>
</tr>
<tr>
<td>4. parts of old machines</td>
</tr>
<tr>
<td>- little shells</td>
</tr>
<tr>
<td>- old bikes</td>
</tr>
<tr>
<td>- sometimes you see them</td>
</tr>
<tr>
<td>- on the beach</td>
</tr>
<tr>
<td>- not alive</td>
</tr>
<tr>
<td>5. eagles</td>
</tr>
<tr>
<td>- seagulls</td>
</tr>
<tr>
<td>- crows</td>
</tr>
<tr>
<td>pigeons</td>
</tr>
<tr>
<td>- sometimes eagles eat seagulls, crows and</td>
</tr>
<tr>
<td>pigeons</td>
</tr>
<tr>
<td>- sometimes seagulls fly at the eagles</td>
</tr>
<tr>
<td>- sometimes the pigeons fly after the crows</td>
</tr>
</tbody>
</table>

For this second set of interviews, I asked the students to draw pictures of six common seashore animals at high tide (or when covered with seawater) and at low tide (or when out of seawater), and to answer my questions about seashore relationships. For illustration, in the pre-instructional interviews, Luke drew the pictures of barnacles (Figure 1), and answered my questions:
R. What does a barnacle look like?
L. A little mountain.
R. Can you tell me anything else about what it looks like?
L. Little crowns. It looks like a crown. The barnacle is the orange thing.
R. What does the barnacle do at high tide when the tide comes in and covers it?
L. Brings in food.
R. How does it do that?
L. It has a little mouth that takes stuff in.
R. Have you seen it moving?
L. Yes.
R. Any idea what it takes in from the water?
L. No.
R. But you think it's eating?
L. Yes.
R. Does it eat when the tide goes out?
L. No.
R. Those little things that it eats with, what are they like?
L. I don't know.
R. What do those things that move do when the tide goes out?
L. It closes up. It closes up its mouth.
R. Does a barnacle move once it gets to a rock?
L. No.
R. Can you show me with your hand how that barnacle eats?
L. You can see it move, but you need a magnifying glass.
(moves hand by opening and closing fist in rapid movements).
R. Does anything eat a barnacle?
L. I don't know.
R. When the tide goes out, would any animals try to eat it?
L. Seagulls, crows.
R. Would they be very successful?
L. No.
R. Would anything try to eat it at high tide?
L. Eels.
R. Would they be very successful?
L. No.
R. Why?
L. They can't break the shell open.
R. So the shell does what?
L. Protects it.

From the literal interviews, Luke demonstrates that he has observed barnacles feeding by opening and closing his fist in rapid movements. In addition, he is aware of how barnacles protect themselves from predators ("a barnacle has a shell that protects it"), and that barnacles feed at high tide ("It brings in food"), and close up tight at low tide ("It closes up. It closes up its mouth.")

To see how data identified in the literal interviews confirmed data identified in the metaphor interviews, I briefly focus on the concepts predator-prey and recycle, and compare and contrast Luke's responses from both the metaphor and literal interviews.

From the metaphor interviews, Luke identified three predator-prey relationships:

A barnacle is a fisherman. It eats that stuff in the ocean. It's really, really small. You can't see it.

A clam is a vacuum cleaner. It opens its shell and pulls the food in real fast.

The seashore is a battleground. If the sharks attacked the killer whales, the dolphins will come and
save the killer whale.

Although Luke never mentions the term "plankton" he is clearly aware of plankton as a source of food for filter feeders, and describes a relationship between the killer whale and dolphins that actually exists.

From both the metaphor interviews and the literal interviews focusing on the six common seashore animals, Luke correctly identified eleven predator-prey relationships, and no incorrect predator-prey relationships:

Table 3

| Prey     | Predator
|----------|----------|
| barnacles| tiny stuff
| clams    | same stuff
| eels     | bullheads
| crows    | sea urchins
| seagulls | sea urchins

| Prey     | Predator
|----------|----------|
| eagle   | crab
| starfish| clams
| eagle   | starfish
| seagulls| starfish
| crows   | starfish

From the metaphor interviews, he identified animals that recycle the remains and wastes of other animals:

A seagull is a janitor. It eats fish guts when you throw guts on the beach. It cleans up the beach.

A seagull is a robber. It rips people's garbage apart.

In the literal interviews, a crab "eats parts of fish, dead fish, and fish guts." Although Luke never mentions terms like "scavenger" or "recycle" he shows at least an awareness of animals that eat the remains and wastes of other animals.

By comparing and contrasting data for all of the students in this way, I was able to identify their knowledge of
certain pre-determined concepts, as well as the relationships among concepts: predator-prey, recycle, habitat, tidal cycle desiccation, protection. Then, after observing that data identified from the literal interviews confirmed data identified from the metaphor interviews, I inferred the presence or absence of additional concepts identified only from the metaphor interviews: e.g., types of coastlines, types of seashores, energy from the sun, food chain, zonation, community, interdependence, pollution, conservation. It was judged to be too time consuming and too exhaustive for the students to check for the validity of all of the concepts identified from the metaphor interviews.

The Target Students

From the interview data collected, I selected six target students for in-depth study. It was anticipated that it would be impossible to closely monitor more than six or seven students during class time. The main criterion used in the selection of the target students was that students should represent a cross section of orientations towards the seashore. Additional criteria included the following; there should be equal numbers of boys and girls, there should be both native and non-native students, there should be students born and raised in Salmon Cove as well as newcomers, and students should maintain high attendance throughout.

For each orientation, I identified the student in the class who had the highest proportion of responses categorized by
that orientation. This led to the identification of five students: (Dan) the student with a preferred scientific orientation, (Jimmy) a preferred utilitarian orientation, (Mary) a preferred aesthetic orientation, and (Luke) a preferred spiritual orientation. In addition, I identified the student who had the greatest combination of responses, (Sharon) a student with no preferred orientation.

**Phase III The Classroom Interaction Study**

A major part of the study, the classroom interaction study, began May 6 and ended June 4, 1982. The data collected addressed the following question:

- What interactions occur between the students' orientations towards the seashore and their experiences during instruction?

This section describes the strategy of instruction which was used to increase the students' knowledge of beach ecology, and the method of collecting classroom observations.

**The Strategies of Instruction**

The primary purpose of instruction was to increase the students' knowledge of the basic ecological concepts of seashore relationships: types of coastlines, types of seashores, tidal cycle, habitat, desiccation, predator-prey, protection, recycle, energy, food chain, zonation, interdependence, community,
pollution, and conservation. A major strategy of instruction involved using the students' preferred orientations during instruction to increase their knowledge of specific science concepts. A second purpose of instruction was to enhance the students' ability to view the seashore from a range of orientations. In order to take into account the students' orientations, I had to revise *Once Upon a Seashore*. Many of the activities remained the same, but others were dropped and new ones were developed--some specifically designed to suit the students' preferred orientations.

The science activities and the specific concepts they were designed to teach are outlined in Chapter 5. In this section, I show how the strategy of instruction involved constructing metaphors from a range of scientific, aesthetic, utilitarian, spiritual, etc., metaphors that took into account the students' preferred orientations. To do this I elaborate on the use of the metaphor "The seashore is a community" to show how students might better understand the ecological concept of community and other related scientific concepts. Last, I show how non-verbal metaphors were used to teach ecological concepts.

**The Use of Verbal Metaphors to Create New Meaning.**

Relying heavily on the work of Lakoff and Johnson (1980), I am arguing that when used in an instructional setting, metaphors are capable of giving new meaning to the students' past, to their beliefs about the seashore, and to what they say and do. To see how it is possible for a metaphor to create new meaning,
I discuss the instructional metaphor "The seashore is a community."

For many adults "The seashore is a community" metaphor is particularly pleasing, perceptive, and appropriate, given our experiences, generation, and culture. The reason that the community metaphor makes our experiences of the seashore coherent is that it makes sense of them--"it provides coherent structure, highlighting some things and hiding others" (Lakoff and Johnson, 1980).

"The seashore is a community" metaphor reflects on our everyday language in different ways. These expressions arise from our past experiences, and our beliefs about what it means for something to be a community. Some of these expressions include metaphors and literal statements as well. Our personal views of "communities" give rise to at least the following implications for this metaphor:

The seashore is families, birth, and growth.
The seashore is houses.
The seashore is zones.
The seashore is graveyards.
The seashore is factories.
The seashore is balance and harmony
The seashore is cycles.
The seashore is living together.
The seashore is a system.

I will be more specific about what I believe Lakoff and Johnson
mean by metaphorical systematicity in "The seashore is a community" metaphor.

First, the metaphor highlights certain features while suppressing others. For example, the scientific (or ecological) side of the seashore is brought into the foreground through the notion of community. This requires the masking of certain aspects of the seashore that are viewed, for example, as leisure activities. In fact, the recreational aspects of the seashore are frequently viewed as not serving the seashore's interests as an ecological system. In "The seashore is a community" metaphor, the recreational aspects of the seashore are suppressed, since some forms of recreation may be "too costly" or "too destructive" or "too out-of-balance."

Second, the metaphor does not merely entail other aspects, like ecology, but it entails very specific aspects of these concepts. It is an ecological notion of a community that requires that specific balance of diversity, competition, interdependence, etc. And though the metaphor may suppress the recreational aspects of the seashore, it highlights other aspects—namely the sense of living together that lies behind our cultural notion of community and communality.

During instruction, "The seashore is a community" metaphor allowed the students to conceptualize a seashore community in terms of something they understood more readily, namely their own community of Salmon Cove. This large metaphor also included several smaller metaphors that allowed the students to study several concepts. Habitat could be explored through the
metaphors "A tidal pool is a town" and "A cobblestone is a hotel." Recycle could be explored through the metaphor "A seagull is a garbage collector." Energy could be explored through the metaphor "The sun is a factory", and so on.

Because the metaphors highlighted important seashore experiences and made them coherent while they masked other seashore experiences, the metaphors gave the seashore a new meaning. If those things entailed by such metaphors were for the students the most important aspects of their seashore experiences, then the metaphors gave new meaning to the students' concept of the seashore.

For many adults of our culture "The seashore is a community"; and because it is, the metaphor can act as a guide for future action in accordance with the metaphor. Therefore, if a new metaphorical concept enters a students' conceptual system, it may alter that conceptual system and the perceptions and actions that the system gives rise to.

An additional attempt at increasing the students' knowledge of beach ecology and their ability to view the seashore from various orientations involved constructing metaphors from a range of aesthetic, spiritual, or utilitarian images. For example, I thought that when discussing barnacles, the image of a fisherman would appeal to "utilitarian" students living in a small coastal fishing community. It would also help other students to view the seashore from a utilitarian orientation. In other words, the metaphor "A barnacle is a fisherman" was viewed loosely as a "utilitarian" metaphor
designed to teach the concept of predator-prey relationships. I thought that when discussing the tidal cycle, the image of a symphony orchestra would appeal to certain "aesthetic" students, and encourage other students to view the seashore from an aesthetic orientation. I devised scientific, aesthetic, spiritual, and utilitarian metaphors to teach specific science concepts. Discussion of the way these metaphors were used during instruction, and how the students responded to the type of instruction that occurred is included in Chapter 5. The complete set of instructional metaphors is included in Appendix C.

The Use of Non-verbal Metaphors to Create New Meaning.

Understanding and accepting a non-verbal metaphor (as well as a language metaphor) in a given situation involves the students fitting their understanding of the metaphor to their understanding of situations. When we recall the children playing at the seashore--their becoming a graceful seagull, a pulsing wave, a magnificent thunderbird--we become aware of how play fits their understanding of situations. Because the students can conceptualize situations in metaphorical terms, it is possible for stories and play containing metaphors to give new meaning to the seashore.

Therefore, to increase the students' knowledge of the organism-tidal cycle relationship, the teacher and I planned a series of dramatizations at the seashore. To develop an understanding of the concept of desiccation, the students
dramatized the situation of seashore organisms at low tide and at high tide. To "become" the hot sun burning bright they formed a circle, stretched as tall as they could, and created the "blood red rays of the sun beating down upon the land and the sea." To dramatize the situation of seashore organisms at high tide, they "became" barnacles with long feathery legs sweeping the water for microscopic plankton, or sea anemones with stinging tentacles paralyzing tiny crabs or shrimp, or starfish prying open clams and mussels and eating the soft parts inside. To dramatize the situation of seashore organisms at low tide, they "became" stony gray barnacles—pulling their long feathery legs inside and closing the six hard shellplates up tight and creating a moist shellhouse inside, or seagulls picking and probing among the rocks looking for edible items to eat, or shore crabs—scurrying under rocks or into dark crevices or under moist seaweeds.

Thus, the teacher and I worked with the students to construct a coherent story of the tidal cycle, a narrative highlighting certain parts and ignoring or hiding others. The play involved seeing the tidal cycle in terms of relationships or connections among the parts. In general, the story-line imposed a coherent structure. It is the coherence they see in the story that gives it meaning and significance.

In sum, during instruction the teacher introduced "The seashore is a community" metaphor as a new model for his class. Even to address the metaphor requires the students to look at the seashore in a different way and to consider new
possibilities. The teacher introduced a whole set of instructional metaphors (both language metaphors and non-verbal metaphors) that are capable of further defining the students' beliefs about specific science concepts, in certain cases, of changing them and in encouraging the students to view the seashore from a variety of orientations.

Last, it must be acknowledged that in this study, the metaphorical strategy of instruction was rather heavy handed. Because the strategy was to take into account the students' preferred orientations, there had to be a close relationship between the teacher and myself. Each day after school the teacher and I met to discuss the events of the day and plan specific lessons. We developed metaphorical teaching strategies based on patterns in the students' preferred orientations and their behavior during instruction. As a result of this procedure the relationship between the teacher and myself ranged from one of cooperative lesson planning to detailed prior structuring of the teacher's presentations on my part. For the purpose of the present investigation this relationship between the teacher and myself was necessary, since the teaching strategy was to use socially and culturally sensitive metaphors to enter into the students' own thinking in order to teach specific science concepts.
Classroom Observations

I collected classroom data by observing and talking to large groups and individual students. I collected large group data when the teacher was applying instructional metaphors, providing information, or interacting with the class as a whole, both during instruction in the classroom and during field trips to the seashore. I observed all students and the nature of the teacher's responses to the students. For example, the teacher might encourage discussion by using the students' personal metaphors as a focus of exploration, or the teacher might introduce a concept by introducing a new instructional metaphor. These observations included details such as verbatim teacher-pupil talk, a record of names of students who were speaking, and the actions of the students.

I collected individual student data when students were working in small groups or on their own. I rotated among the target students recording verbatim their talk—paying attention to the metaphors they generated, the questions they asked, the particular task, and results obtained. From time to time individual target students were questioned to ensure I understood the manner in which the student was interpreting his or her experience. For example, when a student called a sea anemone a "blood sucker," or a barnacle a "snake," or said a crab was "behaving like a child," I later questioned the student in an attempt to understand the student's own meaning for the metaphor. Also, I made copies of the target students' daily
assignments—science project reports, descriptive paragraphs of seashore animals, creative writing stories, legends, etc.

**Phase IV Post-instructional Interviews and Community Inquiries**

Upon completion of the unit, from June 7 to June 25, 1982, all of the students were re-interviewed, using both the metaphor interviews and the literal interviews. The purpose of the post-instructional interviews was to collect data concerning the following questions:

- What is the nature of the students' orientations towards the seashore after instruction?

- What is the nature of the students' beliefs about specific seashore relationships after instruction?

- What is the relationship between the students' orientations and beliefs after instruction?

A second aspect of Phase IV involved the collection of interview data from selected individuals in the school and community regarding the target students' personal backgrounds: the school principal, the grade 6 teacher, the primary teachers, the four native language teachers, elders, and the home school coordinator. The purpose of this part of the study was to collect data concerning the following question:

- What is the relationship between the students' orientations and their social and/or cultural backgrounds?
Phase V Long-term Post-instructional Interviews and Community Inquiries

Seven months after completion of the teaching unit, in November of 1982, I returned to conduct the long-term interviews. Only the six target students were interviewed using a short form of the metaphor interviews. The literal interviews were not used. The purpose of the long-term interviews was to collect data on the following questions:

- How stable are changes that have taken place in the students' use of orientations?
- How stable are changes in the students' beliefs about specific seashore relationships?

I collected additional interview data from individuals in the school and community concerning the extent to which the students' personal backgrounds supported the analysis of the metaphor interviews—in other words, the students' orientations towards the seashore.

Phase VI Analysis of the Data

For all of the students, responses on the pre-instructional interviews and the post-instructional interviews were compared, looking for evidence of change. For the target students, responses on the pre-instructional interviews, the post-instructional interviews, and the long-term interviews were compared, looking for evidence of change or
stability over time. When comparing beginning responses with post-instructional responses and final responses, all data collected on each individual target student were considered. In sum, I attempted to make available fully documented accounts of individual cases.

Validity

This study took six complementary approaches to addressing the question of validity. First, the process of triangulation by multiple methods provided a consistent check on validity during data collection and analysis. I interviewed the students using forced-choice metaphor interviews, asked questions which probed how they answered specific questions, and asked them to discuss their particular choices. I interviewed the students using open-ended literal interviews which asked them to discuss their knowledge of specific seashore relationships. These pre-instructional interviews served to identify and analyze the prior conceptual knowledge of the students. Thus, I checked to see that data gathered in the literal interviews confirmed data gathered in the metaphor interviews. The same two sets of interviews were used after instruction to identify and analyze the effect of the instructional strategies. I collected data by means of participant observation during classroom instruction to understand individual patterns of metaphorical thinking. I interviewed individuals in the school and community to further
confirm patterns of metaphorical thinking and to speculate from the data recorded. By triangulating the data in this way, I was better able to ensure a valid interpretation of the students' orientations and beliefs, their experiences during instruction, and their previous social and cultural experiences. In addition, the same set of metaphor interviews was given six months after instruction to compare and contrast the stability of the students' orientations and beliefs over time. All of the above provide a rich data base for providing checks for coherence in the students' responses to a variety of experiential settings.

Second, I attempted to strike a balance between understanding the meanings the participants gave to their experience, and the temptation to fit their responses into the conceptual constructs which were generated during the pilot studies. On the one hand I was careful not to have my own interpretations prematurely over-structured by theory or previous research. In other words, I attempted to uncover the students' interpretive frameworks and provide descriptions in terms of the meaning which they appeared to be assigning to the various situations involved in this study. On the other hand, I did not disregard previous research work. I used previous research and theory to provide the initial focus of information gathering. As such, the development of the construct of an orientation was not haphazard. I constantly tested my emerging hypotheses against the reality I was observing. For example, during the pilot studies I identified five orientations towards
the seashore (scientific, utilitarian, aesthetic, spiritual, and health and safety). Then, when looking for patterns in the Salmon Cove data, I identified a recreational orientation as an additional dimension to the set of orientations identified earlier. I had to be open to adjusting my interpretation of the data and took this into consideration in the analysis of the data. I accepted the uniqueness of the students the complexity of the classroom setting.

Third, to ensure that I understood the meanings that the students gave to their experiences, I interpreted the data in terms of the situation where it was gathered. In order to understand hidden or unexpressed meanings, I attempted to "systematically empathize with the participants to comprehend the subtleties of their actions, thoughts and feelings" (Wilson, 1977). For example, by observing seashore organisms with microscopes, I was better able to see and understand what the students were experiencing. By having previous experience in marine studies and knowledge of local beaches, I was better able to interpret "on the spot" situations and probe for more information. For example, without having observed zonation patterns on different types of beaches, I simply would not have known to probe for more information in the pilot study interviews, and consequently would not have recognized the subtleties of the student's ideas and beliefs about zonation or the ability of the metaphor interview to project the students' ideas onto exterior forms in an imaginative way.

Fourth, I tried to view the data from differing
perspectives. Besides systematically taking the perspective of the subjects, I also viewed actions from the perspective of the "outsider" (Wilson, 1977). On the one hand, I was an "outsider" to Salmon Cove, being from a large metropolitan center such as Vancouver and coming into a small isolated coastal community such as Salmon Cove, and also because many of the students were of a very different ethnic background. On the other hand, I was an "insider" in the sense that I was an educator with previous experience teaching elementary students, and because I was a marine educator with knowledge and experience of local marine environments. These "tensions in point of view" between "outsider" and "insider" and "between insider roles" helped me to monitor my own reactions and provided an additional check on validity during data collection and analysis.

Fifth, there was a search for consistency between the perspective that underlies this study and the application of that perspective. That is, there was a consistency between the basic assumption that teachers can make more effective use of learning situations if they arrive at knowledge and understanding of the students' orientations, and the application of that perspective by taking into account the students' orientations during the instructional phase of the study. In addition, there was a consistency between the assumption that metaphors have educational potential and the application of aesthetic metaphors, for example, to increase the students' understanding of specific science concepts. To the extent that the results of the study showed an increase in comprehension of
the science concepts of interest the validity of the construct of an orientation is heightened by its apparent usefulness in an instructional setting.

Sixth, validity comes from the extent to which the data make sense to others in the situation where it was gathered. In writing up the report I provided accounts of the instructional experiences of individual students, each with a different set of orientations and beliefs. As a validation exercise, I asked the school principal and cultural language teachers to read these reports carefully looking for possible errors in the accuracy of the details reported and I asked them to comment on the interpretation given to the data. I also returned to Salmon Cove School and presented the findings to the teachers and elders in the community. While there were some minor comments and suggestions all of these "knowledgeable insiders" felt that the reports were consistent with their perceptions of the personalities and the cultural influences for each of the students.

All of the above data provide support for the claim of validity in this study.

Limitations of the Study

There are inherent limitations in all empirical studies. In this particular study, observer bias is likely the most serious potential problem. Participant observation and interview techniques all share a high potential for observer
bias (Borg and Gall, 1979). As such, it should be understood that the primary focus of this study was to generate a better understanding of the sources and dynamics of students' conceptual structures towards the seashore, and to provide some empirical documentation of how the students' beliefs and values have an impact upon the ways in which they respond to and interpret instruction in science. In this particular endeavor, I had no vested interest in the results of the study. Additionally, I had extensive professional experience training teachers in the techniques of classroom observation, interviewing, and clinical supervision. I was aware of the potential for observer bias. Efforts were made to carefully cross-check the major analytical claims that were made on the basis of the observational data.

The second limitation was due to time constraints in the case under study. To study the relationships between the students' orientations towards the seashore, their beliefs about specific seashore relationships, and their experiences during instruction represents an enormous task. An exhaustive case study, even for a limited number of students, could take years of intensive research. Therefore, I had to limit the scope of the case by selecting an in-depth analysis of a few questions while still attempting to gain a surface understanding of related questions. For example, I attempted to gain a detailed analysis of the relationships between the students' orientations and beliefs, while still attempting to gain a surface understanding of the relationships between the students'
orientations and their social and cultural backgrounds. I was an "outsider" coming in and talking to and observing "insiders"; many of the students have lived their entire lives in a small isolated coastal community, and many were of a very different ethnic background. As an "outsider", I did not have the time or opportunity to systematically cultivate and monitor a role that facilitates collection of all kinds and levels of information. Clearly, there were instances when students, especially those with a traditional native Indian perspective were hesitant to share their thinking. When I was aware of such situations, I painstakingly noted such occurrences in the write up and took these into consideration when interpreting the data. I took steps to be sensitive to the way I entered the setting and established a role that facilitated collection of information. Nonetheless, the study was limited to the extent that I was able to adequately collect data and accurately interpret the findings.

The third limitation was due to the vulnerability of the individuals in the Salmon Cove study, and the uses to which research findings are put. Salmon Cove has been the subject of many anthropological and sociological studies. Many individuals in Salmon Cove resent any form of research by outsiders. That knowledge placed an ethical responsibility on me regarding the publication of the thesis. I had to consider the students and their families and the potential uses of the data. Additionally, I had to be careful not to alienate individuals with whom I was not familiar. In this regard, the school
principal and the cultural language teachers advised that I not interview the students' parents. Because of these facts, I made efforts to cultivate selected informants in the school and community. The school principal was native Indian as were the cultural language teachers, and all were aunts and uncles of most of the native students in the class.

Last, the study was limited to the extent that the students may have viewed one orientation to be more correct or more rewarding than the others. Given an instructional setting, it seems likely that some students may have responded to the post-instructional metaphor interviews with a higher scientific orientation than they might have in another context. In attempting to decrease such bias I stressed that in responding to the metaphor questions there were no "right" or "wrong" answers. In addition, the metaphor interviews appeared to be less open to this kind of bias than the literal interviews. For illustration, on two occasions I overheard students querying other students who had completed the literal interviews; e.g., how to draw a picture of a barnacle, what does a barnacle eat? By sharp contrast, I also overheard conversations where students attempted to gain information from students who had completed the metaphor interviews. Imagine attempting to give the "right answers" when asked if the seashore was a factory, or a community or a pin cushion. Or better yet, to give the "right answer" when asked if their own relationship to the seashore was like a passenger to a car, or a driver to a car, or a mechanic to a car.
In a further attempt to reduce bias, I attempted to support each of the orientations during the instructional activities; that is, I participated in the "aesthetic activities" by painting seascapes, I took part in the "utilitarian activities" by cooking a seafood dish and attending the seafood dinner, I took part in the "spiritual activities" by attending a potlatch and supporting the work of the native Indian cultural teachers, I took part in the "recreational activities" by participating in beach walks, picnics, mudfights, and so on. Nonetheless, the study was limited to the extent that the students may well have perceived a scientific viewpoint to be the most appropriate given a school-based setting.
Chapter 4

THE RELATIONSHIP BETWEEN THE STUDENTS' ORIENTATIONS
AND BELIEFS PRIOR TO INSTRUCTION

This chapter describes the organization of each student's orientations and beliefs prior to instruction. I begin by describing the students' orientations to the seashore, as determined from the pre-instructional metaphor interviews. Second, I describe how the students' orientations are related to their interactions with the physical and cultural environment they live in. Third, I describe each student's specific beliefs about seashore relationships, as determined from the pre-instructional metaphor interviews and the pre-instructional literal interviews. In so doing, I show that some of the students' beliefs are consistent with accepted science ideas, and that some of the students' beliefs are quite different. And fourth, I show that there is a relationship between the students' orientations towards the seashore and their beliefs about specific seashore relationships. I also show that there is an internal coherence for all of the students between their set of orientations towards the seashore and their specific beliefs about seashore relationships; and an external coherence between their orientations and beliefs, and the type of physical, social and cultural environment in which they live.
The Students' Orientations Towards the Seashore
Prior to Instruction

The metaphor interviews enabled me to identify the different orientations of the students: utilitarian, aesthetic, spiritual, recreational, scientific, and health and safety. While all of the students exhibited several orientations when describing the seashore, some students used one orientation predominantly, and some showed a greater mix of orientations. Although some combinations of orientations would appear to be more probable than others, the data suggest that any combination of orientations is possible.

Six target students were identified in Chapter 3. One had a preferred scientific orientation (Dan). Others had a preferred utilitarian orientation (Jimmy), a preferred aesthetic orientation (Mary), a preferred spiritual orientation (Luke), a preferred recreational orientation (Anna), and the student with no preferred orientation (Sharon).

To begin, I explore some of the orientations and the metaphor responses of individual target students. For the sake of brevity, I describe the students' preferred orientations only. At a later point I describe the entire set of orientations for selected students.

Dan

Dan's pre-instructional interviews pointed towards a
preferred scientific orientation, as evidenced by the great proportion of responses reflecting an understanding of beach ecology. For example, he demonstrated an awareness of birth, growth, and death:

The seashore is a factory. Many things are born on the seashore: crabs, fish, barnacles. Seaweeds grow.

The seashore is a graveyard. The salmon come and die ... The animals that get eaten.

Dan correctly identified numerous predator-prey relationships. For example:

A barnacle is a fisherman. It comes out and collects plankton from the water.

A starfish is a can opener. It can open clams, mussels, and many other shellfish.

A seagull is a robber. It steals food: baby birds and other things, little crows and peregrine babies.

Dan observed that certain animals recycle dead and dying animals:

A seagull is a janitor. It cleans up the beach, all the bits of food.

A crab is a garbage collector. Because it's a scavenger. It eats up all the left-overs.

Dan identified at least three different habitats—under rocks, in tidal pools, in mud:

A cobblestone is a hotel. It acts like a house for crabs, eels, bullheads and snails, as well as many other animals.

A tidal pool is a town. Because of all the crabs, bullheads, and eels, barnacles and seaweeds that live there.

Mud is a pillow. The ducks and geese that wade in
the mud and look for food.

Dan was one of the few students to express an awareness of the sun as a source of energy:

*The sun is a factory. It makes all living things grow.*

Several of his metaphor responses stressed a concern for the care and preservation of living things:

*The seashore is a blackberry bush. When I pick blackberries I pick them from on and under the bushes and put them in buckets. On the seashore, I pick up animals and put them in buckets. Usually I just look at them. Then, after a while I let them go again.*

Compared to the other students, Dan expressed the greatest awareness of seashore relationships and, in addition, expressed an understanding of the seashore which was generally consistent with accepted science ideas.

**Jimmy**

The results of Jimmy's pre-instructional metaphor interviews pointed towards a preferred utilitarian orientation to the seashore.

Jimmy's utilitarian orientation was almost wholly associated with commercial fishing:

*I am the driver and the seashore is the car. I drive a seine boat and go fishing.*

*I would be a high tide. I would go check my fish net up the river for steelhead or sockeye or dogfish. I go up once a week and check my crab traps too.*

When asked which animal, object or event Jimmy would most like
to be, Jimmy said:

A crab. You could eat them. Boil them and eat them.

And he said:

A clam is a potlatch. When they have a potlatch feast, they make clam soup.

The seashore is a factory. It's got lots of animals.
You can sell them to people for meat.

It is interesting to notice how Jimmy's affinity with commercial fishing was so strong that he consistently turned even aesthetic images into utilitarian ones:

I would be a bead to a necklace. You put beads on a necklace. You put the nets and the skiff on the ropes and tie them to the seine. You tow the skiff on the back of the seine.

I would be a cloth to a curtain... You could put curtains on the windows of the seiners and the gill netters.

In all these metaphor responses attention is paid to fishing, crabbing, clamming, eating, and to selling fish and making money.

Mary

The results of Mary's pre-instructional metaphor interviews pointed towards a preferred aesthetic orientation to the seashore. Several metaphor responses expressed an awareness of the beauty in nature:

The seashore looks like a painting an artist would paint.

A cobblestone is a totem pole. It has different shapes and different colors. The way it looks is
I would be the curtain. The seashore would be the lace. It decorates. The beach decorates Salmon Cove up.

Several of Mary's metaphor responses made connections to music and dance:

The tide is music. It sways. I like the way it sways. It looks like it dances.

I would be a killer whale. . . I like the coordinated movement and all their colors.

A seagull is a dance. The way it moves. It makes all that noise like music you dance too.

Interestingly, connections were made between Mary's own physical beauty, social relationships, and seashore relationships:

I would be a sunny day. Everybody would like me. I would be big and bright.

I would be an eagle. I could fly good, soar around my living room, be really smooth and look nice.

I would be a polished beach pebble. It's shiny, not too big and beautiful.

Luke

The results of Luke's pre-instructional metaphor interviews pointed to a preferred spiritual orientation towards the seashore, with numerous references reflecting the spiritual beliefs of the traditional native Indian people of Salmon Cove:

I would be a listener to a story. I would listen to what happened a long, long time ago about the Killer Whale, the Thunderbird, the Raven. My uncle would be the story teller.

The seashore is a legend. There's a legend about this man who became wild and he went down to the
beach every day and he ate mussels, clams and abalone. One day one of his brothers went down to the beach. He saw his brother and went to tell his parents. They couldn't catch him. But he was wild and he lived in a tree stump. He was wild and he could do things that the animals could do.

I would be a raven. If I were Gwa'wina I could soar and catch killer whales. Only ravens and thunderbirds can catch the killer whale. Raven played tricks on its cousins and brothers.

When asked what animal, object, or event at the seashore he would most like to be, Luke replied:

The Thunderbird. The Thunderbird can make thunder and lightning from its eyes. The Thunderbird is the ruler of the sky.

Luke's responses reflect the traditional stories of his people: stories about "The Wild Man in the Wood" who "could do things that the animals could do," and "Thunderbird" the "ruler of the sky," and "Raven" who "played tricks on its cousins and brothers." These spiritual stories portray an awareness of all animals as fellow creatures. Humans are not separated from nature, but are connected with it.

Anna

The results of Anna's pre-instructional metaphor interviews pointed towards a preferred recreational orientation to the seashore:

The seashore is a playground. To me it's like playing. It's like a big playground with little pools and sand. We can play in sand, in big pools and on the nice smooth logs. . .

I would be a sunny day. People like the sun. It's nice. You could go swimming, sailing, and surfing. You can get a sun tan.
I would be a uniform and the seashore would be a hockey team. A person who plays hockey games has a uniform and feels real close together. Like the hockey team, I feel real close to the sea. Seems like ever since I was old enough to go to the beach I've been there off and on: having fun, making sandcastles, playing on the beach, digging clams, playing frisby. We play tag down at the shallow end.

I would be the flower. The seashore would be the blackberry bush. . . . Like as the flowers turn into fruit, I turn into the older generation, and I'm still going to the seashore when I die. Like the berries that are eaten, I pass away. Like, I'm thinking how I love the beach. It's my favorite place to play.

In all these metaphor responses, notice the attention paid to swimming, sailing, suntanning, surfing, and having picnics at the seashore.

Further evidence of the students' propensity to view the seashore from preferred orientations comes from their preferred metaphor choices. Dan chose "playground" as his first metaphor and gave a scientific and recreational response, "town" was his second metaphor and he gave a scientific response, and "killer whale" was the animal he would most like to be and he gave a scientific response. By comparison, Jimmy chose "farm" as his first metaphor and gave a utilitarian response, "playground" as his second metaphor and gave a utilitarian and recreational response, and "edible crab" as the animal he would most like to be and he gave a scientific response. By comparison, Luke chose "battleground" as his first metaphor and gave a spiritual and scientific response, "legend" as his second metaphor and gave a spiritual response,
and "Thunderbird" as the animal he would most like to be and gave a spiritual response. Mary chose "playground" as her first metaphor and gave an aesthetic and recreational response, "family" as her second metaphor and gave an aesthetic response, and "starfish" as the animal she would most like to be and gave an aesthetic response. Anna's first, second, and third-choice metaphors involved recreational and aesthetic responses.

Sets of Orientations

In studying the patterns of the students' orientations, it is important to understand how all of the students relied on several orientations to describe the seashore. Where there were several orientations, there tended to be two or more orientations represented in each metaphor. These are exemplified in Dan's, Luke's, and Sharon's sets of orientations.

Dan

In addition to a preferred scientific orientation to the seashore, Dan exhibited a spiritual orientation. Although Dan made no direct references to religion—traditional native Indian, or Christian, or any other organized religion—Dan's metaphor responses represent an individualistic spiritual orientation. Numerous references were made to the amount of time spent at the seashore:

I would be a uniform to a hockey team because I'm on the beach a lot of the time. A uniform is always on
the team players. . .

I could be a leaf to a tree. . . and I could be bark to a tree because I'm there all the time.

Interestingly, numerous responses expressed a unique tendency to "indwell" or become part of nature:

I could be all of them: the flower, the fruit, the thorn to a blackberry bush. I'm always down at the seashore and I seem to be part of it. . . I always think about the seashore, even when I'm not there.

I would be the curtain and the seashore would be the stitches. The seashore would hold me all together. I wouldn't be able to do everything without the seashore. I'm just part of me. It's like my arms to me.

Several references were made to being the least in nature:

I couldn't be the root to a tree, I'm not really the base of the seashore.

Other responses stressed the inability of humans to control or to own the seashore:

I wouldn't be a driver to a car or a mechanic to a car. I couldn't fix the seashore. I couldn't drive the seashore.

I would be the deckhand and the seashore would be the fishing boat. I wouldn't be the captain or the owner because I couldn't really run the seashore or be the boss of the sea. . . There isn't a captain. The seashore is everybody's.

There is a sense of unity with nature that transcends physical presence. Dan's relationship to the seashore can be seen as rooted in his view of himself as part of nature, not the most complex or important, but just another species sharing this world. And finally, in all these metaphor responses, it is
important to notice the integration of emotion, feelings, and intellectual reflection: "I'm sort of like part of the seashore" and "I always think about the seashore, even when I'm not there.

A recreational orientation towards the seashore was also evident:

The seashore is a playground. I play at the beach a lot: catching animals, looking at them. I fly my kite.

The seashore is a gift because of the many things that live there . . . it's nice to play by and enjoy.

I would be all of them: a door, a window, a roof to a house. They're always there. I'm at the seashore a lot too. I'm playing and I might go out in my boat.

Once again, notice the scientific, spiritual, and recreational aspects: "playing at the seashore," "catching animals," "looking at them", and "enjoying it."

Dan also used an aesthetic orientation towards the seashore. Several metaphor responses expressed an appreciation of the beauty in nature:

A starfish is a flower. It sort of looks like one, its shape and color. . . Some of them are pretty.

There were associations between aesthetics, the seashore, and Dan's personal life:

I'd mostly be the lace to a curtain. . . The seashore decorates all my life and makes it nice.

Also, notice the scientific and aesthetic aspects:

I would be a killer whale. The way it looks. How it moves. . . easy . . . slow. How it can move fast! And its speed for catching fish and catching seals and sea lions.

Only three of Dan's metaphor responses suggested a
utilitarian orientation:

I could only be the deckhand to a fishing boat. . . A deckhand isn't there all the time, but he's there on a fishing boat when it's fishing time.

I could be a fishing boat. I could catch fish. I could catch cod and halibut.

A clam is a potlatch. You can eat it.

And finally, only three of Dan's metaphor responses suggested a concern for health and safety:

Seaweed is a banana peeling. It's slippery. You slide and fall down.

Seaweed is a curtain. It covers the rocks and barnacles. You don't see the barnacles because of the seaweed, and you fall down and get cut on the barnacles.

A crab is a pair of pliers because of the pinchers that can pinch you.

Clearly, the proportion of scientific responses indicate that he brought to his curricular experiences a preferred scientific orientation towards the seashore, although several orientations were evident, including spiritual, recreational, and aesthetic. The utilitarian and health and safety orientations were almost lacking.

Luke

Recall that Luke's metaphor interviews pointed to a preferred spiritual orientation to the seashore, with numerous responses reflecting the spiritual beliefs of the native people of Salmon Cove. In addition, Luke demonstrated a strong health and safety orientation, with several responses expressing a fear
of certain seashore animals:

A crab is a pair of pliers, it pinches people.

A sea urchin is a pin cushion, it has long needles that sting.

There was a reference to getting cut on broken glass:

The seashore is a blackberry bush. . . when you pick real blackberries, their stems scratch . . . it's like the broken glass on the beach that cuts you."

Metaphor responses also referred to getting lost at the seashore or lost in the woods:

I would be a sunny day. . . foggy days are too spooky.

Seaweed is a forest . . . little animals get lost in the forest. I get lost, but I always find my way back.

It is interesting to note how a solution to a health and safety problem is consistent with a reliance on supernatural animals to care for people:

If the fishermen get lost, the seagulls will show them the way back home.

While some of the experiential bases of the above response may be utilitarian or scientific, "the seagulls will show them back home" is probably an implicit statement about the spiritual aspects of the seashore that is grounded in cultural experience. In traditional stories, the animals frequently come to the aid of humans by providing food or rescuing them from danger.

Luke had an aesthetic orientation, with several metaphor responses expressing an awareness of the beauty in nature:

The seashore is a painting. If it was a blue sky, it would look like a painting. And if the water was real calm, it would be a nice painting.
The seashore is a gift, the way it looks pretty.

The tide is music, the noise it makes sounds like drums.

I would be lace to a curtain. I would be lace to show off my beauty, like the seaweed at the seashore. Like the killer whale, the starfish, and the tiger fish show off their beauty.

Luke's responses also reflect a scientific orientation, with an awareness of certain ecological relationships (e.g., that plants and animals are found in different types of habitats that protect them from weather):

A tidal pool is a little town, all kinds of little animals live in it: bullheads, hermit crabs, eels. . . The rocks are like their homes.

A cobblestone is an umbrella . . . for the little crabs and eels. It protects them from the rain.

An awareness of predator-prey relationships was indicated, including microscopic plankton:

A barnacle is a fisherman, it eats that stuff in the ocean. It's really, really small. You can't see it.

An awareness that certain animals recycle dead animals was also indicated:

A seagull is a janitor, it eats fish guts when you throw the guts on the beach. It cleans up the beach.

There was an understanding of the sun as an important source of energy:

I would be a sunny day, I would make the grass, trees and flowers grow.

Luke was aware of pollution and wanted the preservation of the seashore:
I would be a thorn to a blackberry bush . . . The blackberry bush has pretty flowers on it. If someone tried to pick the flowers, I would hurt them. The starfish and sea anemones would be the flowers.

There was at least some suggestion of a utilitarian orientation:

I would be Kutala. I like salmon. I like to barbeque it. It's nice juicy red meat.

A crab is a feast. A certain kind of crab. Good eating.

Sea water is soup . . . Fish that you eat are like vegetables in soup.

Again, notice the spiritual and utilitarian aspects:

There is a legend about this man who became wild and he went down to the beach every day and he ate mussels, clams, and abalone.

I would be a fishing boat and tell the captain where all the fish are.

I would be a high tide. . . I would put food higher on the beach.

Luke also demonstrated a recreational orientation to some degree:

The seashore is a playground. I play hide-and-go-seek, make sandcastles, throw rocks on the water or at cans.

I would be a polished beach pebble. . . I like to play in the sand and make sand castles.

Some of Luke's responses show the spiritual and recreational aspects:

Sand is a sand castle. I like to make sand castles at the seashore. I make sand castles and play 'save the killer whale'.
I would be maxinus (the killer whale) and be a show off: swim upside down on my back, jump out of the water and do tricks. Because of the fun of it.

The results of Luke's pre-instructional interviews show several themes. The preferred orientation is clearly spiritual. There are also aesthetic, scientific, and health and safety orientations, and some mention of utilitarian and recreational orientations.

Sharon

Although Sharon's pre-instructional interviews showed no preferred orientation, a large proportion of responses stressed a scientific orientation towards the seashore. To begin, several metaphor responses expressed an interest in observing, questioning, problem solving, and learning from books. For example:

I would be a listener to a story. I would listen to the story and learn things. I would listen to stories and shows and read books about it. I would listen to the sounds in the sea. I would listen to the sea and learn things about it.

Sharon was aware of a wide range of seashore relationships. For example, she knew that plants and animals live in different types of habitats—under rocks, in tidal pools, and in caves:

A cobblestone is a hotel. Underneath the rocks there's all sorts of little things; crabs, sand fleas, eels.

A tidal pool is a town. Fish, eels, crabs, seaweeds, shells are all there, like a little town.

The seashore is a town. They've got little villages. Octopuses live in caves. Everything lives on its own.

Sharon correctly identified predator-prey relationships:
A clam is a vacuum cleaner. The way it moves on the ocean floor and scoops things up in its mouth. I think it eats plankton.

A seagull is a robber. I've seen them steal things from other birds. Sometimes they go into other bird's nests.

A sea anemone is a person. If fish get caught in their tentacles they wouldn't be able to get out unless they really struggled.

Sharon's metaphor responses showed that she knew that certain animals recycle the remains and wastes of other animals;

A seagull is a janitor. They eat garbage. They help keep our beaches clean so they look better.

She knew that seashore animals must protect themselves from predators:

A barnacle is a rock. They're hard and they're hard to break. Seagulls want to eat them, but they can't get in.

A crab is a pair of pliers. Their pinchers are sharp like pliers for protection.

A large proportion of Sharon's metaphor responses expressed a concern with pollution, and at least an implicit awareness of the interdependence of all living things. For example:

I would be stitches to a curtain. The seashore would be the curtain. If the stitches weren't there to hold the curtain together, the curtain would fall apart. If you weren't there to keep the beach clean, the beach would fall apart and there would be nothing.

Compared with the other students (with the possible exception of Dan), Sharon expressed the greatest awareness of a wide range of seashore relationships; she also demonstrated an emotional commitment to the preservation of living things.

An aesthetic orientation to the seashore was also
evident, with several of Sharon's responses expressing an appreciation of the beauty in nature:

The seashore is a garden. There's plants and bright colored animals. Some of the bright colored animals don't look like animals, but like flowers. They're really nice and pretty.

A tidal pool is a garden. All the shells, living shells and empty shells decorate it. The seaweed decorates it too.

A starfish is a jewel. It's brightly colored and precious like a jewel. The beauty.

It is interesting to notice the connection between aesthetics and Sharon's concern about pollution:

I would be a deckhand to a fishing boat. . . The deckhand cleans up after, he takes care of the boat. . . The beach doesn't look nice when it's all dirty, and neither does the boat.

Sharon's responses also suggested a utilitarian orientation to the seashore, with numerous references to eating seafoods, making things from the sea, and selling things from the sea:

The seashore is a gift. It's given to us to use; fish for food, whalebones for making spears like the Eskimos. We can sell the things we use. It's useful.

The tide is a gift. If the tide didn't go out, we would have to go underwater to get seaweed.

I would be the tree. The seashore would be the root. The roots bring food to the tree. The roots are important to the tree. I could take things from the sea. Like the sea brings food to me or other people.

Once again, notice Sharon's awareness of the concept of interdependence, and the scientific, utilitarian, and recreational orientations:

I would be a bead to a necklace. If there was a whole strand of beads, and you lost one, if one would be missing, it wouldn't look right. If there was a whole
pile of seas, and you took one away and you destroyed it, like littering, you wouldn't be able to use it. You couldn't use it for food, for selling things, or just to be there to have fun on it. It would be like you ruined the necklace.

Several metaphor responses stressed a recreational orientation:

The seashore is a playground. Kids can go down to the beach and make sandcastles. Having fun in the sun.

I would be a sailboat. I could go fast. It's fun to go in the water.

Once again notice the scientific and recreational orientations:

A seagull is a janitor. They eat garbage. They help keep our beaches clean so they look better. It's safe to play too.

Only three metaphor responses expressed a health and safety orientation:

Mud is a mousetrap. If little things get in it, they would have a hard time getting out of it. You could get stuck.

Mud is a mattress. If you fell, it wouldn't hurt. . .

A seagull is a janitor. . . They help keep our beaches clean. . . It's safe to play.

Only one metaphor response seemed to express an implicit spiritual orientation:

The seashore is a gift. It's given to us to use . . . fish for food . . .

The results of Sharon's pre-instructional interviews point to several orientations; a large proportion of responses stressing a scientific orientation and an almost equally large proportion of responses stressing an aesthetic orientation, also utilitarian and recreational orientations; a health and safety
orientation was barely in evidence, and a spiritual orientation seemed to be absent.

The Experiential Bases of the Students' Orientations

So far, I have described the orientations that the six target students brought to their instructional experiences. Additionally, there are important variations within each orientation which "highlight" and "hide" the range of experience at the seashore. For example, within the broad aesthetic orientation, was a great diversity in terms of the various aesthetic aspects of an experience which were stressed, e.g., drawing, painting, music, dance, drama, jewelry. Dan's and Sharon's aesthetic orientations tended to be associated with drawing and painting; Anna's aesthetic orientation tended to be associated with music, dance, and drama; Mary's aesthetic orientation tended to be associated with music, jewelry and cosmetics, while Luke's aesthetic orientations tended to be associated with painting, music, dance, and carving in relation to the Indian culture. Similarly, within the broad category of a spiritual orientation, Luke stressed the traditional beliefs of the native Indian people of Salmon Cove as well as Christianity, while Dan associated with the ability to indwell a plant or an animal. Jimmy's utilitarian orientation was associated with commercial fishing, crabbing, and making money, while Anna's and Sharon's utilitarian orientations were associated with sea foods nourishing the body, selling things,
and making money. Jimmy's health and safety orientation was almost wholly associated with the hazards of commercial fishing on the open ocean; Luke's health and safety orientation was almost wholly associated with hazardous animals and conditions at the seashore, and with a fear of spooks and ghosts. While Dan's recreational orientation was associated with exploring the seashore, catching animals and letting them go again, Anna's recreational orientation was associated with surfing, swimming, sailing, suntanning, and picnicking.

Some data in the metaphor interviews suggested a relationship between the experiential bases of the students' orientations and sex differences. When compared with the boys, the girls strongly favored an aesthetic orientation to the seashore. Girls far more than boys stressed the social aspects of an experience and made connections between their own physical beauty, social relationships and their own relationship to the seashore. Some data suggest that girls more than boys stressed personal feelings and emotions. Also, girls with a utilitarian orientation tended to stress seafoods nourishing the body; boys with a utilitarian orientation tended to stress commercial fishing, crabbing, duck hunting, and making money. Girls with a recreational orientation tended to stress swimming, sailing, picnicking, suntanning, looking for animals and seashells; boys with a recreational orientation tended to stress swimming, going out in skiffs, exploring, and looking for animals.

Although differences between boys and girls could be clearly seen to exist, some students more than others stressed
both masculine and feminine kinds of experiences. For example, Sharon's utilitarian orientation stressed both seafoods nourishing the body and selling things and making money. Luke's aesthetic orientation stressed music, dance, and painting, as well as very strong feelings of aesthetic appreciation. What these variations suggest is that boys and girls tend to have basic kinds of experiences, but they then stress different aspects of an experience.

**Internal Coherence**

The data suggest a certain internal coherence among the various orientations shown by each student. In the case of Dan, for example, several of his orientations tended to point to his preferred scientific orientation towards the seashore. For example, his particular spiritual orientation, which stressed a unity with nature and an ability to indwell, was mixed with his scientific orientation. His particular recreational orientation, which stressed independent exploration at the seashore: "going out in boats," "catching animals and looking at them"—was consistent with his scientific orientation. His particular aesthetic orientation, which stressed recording information, drawing and painting seascapes and seashore animals, was consistent with his scientific orientation. Although most of Dan's metaphor responses did not stress a utilitarian orientation, his interest in commercial fishing and duck hunting was coherent with his interest in science. Even
the near absence of a health and safety orientation is consistent with a scientific understanding and experiencing of life at the seashore since Salmon Cove beaches are protected by the shape of the bay and by offshore islands and inlets, and very few seashore organisms are capable of inflicting injury to humans.

Summary

On the basis of these examples and others, the following conclusions may be drawn about the nature of the students' orientations prior to instruction:

1. The metaphor interviews effectively enabled me to identify several different orientations used by the students. While some students tended to use one orientation predominantly, others used several orientations, depending upon the context of the interview questions. Although some combinations of orientations appear to be more probable than others, the data suggest that any combination of orientations is possible.

2. There was diversity in the various aspects of an experience that were associated with a particular orientation. For example, within the broad category of an aesthetic orientation, individual students stressed drawing, painting, music, dance, drama, jewelry, and so on. The data also suggest a relationship between orientations and differences between boys and girls. For example, girls
far more than boys stressed an aesthetic orientation to the seashore.

3. For all of the students, there was a general internal coherence among the various orientations shown by each student.
The Relationship Between the Students' Orientations and Their Social and Cultural Backgrounds

To gain some idea of what it means for the students' orientations to be grounded in their previous experiences, I explored the relationships between each student's set of orientations and their physical, social, and cultural environments. Data included interviews with teachers and elders in Salmon Cove. For brevity and continuity, I continue the biographies of Dan, Luke, and Sharon. (For comparison, I have provided a brief account of the social and cultural backgrounds of the other students' preferred orientations.)

Dan

As discussed, Dan had a preferred scientific orientation to the seashore. When asked if the seashore is important, Dan replied:

I live right by it. As soon as I look out the window, there it is. So many animals and things. It's a big part of my life. I never get tired of going there.

Additional data were gathered in an interview with the Salmon Cove primary teachers:

Dan goes duck hunting with his dad, then identifies ducks in books. His dad has a library on his fishing boat. They identify whatever animals they don't know.

Further information was gathered in an interview with the principal:

Dan's interest in science was developed primarily at
home, particularly from his dad. Dan was definitely taught to be observant. William, his dad, constantly stops along the beach to say "look at this and that." Dan had things pointed out to him as a little boy.

Such sensory-imbedded experience at the seashore would account, at least in part, for Dan's awareness of the more subtle aspects of seashore relationships. Also, Dan's scientific orientation has been nourished by a father who encouraged Dan to observe carefully and to identify and gain knowledge about seashore plants and animals from books.

More data collected in interviews with the primary teachers provide insights into the relationship between Dan's scientific orientation and his family and school background:

Dan learned to read by reading factual science books; machines, how to fix things, identifying animals, dinosaurs, and whales. He learned to read by reading science books rather than through more traditional reading instruction. He spent a lot of time in the science center doing little experiments. He's been reading more widely since.

And finally, additional data were gathered in an interview with Dan:

We have a big machine shop, bigger than our house. There's about a thousand dollars worth of big machinery, big saws and big planes - for building the fishing boat, the house and the roof.

We have an Apple Computer at home. There's about thirty games. Asteroid and Spaceman are my favorites. My dad plans to put the fishing business on it.

Dan's scientific orientation seems to have been encouraged both at school by the primary teachers and in the home by a father who encouraged scientific attitudes: to observe, ask questions, invent and solve everyday problems
through inquiry.

Also, to understand the disparity between Dan's superior scientific orientation towards the seashore, and the comparatively low scientific orientation of the other students in the class, a few additional details may be helpful. When I returned to Salmon Cove in the fall of 1982 to complete the long-term interviews, I heard stories about a unique salmon enhancement project that had taken place in Salmon Cove over the summer. Since the project had been organized by Dan's father, I asked Dan if he would give me a more detailed description. Dan seemed especially delighted to talk about the project, and eager to show off its independence from the government:

It was my dad and fifty guys. It had nothing to do with the government. Everybody's going broke. The fishing isn't good. Some people are losing their boats. The creeks are ruined for spawning because of the logging. One creek used to be good for spawning, the best one, it's covered with logs. The flooding caused sand and gravel to wash away the salmon eggs. My dad got everyone to volunteer their time and money. One boat was anchored in the bay. Every boat that came in gave two fish per catch. We paid for a helicopter to fly eggs from a fish hatchery to the spawning grounds. It would take hours by boat and the fish would all die, but it took just a few minutes by helicopter.

I was the only kid that helped. We cleaned up the creeks ourselves. Took all the logs and junk out. I helped catch the fish and milk the eggs. Me and my mom and Rika. We put in 100,000,000 eggs. We estimate about 3 per cent will come back, but in four years there will be lots more fish. Next year we plan to put in a salmon hatchery right at the river. Raise the eggs till they get eyes.

We did it ourselves rather than through the government because it was cheaper. This way it cost each family about $500 plus their time. If we had done it through the government it would have cost a
whole lot more, about $1500 in taxes.

This involvement in a locally initiated salmon enhancement project (as well as Dan's involvement in previous salmon enhancement projects), provides additional evidence for understanding Dan's superior knowledge of seashore relationships—specifically the concepts life cycle, habitat, predator-prey, interdependence, pollution, and conservation. Although the project was designed to help solve the immediate utilitarian problems of Salmon Cove, the underlying conservation and management techniques were clearly scientific. Considering Dan's experiences using a scientific framework to conserve and manage the salmon industry, and his wealth of firsthand experiences at the seashore, it is not surprising that he would have brought to his curricular experiences a wide range of beliefs consistent with a scientific orientation to the seashore.

Additionally, Dan had a strong recreational orientation towards the seashore: the seashore is a place for "going out in my boat", "catching animals and looking at them," and "having fun." Some idea of the possible grounding of Dan's particular recreational orientation is provided by the school principal:

Dan's grandfather is a non-status native Indian from Salmon Cove who married a French girl from Wallace Island. William (Dan's father), is a very successful fisherman. He fishes about four months of the year. During the winter months William works in his shop at home. There's a lot of time for arts and crafts, music and reading. They have a lot of free time. An enviable lifestyle.
The metaphor interviews have also shown that Dan had an aesthetic orientation to the seashore: "The seashore decorates my life and makes it nice." The following data from the school principal provide some understanding of the possible grounding of Dan's aesthetic orientation:

The mother is a very talented artist who does mostly water colors. She excells as a homemaker—needle craft, jewelry work, an excellent cook. Her water colors and jewelry are sold in the art store.

William is a craftsman, makes beautiful mandolins and guitars, as well as silver work.

Additional data were gained in an interview with Dan:

Every Friday night ten or fifteen people come over. Mom plays autoharp and dad plays the mandolin. I play saxophone, also guitar, mandolin, and ukulele. We sing a lot too.

My mom paints pictures: mostly water color, then acrylics. I draw more than anything I've ever done: boats, lots of animals, cars—over and over again. Now I'm drawing scenery—a few boats together or a close-up of one just ahead of the other.

Considering that Dan had a lot of free time, and that the arts were encouraged in the home by both parents, it is not surprising that he exhibited recreational and aesthetic orientations towards the seashore.

Recall that many of Dan's metaphor responses expressed a spiritual orientation towards the seashore, even though no responses suggested a traditional native Indian spirituality, or Christianity, or any other organized religious affiliations. To find possible reason for the absence of organized religious beliefs, I interviewed the school principal:

When the first fish of the season is caught, William
always has a ceremony. They drop anchor and go into a bay. It's not really a spiritual thing - not like a traditional Indian ceremony. They don't practise traditional Indian beliefs. It's simply an appreciation. They have a picnic and relax. All the other fisherman think it's strange, they're competitive and always in a hurry to get out there, and there's William having a picnic.

Although the family appears not to practise traditional native Indian customs, it is interesting to compare their "appreciation of the first salmon" to the traditional practice of the Salmon Cove Indian people: the "Salmon Dance" and the "Prayer to the Salmon." Also, it is important to notice Dan's emotional feelings and respect for the seashore: "I would be all of them--a door, a window, and a roof to a house... I'm sort of like part of the seashore, even when I'm not there."

Although there are no spiritual beliefs that clearly reflect a traditional native Indian or organized religion, there is an attachment and a sense of unity with nature. To say that there are no underlying spiritual structures would be failing to see the depth and complexity in Dan's love for the seashore. Dan's scientific orientation is grounded in a highly spiritual effort to protect and secure the human connection with nature.

Recall that only three of Dan's metaphor responses expressed a utilitarian orientation towards the seashore: the seashore is a place where Dan can "fish for cod" and "halibut" and "eat clams." At first, the surprisingly infrequent mentions of the more utilitarian aspects of the seashore appear to contradict Dan's love of commercial fishing. For example, when asked what he most wanted to be when he grows
up, Dan replied:

I would most like to be a fisherman because my father is a fisherman. My grandfather was the best fisherman on the coast.

To gain further insights into the possible reason for this apparent contradiction, I sought additional data from the school principal:

Dan's parents aren't into competitive fishing. William has good fishing skills and good management skills. Catching a lot of fish and making a lot of money isn't as critical. He consumes and conserves. His boat is much more relaxed.

These data suggest that the problems of catching large numbers of fish and of meeting financial obligations are not immediately obvious in a home where the father is a "very successful fisherman" and a "good manager." In a later attempt to comprehend Dan's lack of utilitarian responses to the seashore, I asked Dan what his second choice would be if he couldn't be a fisherman when he grows up:

I would be a park naturalist or a marine biologist, but only if I didn't have to move away from Salmon Cove. I wouldn't move to Vancouver, or U.B.C. to study there. I want to look and study, go live in the wilderness. I want my boat to fish in the summer and work in the winter on films, and draw pictures, and do wildlife books. I want to go there and feed the animals, and study and do Landsdowne books, but do it about sea animals.

Those people from Vancouver shouldn't log around the rivers. All those people fight over who's going to log what. They want to log the Bear Valley. Ruin the creeks for spawning so the salmon eggs wash away. Ruin everything. Everybody's concerned. I can't do anything right now, but when I get older I will.

Once again, notice the utilitarian, aesthetic, and scientific orientations: Dan would be a fisherman in the summer and draw
pictures and write wildlife books in the winter. Notice too, the scientific and utilitarian orientations: Dan wants to use conservation and management practices to help solve the fishing crisis.

The above data suggest that Dan was more aware of the utilitarian aspects of the seashore than the relative proportion of his metaphor responses seemed to suggest. He simply didn't demonstrate much use of a utilitarian orientation when describing his present relationship to the seashore. As an adult Dan will likely express his relationship to the seashore in a more utilitarian way: "I can't do anything right now, but when I get older I will."

And finally, only three of Dan's metaphor responses expressed a health and safety orientation towards the seashore: You could "slide and fall because of the seaweed," "get cut on rocks," or "be pinched by a crab." Dan's low health and safety orientation seems surprising, given his interest in a potentially dangerous occupation such as commercial fishing. To understand Dan's low health and safety orientation, I interviewed the school principal:

There aren't that many fishing days. If you're going to make your money you have to make it right then. The fisheries department declares open fishing days, and you have to get out, storm or no storm.

The whole fishing world isn't cooperative anymore. It's too competitive. Too rough. William's boat is much more relaxed. When there's a storm, they go on shore, read and identify things. William doesn't struggle.

Considering Dan's familiarity with seashore animals, and his father's relaxed attitudes towards commercial fishing, it
follows that Dan would have a low health and safety orientation towards the seashore.

Luke

Recall that Luke's initial metaphor responses suggested a preferred spiritual orientation to the seashore, expressed by numerous references to the spiritual beliefs of the traditional native Indian people of Salmon Cove, and with some references to Christianity. The following data collected in interviews with the native Indian cultural teachers provide insight into Luke's particular spiritual orientation:

Luke takes Indian dancing, Indian language, and Indian art in school. He is very interested in the Indian culture. A good listener. He visits the elders regularly and listens to our spiritual stories. He dances a lot in the big-house. Luke will be a wise man some day.

Further information was gathered in an interview with the school principal:

Luke is a full-status native Indian. He was originally from Salmon Cove, but has moved back and forth a lot between Vancouver, Bear Creek and Salmon Cove. He moved to Salmon Cove for grades 5 and 6 to live with his granny. Luke's great uncle Billy is a very well known Indian artist. His granny is a very traditional native Indian, but also attends the Pentecostal Church here in Salmon Cove. The granny has a very strong influence on Luke. Luke doesn't go out and fish in the seiners. He has a lot of free time and stays at home a lot and watches T.V.

And finally, when I returned to Salmon Cove to complete the long-term interviews, I heard stories about a potlatch that Luke's granny had given over the summer. I asked Luke if he
would tell me about the potlatch:

I danced two dances all by myself. It was the first time. I danced the Hamatsa, a dance about the return of the chief's son. It's the story of the "Wild Man in the Woods." He was lost in the woods. The people tried to catch him, but he jumped over them. They made a cage for him.

We had a big pot-luck dinner. It was really good: baked salmon, barbecued salmon, clam chowder, homemade buns. Mmmmmmmmmmmmm! My Granny gave away pillows, laundry baskets, blankets, homemade clothes, homemade shawls, homemade cushions, homemade dolls. I saved up my money and had a potlatch at the same time. I gave out toys: necklaces, squirt guns, dolls, magnifying glasses, quarters, nickles, dimes, and key chains.

Luke's involvement in the native cultural program at school, and the fact that traditional spiritual beliefs are encouraged at home by his granny and his uncle Billy, helps explain why Luke would understand and experience the seashore through the oral traditions of his people. This telling and re-telling of the spiritual stories, and the watching and enacting of his ancestors' encounters with supernatural beings would account, at least in part, for Luke's preferred spiritual orientation to the seashore.

Luke's spiritual orientation is also grounded in the Pentecostal Church whose revival-like qualities are emotional and whose doctrines are fundamentalist in character. The following data were collected in an informal conversation with Luke as I was driving him to his granny's house to get his science project. When we passed the ferry dock, Luke laughed, then said:

When Jesus Christ comes to Salmon Cove he won't have to use the ferry dock because he'll float down on a
great white cloud. He'll wear a big crown with lots of jewels on his head, and there will be angels all around with silver wings.

Because the beliefs of the Pentecostal Church seem divorced from the spiritual beliefs of the native Indian people, the blending of the two might appear strange. But if one examines many of the stories of the two religions, one finds there are certain common characteristics. Look at the metaphors involved in the ceremonies, the masks, the dances, and the legends of the Indian people, and the metaphors involved in the ceremonies of a fundamentalist church, the parables and miracles of the Bible. Luke's metaphor responses embody an integration of spiritual ideas about humans and animals.

To provide some idea of the possible grounding of Luke's particular aesthetic orientation, I include information that was gathered in interviews with Luke:

When I grow up I would most like to be a carver: carve totem poles and talking sticks. If the chief wants to talk he has to hold the talking stick. I would carve a stick with eagles, bears, and frogs. I would also be a painter and paint Indian designs, or be a silversmith and make Indian designs on bracelets, necklaces, and rings.

The fact that Indian art is clearly encouraged at school and in the home by Luke's granny, and that Luke's great uncle is a well known Indian artist, suggests why Luke demonstrated an aesthetic orientation to the seashore.

Recall also, that Luke had a health and safety orientation towards the seashore. He was concerned with barnacles "that cut," sea urchins with "long sharp needles
that sting," "broken glass on the beach," and "foggy days that are too spooky." At first, Luke's concern for getting hurt at the seashore seems fairly typical of many grade six boys and girls who are unfamiliar with the seashore. But considering that Luke lives across the road from the seashore and is generally familiar with seashore plants and animals, his strong health and safety orientation seems unexpected. What helps explain this in part is Luke's repeated concern with "getting lost." This suggests both health and safety and spiritual aspects expressed by the dance of the Hamatsa--the story of the "Wild Man in the Woods." Such spiritual stories reflect the Indian concern with potentially dangerous spirits and ghosts that live in the forest, the ocean and in certain people's houses. These spirits have two forms—one animal, the other human—and can be good or evil. Considering that Luke was learning to dance the Hamatsa when he was interviewed, it is not surprising that he would have expressed such a concern for health and safety at the seashore.

Luke's utilitarian orientation also had spiritual aspects. Recall some of Luke's metaphor responses: "I would be a fishing boat and tell the captain where all the fish are." Or, "I would be a high tide... and I would put food higher on the beach." Or, "There is a legend about this man who became wild and he went down to the beach and he ate mussels, clams, and abalone"... Listening to traditional stories of spirits and survival, experiencing the seasonal abundance of food when preparing for a potlatch, enacting "The
Wild Man in the Woods"—all of this would lead Luke, at least in part, to a utilitarian orientation grounded in the spiritual traditions of his people. Luke's participation in gathering, preparing, and eating seafoods would also develop a utilitarian orientation. An interview with Luke revealed the following:

Sometimes, I go to Bear Island with my uncle to dig clams. Sometimes my mom (Luke calls his granny "Mom") makes clam chowder. Sometimes we make fish chowder too. My mom puts in seaweed, usually the black kind. Do you eat herring eggs? My mom knows a lady who eats sea urchins.

So, although Luke's utilitarian orientation was not preferred, it was an integral part of his overall orientations, and an important dimension to the traditional way of life in Salmon Cove.

External Coherence

As previously described, the data suggest a certain internal coherence across a student's various orientations to the seashore, and a certain external coherence between a student's various orientations and his or her physical, social and cultural backgrounds.

To understand how orientations are grounded in connections with physical experience, I compare and contrast the cases of Dan, Jimmy, and Anna. Recall that Dan interpreted the word "seashore" specifically as the inter-tidal region between the land and the sea, Jimmy interpreted the word "seashore" more broadly as the offshore water and the open ocean, while Anna focused partially on the seashore in Salmon Cove and partially
on the seashore in the Solomon Islands. The fact that each student interpreted the word "seashore" as a different type of marine environment reverberated through the metaphorical connections each chose.

In the case of Dan, there was an external coherence between his particular set of orientations and the type of physical environment that exists in Salmon Cove. As such, Dan's scientific orientation was coherent with a type of seashore that is home to a diversity of seashore plants and animals. Dan's particular recreational orientation is externally coherent with a seashore that is good for exploring, finding animals and looking at them, and just having fun. His particular aesthetic orientation is externally coherent with a picturesque harbor filled with fishing boats, beaches with gnarled trunks and twisted branches meeting the sea, and a continuous chain of spectacular white-capped mountains in the distance. His comparatively low health and safety orientation is also coherent with the type of seashore that exists in Salmon Cove; there are very few harmful plants and animals. Salmon Cove beaches are comparatively safe because they have offshore islands and inlets to provide shelter from currents and the full force of waves. Indeed, any student growing up in Salmon Cove with a scientific orientation towards the seashore, and with a wealth of first hand experiences at the seashore, would know that Salmon Cove beaches are relatively safe. Similarly, Dan's low utilitarian orientation is consistent with a type of seashore that supports comparatively few edible plants and animals. Salmon Cove
beaches are cobblestone set on hard rock, and support very few preferred edible organisms such as clams, scallops, oysters, Dungeness crab.

In the case of Jimmy, there was a certain external coherence between his particular set of orientations, and the type of physical environment that exists in Salmon Cove, and indeed, along the entire British Columbia coastline. Since Jimmy frequently interpreted the word "seashore" as the offshore waters and the open ocean, his utilitarian orientation is externally coherent with a coastline that supports a great diversity of commercial fish (sockeye salmon, chum salmon, halibut, cod, flounder, etc.) as well as the wide-ranging Dungeness crab, shrimp, etc. Jimmy's almost equally preferred health and safety orientation is coherent with the hazards of commercial fishing in often violent storms along a rugged rocky coastline. At the other extreme, Jimmy's comparatively low recreational orientation is externally coherent with the type of coastline and with the type of lifestyle that frequently goes with commercial fishing. It suggests that Jimmy may have had a greater recreational orientation had he more consistently interpreted the word "seashore" in terms of Salmon Cove beaches. Jimmy's lack of an aesthetic orientation seems surprising given the aesthetic qualities of a coastline of jagged rocks, haystacks, and rocky islands, and given the aesthetic qualities of Salmon Cove beaches. Despite these inconsistencies, Jimmy's orientations are externally coherent with the type of physical coastline generally.
In the case of Anna, there was a certain external coherence between her particular set of orientations and the type of physical environment that exists in her native Solomon Islands. Anna's preferred recreational orientation, which stressed swimming, sailing, surfing, picnicking, beach parties and sun tanning, is coherent with long sandy beaches and hot tropical weather. Her particular aesthetic orientation, which stressed music, dance, and drama is coherent with the cultural songs and dances of the Solomon Islanders. Her utilitarian orientation is coherent with a type of marine environment that supports a great diversity of edible organisms: a variety of tropical fish, shrimp crab, clams, etc. The data suggest that Anna may have had a recreational orientation of considerably less weight had she more consistently interpreted the word "seashore" as meaning Salmon Cove beaches, which are cobblestone and generally cold. So it seems that the students' orientations are grounded in systematic connections within their perceived physical environment.

Last, there was a certain external coherence for all of the students, between their particular sets of orientations, and the types of social and cultural environments that exist in Salmon Cove. There was a strong relationship between the parent's profession or job, and economic, and religious affiliations. To see how the students' orientations are grounded in systematic connections within their social and cultural environments, I compare and contrast the scientific orientations of Dan, Anna, and Jimmy.
Briefly, Dan's preferred scientific orientation is externally coherent with a father role-model who taught Dan at an early age to observe the seashore carefully, to identify plants and animals from a library of books in the home and on the fishing boat, and to use conservation and management to help solve the problem of rapidly dwindling salmon stocks. At the other extreme, Anna's low scientific orientation is externally coherent with the lack of a scientific role-model in the home, with parents who support the creative arts, and with other relatives who encourage beach parties and large family gatherings at the seashore. Jimmy's low scientific orientation is externally consistent with an absence of a scientific role-model in the home, and with a father whose interest in commercial fishing does not require a scientific understanding of beach ecology. These data suggest that while complete external coherence is rare, substantial coherence, on the other hand, is typical.

By contrast, the near absence in Jimmy of spiritual and aesthetic orientations seems externally inconsistent with his family background. The absence of a spiritual and aesthetic orientation in Jimmy may in part be associated with a possible learning problem at school. To see this, recall that Jimmy's dad is a traditional native Indian and that in the primary grades Jimmy danced a lot in the big house. In fact, when I returned to Salmon Cove in the spring of 1984 to present the results of the study to the community, the teachers and elders were quick to point out this discrepancy between Jimmy's
orientations and his family background. One possible clue to this apparent incoherence is that Jimmy interpreted the word "seashore" as the offshore waters and open coast. Although such data provide insights into Jimmy's utilitarian and health and safety orientations, they do not provide an adequate account for Jimmy's near absence of a spiritual and aesthetic orientation.

To see how the students' orientations may be determined, at least in part, by their mental and emotional capacities, I interviewed the Salmon Cove primary teachers:

Jimmy had a difficult time learning. He went to learning assistance. He couldn't read at all until grade 4. . . Can he read now? . . We tried everything. . . He drew lots of boats and battles all the time. . . He can read, but is still below grade expectations.

An interview with Jimmy's grade 6 teacher revealed the following:

Jimmy is definitely well below grade level in reading and math. He tries hard when he's here, but his skills are very weak.

More than any of the other students, Jimmy found the metaphor interviews difficult, he even occasionally attempted to avoid the interviews. I would speculate that Jimmy's possible learning problem helps explain the near absence of spiritual and aesthetic orientations. He simply may not have had the ability to respond to the metaphor questions with a rich mix of orientations. A more likely explanation for the absence of spiritual and aesthetic orientations is the fact that Jimmy found the metaphor interviews (and myself as an outsider) threatening. During one session in particular, Jimmy was clearly upset about being interviewed during his physical
education class, as evidenced by his unhappy mood and by the resulting metaphor responses:

I would be a starfish. They're big and they're way out and you can't get them.

I would be a boulder. Nobody can move you.

I would be a bullhead. When the tide is just coming up you just high-ball it out and swim out to the ocean, and stay underwater and go underneath a rock.

I would be a hermit crab. Nobody hardly can pick you up and throw you down on the rocks. It's safer.

Jimmy's reluctance to be interviewed may be associated with being tested and with remedial reading class. To gain additional insights into Jimmy's suspicions, I interviewed the home school coordinator:

Jimmy was raised in the traditional Indian ways. Jimmy respects and relates to his dad (grandfather). He watches his grandfather work: fishing, setting nets, setting out crab pots, driving the boat. The males are dominant in the household. Jimmy is the man of the house. He learns by doing, observing, and by doing it himself. They don't talk much about how to do something. He's easily embarrassed if he can't do something right the first time. Indian boys traditionally watched their fathers. They practised out of sight. Then, when their skills were perfected, they performed in front of their elders. Jimmy has his own motor boat. At home, Jimmy never has to do anything he doesn't want to do.

In school we expose children to testing and practising in front of adults. To be exposed, especially in front of a woman, is a dishonor. Verbal skills and writing skills are not necessary on a fishing boat.

It would appear that Jimmy's reluctance to be interviewed may be grounded in his native Indian family environment—an environment where teaching traditions are different from our own. Although highly speculative, the above data provide an additional explanation for the near absence of spiritual and aesthetic
orientations. Jimmy may have had both a spiritual and an aesthetic orientation of considerably more weight, but he simply preferred not to share certain aspects of his thinking with outsiders. When Jimmy found the metaphor questions difficult, or confusing, or threatening, the various aspects of his utilitarian and health and safety orientations were used possibly at the expense of a spiritual or aesthetic orientation. All of the above data are required to give an account of the interactional properties of Jimmy's orientations and beliefs about the seashore.

So it seems that each student's orientations form a system of relationships grounded within their previous physical, social, and cultural experiences. Following Lakoff and Johnson (1980), I am arguing that the students' orientations are products of their bodies (perceptual, mental, and emotional makeup), their interactions within their physical environment (seeing, hearing, touching, manipulating animals, objects, and conditions at the seashore, etc.), and their interactions with others in their culture (in terms of social, economic, religious, etc. institutions). In other words, the kind of conceptual system the students have is a product of the way they interact with their physical, social and cultural environments.
Summary

On the basis of these examples, I am suggesting the following conclusions about the relationships between the students' orientations and their social and cultural backgrounds:

1. For all of the students, there was an external coherence between the students' orientations and their previous experiences in the physical, social, and cultural world.

2. The data suggest a relationship between the students' interpretation of the word "seashore" and their orientations to the seashore.
The Students' Beliefs Prior to Instruction

One way of attempting to understand the nature of the students' beliefs about seashore relationships prior to instruction, was to document their awareness of the existence of seashore phenomena (crabs, starfish, tide, sun, tidal pools, etc.). Another way was to document their beliefs about specific seashore relationships (habitat, predator-prey, tidal cycle, food chain, zonation, community, etc.).

For the sake of brevity, I begin with a general summary of the students' beliefs prior to instruction. These data are taken from both the metaphor and the literal interviews. At a later point I provide a more detailed analysis of the relationship between the individual students' beliefs and their preferred orientations.

The Students' Awareness of Seashore Phenomena

In Set 2-A of the literal interviews, each student was asked to list all the plants, animals, objects, and events connected with the seashore. (Table 4 compares the responses of the six target students.)
<table>
<thead>
<tr>
<th>Dan</th>
<th>Luke</th>
<th>Sharon</th>
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<tbody>
<tr>
<td>1. bullheads</td>
<td>1. rocks</td>
<td>1. sand</td>
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<tr>
<td>2. crabs</td>
<td>2. eels</td>
<td>2. fish</td>
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<tr>
<td>3. seaweed</td>
<td>3. crabs</td>
<td>3. seaweed</td>
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<tr>
<td>4. barnacles</td>
<td>4. seaweed</td>
<td>4. logs</td>
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<td>5. sea urchins</td>
<td>5. kelp</td>
<td>5. stones</td>
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<td>6. big rocks</td>
<td>6. fish</td>
<td>6. starfish</td>
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<td>7. polls of</td>
<td>7. killer whale</td>
<td>7. crabs</td>
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<td>8. eels</td>
<td>8. logs</td>
<td>8. eels</td>
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<td>9. water</td>
<td>9. clams</td>
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<td>11. machine parts</td>
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<td>12. little shells</td>
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<td>13. starfish</td>
<td>13. chiton</td>
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<td>14. chinese hats (a)</td>
<td>14. octopus</td>
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<td>15. barnacles</td>
<td>15. seagulls</td>
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<tr>
<td>16. rock cod</td>
<td>16. chinese slipper (b)</td>
<td>16. crows</td>
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<td>17. clams</td>
<td>17. chitons</td>
<td>17. whales</td>
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<td>18. otters</td>
<td>18. eagles (P)</td>
<td>18. sharks</td>
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<td>19. killer whale</td>
<td>19. seagulls</td>
<td>19. seals</td>
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<td>20. crows</td>
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<td>22. ducks</td>
<td>22. clams</td>
<td>22. abalone</td>
</tr>
<tr>
<td>23. geese</td>
<td>23. salmon</td>
<td>23. lobster</td>
</tr>
<tr>
<td>24. pintails</td>
<td>24. halibut</td>
<td>24. flies</td>
</tr>
<tr>
<td>25. mallards</td>
<td>25. herring</td>
<td>25. blood</td>
</tr>
<tr>
<td>26. salmon</td>
<td>26. cod (P)</td>
<td>26. sand fleas</td>
</tr>
<tr>
<td>27. red snapper</td>
<td></td>
<td>sucker (c)</td>
</tr>
<tr>
<td>28. ling cod</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. skiff</td>
<td></td>
<td>27. sea anemones</td>
</tr>
<tr>
<td>30. eel eggs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31. fish eggs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32. scallops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33. abalone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34. sea cucumbers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. snails</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36. small rocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jimmy</td>
<td>Mary</td>
<td>Anna</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>1. crabs</td>
<td>1. crabs</td>
<td>1. seaweed</td>
</tr>
<tr>
<td>2. eels</td>
<td>2. seaweed</td>
<td>2. crabs</td>
</tr>
<tr>
<td>3. bullheads</td>
<td>3. rocks</td>
<td>3. eels</td>
</tr>
<tr>
<td>4. shellfish</td>
<td>4. kelp</td>
<td>4. starfish</td>
</tr>
<tr>
<td>5. perch</td>
<td>5. eels</td>
<td>5. jellyfish</td>
</tr>
<tr>
<td>6. ratfish</td>
<td>6. sand</td>
<td>6. barnacles</td>
</tr>
<tr>
<td>7. whisker cod</td>
<td>7. water</td>
<td>7. fish</td>
</tr>
<tr>
<td>8. flounder</td>
<td>8. logs</td>
<td>8. salmon</td>
</tr>
<tr>
<td>9. black bass</td>
<td>9. starfish</td>
<td>9. herring</td>
</tr>
<tr>
<td>10. red snapper</td>
<td>10. barnacles</td>
<td>10. tuna</td>
</tr>
<tr>
<td>11. rock cod</td>
<td>11. flower animals (d)</td>
<td>11. mackerel</td>
</tr>
<tr>
<td>12. trout</td>
<td>12. mussels</td>
<td>12. squishy (P)</td>
</tr>
<tr>
<td>13. ling cod</td>
<td>13. seashore smells (P)</td>
<td></td>
</tr>
<tr>
<td>14. killer whale</td>
<td>14. bugs</td>
<td></td>
</tr>
<tr>
<td>15. sockeye salmon</td>
<td>15. shells</td>
<td></td>
</tr>
<tr>
<td>16. pink salmon</td>
<td>16. glass (P)</td>
<td></td>
</tr>
<tr>
<td>17. hump salmon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. dolphins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. seals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. seagulls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. crows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. eagles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. rocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. barnacles (P)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) chinese hat (limpet)
(b) chinese slipper (different species of limpet)
(c) blood sucker (crab molts)
(d) flower animals (sea anemones)
(e) squishy things (sea anemones)
(P) researcher's probe; e.g., Can you think of anything else at the seashore? In the water? In the air? On the beach?
All of the students began by listing the more common and obvious seashore organisms that inhabit the tidal pools and under-rock habitats of the upper tide zone: barnacles, eels, bullheads, crabs, seaweeds. Dan, Luke, and Sharon listed organisms that are common in the lower tide zone and sub-tidally: chitons, sea urchins, sea anemones, abalone, octopus, scallops, sea cucumbers, etc. Jimmy began by listing common seashore animals, but rapidly listed a number of commercial fish that live in offshore waters (flounder, red snapper, halibut, sockeye salmon, pink salmon, etc.). Dan, Luke, Jimmy, and Sharon listed wide-ranging mammals (seals, otters, whales, sharks) and wide-ranging marine birds (seagulls, eagles, pintails, mallards). Dan and Sharon listed some of the more subtle animals, objects, and conditions at the seashore: mice, rats, eel eggs, fish eggs, plankton, plankton molts, sand fleas, etc. Anna and Sharon listed organisms that do not occur on the Pacific Coast: tuna, mackerel, lobster. These data show that Dan had an exceptional awareness of the existence of seashore phenomena, Sharon and Luke were less aware of the existence of seashore phenomena, while Jimmy, Mary and Anna were not very aware of even some of the more common and obvious seashore phenomena.

The Students' Beliefs About Specific Seashore Relationships

In general, there was a great diversity in terms of the number of beliefs about the seashore--its various organisms and
the relationships among them. From the metaphor interviews, Dan, Sharon, and Luke expressed beliefs about the greatest range of seashore relationships; Mary, Jimmy, and Anna expressed beliefs about a very limited range of seashore relationships.

Specifically, Dan expressed beliefs about the following concepts: diversity of organisms, tidal cycle, habitat, types of seashores, predator-prey, protection, recycle, energy from the sun, and conservation. Although some metaphor responses suggested Dan was implicitly aware of the concepts interdependence and community, no metaphor responses expressed explicit beliefs about the concepts: types of coastlines, desiccation, food chain, zonation, interdependence, and community.

By contrast, Mary expressed beliefs about a limited range of seashore relationships. From the metaphor interviews, she expressed beliefs about the following concepts: diversity of organisms, predator-prey, habitat, pollution, conservation. No metaphor responses expressed beliefs about the concepts: types of coastlines, types of seashores, tidal cycle, desiccation, protection, food chain, energy from the sun, recycle, interdependence, zonation, or community.

While a few students consistently used beliefs about seashore relationships which were consistent with accepted science ideas, most students tended to use beliefs which were quite different. Dan and Sharon tended to use beliefs which were consistent with accepted science ideas; Luke, Jimmy, Mary, and Anna tended to use beliefs which were quite different from
accepted science ideas. For example, Mary had very different ideas about concepts associated with the harsher aspects of seashore life: death, predator-prey, competition, the constant struggle for survival. Luke had very different ideas about almost all concepts associated with beach ecology, and different ideas about concepts associated with evolution or creation: birth, death, food chain, tidal cycle, interdependence, etc. Anna generated far more wild guesses than any other student, and repeated the relatively simple concept of the diversity of organisms over and over.

Summary

1. There was great diversity in terms of the number of beliefs about the seashore—its various organisms and the relationships among them.

2. Only a few students tended to use beliefs which were quite similar to accepted science ideas. Most students used beliefs which were quite different.
The Relationship Between the Students' Orientations and Beliefs Before Instruction

One way of looking at the relationship between the students' orientations and beliefs, is to compare and contrast the specific beliefs that individual students chose to stress on the pre-instructional interviews. The fact that some students stressed certain concepts over others raises a fundamental question. Why did Dan express an awareness of the greatest range of seashore phenomena, while Mary expressed a very limited awareness of seashore phenomena, while Jimmy listed a large proportion of offshore commercial fish? Why did Jimmy stress the concepts predator-prey and habitat, and not the concepts pollution and conservation? Why did Mary have such a limited knowledge of seashore relationships, especially concepts such as death, predator-prey, competition, and survival? Why did Luke have very different ideas about almost all concepts associated with beach ecology? Why did Anna continue a monotonous repetition of the concept of the diversity of organisms?

In this section, I examine the relationship between the students' orientations, their awareness of certain types of seashore phenomena, and their beliefs about specific seashore relationships. I show that prior to instruction, there was a relationship for all of the students between their orientations and the particular beliefs they chose to stress.
The Students' Orientations and Their Awareness of Seashore Phenomena

In general, the data suggest a relationship for all of the students between their preferred orientations and their awareness of certain types of seashore phenomena. For example, the student with a preferred scientific orientation (Dan), had an exceptional awareness of seashore phenomena, regardless of their scientific, or aesthetic, or utilitarian, or spiritual, or health and safety aspects. By comparison, the student with a preferred utilitarian orientation (Jimmy) had a good awareness of commercial fish and of certain edible seashore plants and animals, but a poor awareness of common seashore phenomena of more aesthetic, or spiritual, or scientific aspects. The student with a preferred aesthetic orientation (Mary) had a poor awareness of the existence of seashore plants and animals, regardless of their scientific, or aesthetic, or spiritual, or utilitarian, or health and safety aspects, although some data suggested that she was at least aware of phenomena that she considered of aesthetic significance. The student with the preferred spiritual orientation (Luke) had a good awareness of seashore phenomena in general, and was particularly aware of animals, objects, and events that he considered of spiritual significance. The student with the greatest mix of orientations (Sharon) had a good awareness of seashore phenomena generally, regardless of their association with any given orientation.

In order to see in detail the relationships between the
students' orientations and their awareness of seashore phenomena, I compare and contrast the cases of three students: Jimmy, Mary, and Luke. In the case of Jimmy, a very strong relationship could be seen to exist between his preferred utilitarian orientation, which stressed commercial fishing and crabbing, and his limited awareness of even the more common seashore plants, animals, objects and events. Compared to the other students, Jimmy's list of seashore phenomena included few seashore animals, a conspicuous number of commercial fish, and certain wide-ranging marine mammals frequently spotted when fishing in offshore waters. Additionally, when asked to draw a picture of a crab, Jimmy was the only student who drew the Dungeness crab rather than the more common purple shore crab (the Dungeness crab is the large edible crab harvested commercially in Salmon Cove), and when asked to draw seaweed, Jimmy was one of very few students who drew seaweeds attached to rocks, rather than floating in the water. The fact that Jimmy drew seaweeds attached to rocks is important, since he picks seaweeds from the rocks with his dad and dries them for making soups. These data are consistent with conversations with Jimmy. When asked if the seashore was familiar, Jimmy replied: "I don't go to the seashore very much. When I do go, I look for eels and crabs. Nothing else. I go fishing in the seiners. I go fishing and crabbing." Jimmy's specialized interest in commercial fish and edible seashore plants and animals is consistent with a limited awareness of the common seashore phenomena.
By comparison, a relationship could be seen to exist between Mary's preferred aesthetic orientation, which stressed making jewelry, and her limited awareness of seashore phenomena. For example, Mary's list of seashore phenomena includes few seashore plants and animals, an assortment of objects, and events, and no commercial fish or marine birds or mammals. It is interesting to notice that Mary's list includes starfish, shells, and flower-like animals. Again, this is consistent with conversations with Mary: "I don't go down to the beach too much. It's just like normal. I never find the time." "When I do go to the seashore, I look for shells and things to make jewelry, like necklaces and rings." Considering Mary's limited experiences at the seashore, it is not surprising that she would have brought to her instructional experiences a poor awareness of seashore phenomena.

Luke's list of seashore phenomena includes a range of seashore plants and animals, a range of objects and events, shorebirds, commercial fish, and wide-ranging mammals. Considering that Luke goes "down to the beach lots . . . to dump the fishguts . . . and to have fun, turn over rocks, get eels or crabs or just walk around," it is not surprising that he would have had at least a general awareness of seashore phenomena. Additionally, a connection could be seen to exist between Luke's general awareness of seashore phenomena, and his preferred spiritual orientation. Recall that many of Luke's spiritual responses reflect the traditional stories of the native Indian people of Salmon Cove:
The seashore is a legend. There is a legend about this man who became wild and he went to the beach every day and he ate mussels, clams, and abalone.

I would be a listener to a story. I would listen to what happened a long, long, time ago, about the killer whale, the Thunderbird, the raven.

A clam is a dance. You could use the shells in a dance, a dance called the Kwi Kwi.

The tide is a legend. The wolves used to look after the tide long before anyone was born.

I would be Kutala. I like salmon. I like to barbeque it. It's nice juicy red meat.

The legends and ceremonial dances of the native Indian people of Salmon Cove involve the marine and fresh water animals that are common along the coast and in local rivers and streams. The stories portray the ocean as offering a seasonal abundance of food. What is important to this research, is that Luke's spiritual and utilitarian and aesthetic orientations contributed to a general awareness of certain seashore animals, objects, and events which he considered of spiritual, or utilitarian, or aesthetic significance: killer whales, eagles, ravens, salmon, clams, abalone, tides, etc. Additionally, Luke's particular spiritual orientation allowed him to believe in the existence of supernatural animals or beings: the Thunderbird and the Wild Man in the Woods.

The Students' Orientations and Their Beliefs about Seashore Relationships

So far, I have given an account of how the students'
awareness of seashore phenomena was grounded in their previous experiences with the physical, social and cultural environment. In addition, I have attempted to show that there was a relationship for all of the students between their orientations and their awareness of the existence of seashore plants, animals, objects, events, and conditions. Next, I show that there was a relationship for all of the students, between their set of orientations and their set of specific beliefs about seashore relationships. Because of the importance of this relationship to this thesis, I describe in some detail the cases of four students: Jimmy, Mary, Anna, and Luke.

**Jimmy**

In the case of Jimmy, a strong relationship could be seen to exist between his preferred utilitarian orientation, which stressed commercial fishing and crabbing, and his specific beliefs about seashore relationships. This relationship was so striking that it is worth elaboration. For illustration, when Jimmy was asked to group his list of seashore plants, animals, objects and events into categories, Jimmy used his knowledge of the feeding behavior and habitats of commercial fish as the major criterion for grouping (Table 5).
Jimmy's Category System Prior to Instruction

<table>
<thead>
<tr>
<th>Category</th>
<th>Animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ling cod</td>
<td>ratfish, whisker cod, perch, rock cod, trout</td>
</tr>
<tr>
<td>2. seagulls</td>
<td>eagles, crows</td>
</tr>
<tr>
<td>3. flounders</td>
<td>red snapper, dogfish, sockeye salmon, pink salmon, hump salmon, black bass</td>
</tr>
<tr>
<td>4. shellcrab (Dungeness)</td>
<td>bullheads, eels, crabs</td>
</tr>
<tr>
<td>5. barnacles</td>
<td>rocks</td>
</tr>
<tr>
<td>6. killer whales</td>
<td>dolphins, seals</td>
</tr>
</tbody>
</table>

- They don't go deep in the sea
- Close to the seashore, just a little way out
- You catch them from a line on the beach or a little boat
- They all fly
- Dive into the water to get fish
- They all go deep out in the sea
- You catch them in nets in the seiners
- When the tide goes down they're all under the rocks at low tide
- At the bottom of the sea
- Can see them when the tide goes down
- They swim together
- Eat fish
- Some people catch seals in nets to eat

Although several boys listed a large proportion of commercial fish, Jimmy was the only student who grouped animals from a general utilitarian viewpoint: edible or non-edible, habitats for catching fish, and types of fishing methods.

Additionally, Jimmy was the only student who generalized his knowledge of the feeding behavior and habitats of offshore commercial fish to describe the feeding behavior and habitats of seashore animals. In the following literal interview focusing on barnacles, Jimmy had little or no information about
barnacles, but notice what happens when Jimmy is asked what barnacles eat:

R. Is there anything inside it?
J. Just that hard white stuff that helps it stick to rocks.
R. Is there anything else inside it?
J. No.
R. Do you think the barnacle is an animal?
J. No.
R. So, it's just a shell and something that helps it stick on?
J. Yep.
R. Does the shell actually move around on the rock?
J. Yes. Sometimes it does.
R. Does any part of the shell move?
J. Just that sticky thing on the bottom.
R. Any idea what a barnacle eats?
J. No.
R. Do you think it does eat?
J. Yep. Those little things that float in the water.
R. Any idea how it would eat?
J. The top of it.
R. When would it eat, at high tide or at low tide?
J. Just before low tide.
R. Why would it eat just before low tide?
J. That's when all the food, all the bugs come down. (pause)
R. That's when all the fish eat. Is that what you're thinking? Is that why you think the barnacles eat just before low tide?
J. Ya.

In interpreting Jimmy's incorrect assumption about barnacles feeding, it is helpful to know that many fish feed when the tide changes, as upwellings render planktonic animals vulnerable. In an interview focusing on tidepool sculpins, Jimmy again reached an incorrect conclusion when he generalized using his knowledge of the feeding behavior of offshore commercial fish to describe the feeding behavior of tidepool sculpins. It is interesting to notice linkages between Jimmy's beliefs about the concepts pollution and conservation and his dislike for fisheries officers:

I wouldn't be a fisheries officer. Some people shoot
grew over their heads to scare them away. Everybody hates them. They're pigs. You spend all day catching fish and they order you to dump them overboard.

Clearly, Jimmy had many beliefs about seashore relationships which were consistent with accepted science ideas, and many beliefs about seashore relationships which were consistent with his own particular utilitarian orientation.

At first, Jimmy's low scientific orientation seems surprising given his wealth of experience fishing. But having a general knowledge of ecological relationships is quite different from having a general knowledge of commercial fishing. In order to succeed as a commercial fisherman, you must have information of the life history and geographic distribution of particular fish: their feeding habits, when the adults are likely to be present in each stream, their movements at sea, and the numbers that are likely to be present. The commercial fisherman must know how particular fish will react when surrounded by a net; for example, a school of salmon will generally make a wide turn to the right, hence the fisherman must turn his boat in the direction the fish are moving. It is equally important to have information on the number of fish that can be harvested in relation to how much effort and expense is required. In other words, to be a successful fisherman, it is not necessary to know the feeding behavior of barnacles, the life cycle of a starfish, the importance of the sun as a source of energy, or the effects of the tidal cycle on seashore plants and animals.
Mary

In the case of Mary there appears to be a relationship between her preferred aesthetic orientation and her beliefs about specific seashore relationships. It would appear that Mary's particular aesthetic orientation, which was grounded in the social aspects of experience, may have contributed to limiting her awareness of a range of seashore relationships. Although Mary had at least a concept of death and of food requirements, she had very different ideas about the nature of death, predator-prey relationships, competition for food, competition for space, survival, etc. Take for example, the metaphor responses: "The seashore is a family. They all share the same place where they live. They share the same food. They all seem to get along. . . It's peaceful." "The seashore is a farm. Things grow up there. They just grow, like plants that grow on a farm." "I would be a salmon. They go freely on their own way, not getting into fights. . . Being good and free."

In an attempt to understand Mary's specific beliefs about seashore relationships, it is helpful to consider her responses to my questions about barnacles:

R. Do you have any idea what a barnacle might eat?
M. Flies. I don't know. No idea. It could drink the water.
R. Would it eat at high tide or at low tide?
M. At low tide.
R. O.K. At low tide the tide goes out, so you think it might eat at low tide?
M. Yes. It could eat at high tide too. Depends on what it eats.
R. Do you have any idea of what might try to eat a barnacle?
M. No.
R. When the tide is out and the barnacles are sitting on a rock, what must the barnacle protect itself from?
M. Against humans, animals like dogs and cats.
R. Would it be very easy to eat it?
M. No.
R. When the tide is in and it's covered with seawater, would anything try to get it then?
M. No.

Obviously, Mary had little or no information about barnacles. From six literal interviews focusing on common seashore animals, it became clear that Mary had a limited understanding of the concepts predator-prey, habitat, tidal cycle, desiccation, and protection, or of the relationships among them. To see this more clearly, I focus on the concept of predator-prey. In the metaphor interviews, Mary gave only two responses which expressed an implicit awareness of the concept predator-prey, but did not identify any specific predator-prey relationships.

In the literal interviews focusing on six common seashore animals, Mary correctly identified only six predator-prey relationships, and incorrectly identified twelve predator-prey relationships:

Table 6

Mary's List of Predator-prey Relationships

<table>
<thead>
<tr>
<th>Correct Predator-prey Relationships</th>
<th>Incorrect Predator-prey Relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>eels &lt;------- bullheads</td>
<td>barnacles&lt;------ flies</td>
</tr>
<tr>
<td>fish&lt;------- seaweed</td>
<td>barnacles&lt;------ water</td>
</tr>
<tr>
<td>birds&lt;------- clams</td>
<td>dogs &lt;-------- barnacles</td>
</tr>
<tr>
<td>people &lt;------- crabs</td>
<td>cats &lt;-------- barnacles</td>
</tr>
<tr>
<td>people &lt;------- clams</td>
<td>bullheads &lt;------ flies</td>
</tr>
<tr>
<td>people &lt;------- sea urchins</td>
<td>crabs &lt;-------- water</td>
</tr>
<tr>
<td></td>
<td>dogs &lt;-------- crabs</td>
</tr>
<tr>
<td></td>
<td>clams &lt;-------- sand</td>
</tr>
<tr>
<td></td>
<td>clams &lt;-------- water</td>
</tr>
<tr>
<td></td>
<td>dogs &lt;-------- sea urchins</td>
</tr>
<tr>
<td></td>
<td>cats &lt;-------- sea urchins</td>
</tr>
<tr>
<td></td>
<td>whales &lt;-------- crabs</td>
</tr>
</tbody>
</table>


Surprisingly, Mary constructed predator-prey relationships from common household pets (dogs and cats), common household pests (flies and bugs), and from non-living material (sand and water), so that "cats eat barnacles," "dogs eat crabs," "barnacles eat flies," "clams eat sand," and "whales eat crabs." Of the six correct predator-prey relationships, three involved people and two involved broad groups of animals (birds and fish). In this case, the respondent's low awareness of the existence of seashore organisms would have limited her ability to construct predator-prey relationships. In a manner not unlike that of Jimmy, Mary substituted pets to construct predator-prey relationships. Additionally, Mary's stress on concepts such as birth, growth, and family may be associated with a young girl's view of social experience. Her stress on the concepts pollution and conservation may be associated with an aesthetic view of the seashore: "The seashore decorates where I live. It looks nice." Considering that Mary's aesthetic orientation was the most preferred, it is not surprising that she would have brought to her instructional experiences many beliefs and ideas about the seashore which were more consistent with her particular aesthetic orientation, rather than with a scientific orientation.

Anna

In the case of Anna, there were some data to suggest a relationship between her preferred recreational and aesthetic orientations, and her specific beliefs about seashore
relationships. It would appear that Anna's particular recreational orientation—which stressed social and cultural relationships and having fun at the seashore, and her particular aesthetic orientation—which stressed music, dance, and drama, may have contributed, at least in part, to a very limited understanding of seashore relationships.

More specifically, Anna expressed numerous beliefs about seashore relationships which were inconsistent with accepted science ideas. In fact, more than any other student, she was willing to make wild guesses. From both the metaphor and literal interviews, she correctly indentified only seven predator-prey relationships and incorrectly identified nine predator-prey relationships. In a fashion similar to Mary, Anna constructed predator-prey relationships from common household pets ("dogs eat sea urchins, crabs and starfish," "cats eat sea urchins and crabs") and from unlikely marine animals ("whales eat starfish" and "sharks eat sea urchins and starfish").

What was striking was her willingness to venture wild guesses. This use of imaginary associations was so extraordinary, that I include some additional excerpts from the literal interviews:

**Sea Urchins**

R. What does a sea urchin look like?
A. Well, it's like a porcupine, only except it tucks its head underneath itself.
R. You said it has a head. Where is it?
A. I'm sure it has a head somehow. . . It's very shy. I know it has a head. I've seen it, but it tucks its head underneath itself.
R. What might eat a sea urchin?
A. I don't think nothing. It's too dangerous. Unless men come to shoot it.

**Clams**

R. You have a picture of a clam at high tide and at low tide. Is there anything different about what the clam is doing at high tide and at low tide, or are they the same?

A. At high tide the clam comes out of the sand and goes into the water to get its food, and then at low tide it stays underneath the sand.

R. How does a clam move?

A. I think maybe it just opens and closes its shell for legs. It squiggles like this (moves pencil back and forth on table).

R. Can a clam protect itself in any way?

A. Yes.

R. How can it do that?

A. If a clam is open and something comes after it, the clam can just shut its shell tight and it will give an animal pain.

**Starfish**

A. At low tide it stays on a rock. Then when it's looking for food, it moves on the bottom of the ocean looking for food. Then it goes back to its rock at low tide. I think it eats at high tide too. I'm not sure.

R. What does a starfish eat?

A. Little shrimps.

R. Anything else?

A. I don't know.

R. What might eat a starfish?

A. Sharks or whales.

R. How does a starfish move?

A. On its five legs. It just goes through the sand. It goes under the sand. It moves on its five legs.

What was fascinating about Anna, was that she constantly responded to my queries as if she really knew all about seashore relationships. She gave very rapid responses, never paused to think about the questions, and seldom admitted that she simply didn't know the answers. In fact, Anna's willingness to guess may be associated with her particular aesthetic orientation which stressed the creative arts where spontaneity, substitution of words, and changing the order of events, movements, and
scenes are important. Anna's orientation may have allowed her to "invent" imaginative responses to my questions.

**Luke**

There was a strong relationship between Luke's preferred spiritual orientation, which stressed the beliefs of the traditional native Indian people of Salmon Cove, and Luke's specific beliefs about seashore relationship. Many of Luke's responses expressed ideas and beliefs about the seashore which resembled accepted science ideas. To see this, look at the underlying concepts involved in some of Luke's metaphor responses:

> The seashore is a legend. There is a legend about this man who became wild and he went down to the beach everyday and he ate mussels, clams, and abalone.

> I would be a high tide. If it's summer, the water goes out too far. I would be kind. I would put food higher on the beach.

Beneath the metaphor of the "Wild Man in the Woods" are the concepts tidal cycle and diversity of species. Beneath the metaphor of the "High Tide" are the concepts diversity of species, tidal cycle, and habitat. Although the underlying concepts of the above metaphor responses are comparatively obvious, the interpretation of the underlying concepts of other metaphor responses is more difficult, for example:

> I would be a raven. . . Raven played tricks on its cousins and brothers.

In attempting to understand the beliefs that are associated with the above metaphor response, it is helpful to know that the
Raven is commonly portrayed in coastal legends as a greedy scoundrel who steals food from other animals and must be punished. In the story known in Salmon Cove as "Crow and Raven," the Raven played tricks on Lady Crow by stealing her food. One day when Lady Crow returned home and found Raven eating her clams and part of the baby seal she had just cooked, she picked up her digging stick and beat Raven with it as hard as she could. Raven flew away screaming "Gwa-gwa-gwa." It is commonly recognized among native people that such stories portray an implicit effort to protect and secure a common food supply by not taking too much food. Considering that Luke repeatedly expressed a concern about the conservation and preservation of the seashore in several other metaphor responses, I infer a connection between Luke's beliefs about the concepts pollution and conservation and these spiritual stories.

Although some of Luke's spiritual responses expressed beliefs about seashore relationships which resembled accepted science ideas, other spiritual responses expressed beliefs which were quite different. Take, for example, the metaphor response: "The wolves looked after the tide long before anyone was born." Although Luke had at least a concept of tidal cycle, he clearly had different ideas about the nature of the tidal cycle, its origin, and its effects. Or, take the metaphor response: "If I were Gwa'wina (the raven), I would soar to catch the killer whales. Only ravens and thunderbirds can catch the killer whales." Such metaphor responses clearly indicate that Luke had different ideas about such concepts as locomotion and
predator-prey. And if I had pursued the point, I am sure he would have had many different ideas about such concepts as food chain, food web, and food pyramid. Another major distinction arises from the fact that the scientific notion of classification is quite different from Luke's, which works on a hierarchical system, from the simplest form of life to the most complex, which is man. In Luke's system, only "ravens and thunderbirds can catch the killer whales." Hence, Luke also had very different ideas about the concepts family, the origin of life, and evolution.

In keeping with traditional spiritual stories, Luke's metaphor responses portray an implicit effort to protect and secure the human connection with nature. All animals are fellow creatures, and humans are not separated from nature, but are connected with it. Luke clearly "becomes" the raven, the high tide, the Thunderbird, and the fishing boat; and the plants, animals, objects and events in nature clearly "become" human. The supernatural animals have two forms - one animal, the other human - so that animals can talk, give people advice, and aid in solving human problems.

Although Luke had many beliefs about seashore relationships which are quite different from accepted science ideas, he also had many beliefs consistent with accepted science ideas. Quite unlike Mary and Anna, he was far less likely to make wild guesses. For example, he identified twelve correct predator-prey relationships and no incorrect predator-prey relationships. In addition, he was aware of some of the more
subtle aspects of seashore relationships. For example, he knew microscopic plankton is the food of barnacles and clams, and that most seashore animals gather food at high tide and hide under rocks at low tide to avoid seagulls and other shorebirds.

In sum, all of the students' orientations appeared to interact with their beliefs about specific seashore relationships. The fact that Luke's beliefs are grounded in his particular spiritual orientation is perhaps the easiest to accept because so many of his beliefs are culturally different from the dominant society. The fact that Jimmy, Mary, and Anna all used a large proportion of alternate beliefs to describe life at the seashore is also no accident. The data suggest that when a student is presented with new or discrepant information, the various utilitarian, or aesthetic, or recreational, or health and safety aspects of an experience are used to fill the gap; hence barnacles "feed just before low tide" or "the animals all share the same food. They all get along... It's peaceful most of the time" or "nothing eats a sea urchin. It's too dangerous—unless men come to shoot it." So, the organization of each student's beliefs is related, at least in part, to his or her particular set of orientations to the seashore.
Internal Coherences Across Orientations and Beliefs

In general, the data suggest an internal coherence between the students' orientations, the particular aspects of an experience they chose to stress, and their awareness of the existence of seashore plants, animals, objects, events and conditions. For illustration, recall that several students used an aesthetic orientation to the seashore (Mary, Dan, Sharon, Luke, and Anna). Of these, the students who tended to stress drawing and painting (Dan and Sharon) had the greatest awareness of the finer details of seashore plants and animals, the student who stressed Indian carving, painting, and legends (Luke) had a good awareness of seashore plants and animals, the student who tended to stress music, dance, and drama (Anna) and the student who tended to stress music and jewelry (Mary) had a poor awareness of seashore phenomena. Similarly, students with a recreational orientation who stressed exploring and finding animals (Dan and Sharon), had a greater awareness of seashore plants and animals than students with a recreational orientation who stressed picnicking, swimming, suntanning, sailing, and surfing (Anna and Mary).

Similarly, the data suggest an internal coherence for most students, among their various orientations, the particular aspects of an experience they chose to stress, and the specific beliefs about seashore relationships they chose to stress. The student with a preferred scientific orientation (Dan), who stressed observing and looking up answers in books, stressed the
greatest range of concepts consistent with accepted science ideas. The student with a preferred utilitarian orientation (Jimmy), who stressed commercial fishing and crabbing, also stressed the concepts predator-prey and habitat, and specifically in relation to edible organisms. The student with a preferred aesthetic orientation (Mary), who stressed peace and quiet at the seashore, tended to stress the concepts birth, growth, family relationships, and habitat, but the harsher aspects of the seashore were almost completely lacking: death, predator-prey, protection, survival, etc. Except for Dan, the students with a strong aesthetic orientation (Mary, Sharon, Luke, Anna), also stressed pollution and the effects of pollution on the aesthetics of the seashore. By contrast, the student with an absence of an aesthetic orientation (Jimmy), never mentioned conservation or the effects of pollution on the aesthetics of the seashore. The students with a strong utilitarian orientation (Sharon, Luke, Anna), who stressed eating seafoods and seafoods nourishing the body, also stressed conservation and the effects of pollution on edible seashore organisms. On the other extreme, the student with a utilitarian orientation (Jimmy), who stressed eating seafoods, commercial fishing and crabbing and making money, never mentioned pollution or the conservation of edible plants and animals. The student with a spiritual orientation (Luke), who stressed Christianity and the traditional Native Indian religion of Salmon Cove, had very different ideas about almost all concepts associated with evolution or creation: birth, life cycle, death, food chain,
So it seems that the students' orientations and beliefs interact with one another, creating a coherent set of beliefs and values about the seashore. As such, the students' orientations and beliefs play a central role in defining everyday reality, that is, how they think about barnacles, tidal pools, and sun, and how they understand and experience life at the seashore. To Lakoff and Johnson, the students' experiences would be "structured wholes" within their experience and represent a "coherent organization of their experience". Perhaps the most important thing the data suggest is that the students' orientations and beliefs must be understood in terms of "entire domains of experience," and not in terms of isolated experiences (Lakoff and Johnson, 1980).

**Summary**

On the basis of these examples, I am suggesting the following conclusions about the complex relationships between the students' set of orientations and their set of specific beliefs about seashore relationships prior to instruction:

1. For most students, there was a relationship between the types of orientations held and their set of specific beliefs about seashore relationships. For example, the student with a preferred scientific orientation tended to have beliefs which were consistent with accepted science ideas. The student with a preferred spiritual
orientation tended to have beliefs which were consistent with a spiritual orientation, and so on.

2. In some cases, there was a relationship between the particular aspects of an experience the students chose to stress, their awareness of seashore phenomena, and the particular beliefs about specific seashore relationships they chose to stress. For example, the student with a preferred utilitarian orientation tended to stress the concepts predator-prey and habitat, and specifically in relation to edible organisms. The student with a preferred aesthetic orientation tended not to stress beliefs about the harsher aspects of seashore relationships: death, predator-prey, competition, survival, and so on.

3. For all of the students, there was a general internal coherence between their various orientations and their specific beliefs about seashore relationships.
Chapter 5

THE RELATIONSHIPS BETWEEN THE STUDENTS' ORIENTATIONS AND BELIEFS, AND THEIR EXPERIENCES DURING INSTRUCTION

If a student interprets science concepts as being in harmony with his or her own orientations and beliefs, then learning those concepts may be a fairly straightforward task. But if a conflict exists between the beliefs and values of a student and those presented by the curriculum, then students may have difficulty learning acceptable versions of the concepts being taught. This chapter describes and analyzes the relationships between the students' orientations and beliefs, and their experiences during instruction.

The primary purpose of instruction was to increase the students' knowledge about the basic ecological concepts of seashore relationships: tidal cycle, habitat, desiccation, predator-prey, food chain, interdependence, community, conservation, etc. The primary strategy of instruction was to take into account the students' preferred orientations by using instructional metaphors consistent with these orientations to present specific science concepts. A second purpose of instruction was to enhance the students' ability to view the seashore from a variety of different orientations through the use of instructional metaphors representative of different orientations.

The first section of this chapter describes the science concepts that were the focus of instruction (that is, the
concepts required for understanding the seashore as a complex community), and the science activities used to teach the science concepts.

The second section describes how the teacher attempted to take into account the students' orientations during instruction. In other words, how the teacher attempted to "enter" the students' own thinking in order to increase their knowledge of specific science concepts. This section begins by describing the types of metaphors the students generated, the types of questions they asked, and how they used metaphors with questions to interpret discrepant events. The section describes how the teacher used the students' own metaphors to teach specific science concepts. Finally, it describes how the teacher used instructional metaphors designed with aesthetic, or utilitarian, or spiritual images which could be elaborated in specific ways to teach science concepts.

The third section describes the relationships between each student's orientations and beliefs, and behavior during instruction. It describes what the students said and did during the science activities and relates the students' behavior to their orientations and beliefs.

The Science Concepts and Activities

In an attempt to have more students possessing a knowledge of ecological relationships, a number of activities were planned to encourage an understanding of specific science
concepts and of life at the seashore generally. The focus of instruction was the organism-tidal cycle relationship, which led to the concept of a community as a complex system of interrelated plants, animals, objects, events, and conditions. In other words, the concentration on the organism-tidal cycle relationship was aimed at helping students realize that plants and animals do not function in isolation, but interact with other organisms and with non-living objects and events in their surroundings. I will be more specific about the type of activities that were designed to teach certain concepts.

To help students understand that coastlines are made up of different types of seashores, the teacher presented a series of slides showing that seashores on the outer coast exposed to the full force of waves are impossible as habitats for most creatures, but seashores protected by islands, inlets, and bays have a great variety and number of inhabitants. To understand the different types of seashores, the students first explored their own cobblestone beaches, then travelled to Bear Island to explore a sandy beach, and visited a mudflat to discover that each type of seashore supports a different collection of habitats and a different collection of plants and animals.

Students explored the different types of seashores to discover the amazing number and diversity of seashore organisms. They discovered crabs with eggs, empty crab molts, a variety of animals at different stages of development, and shore birds scavenging among the rocks for edible items to eat. Three natural events were observed and discussed: birth, growth, and
death. The students collected marine plankton using a plankton net and observed the vast hordes of tiny plant and animal plankton with microscopes. They observed and drew sketches of a wide variety of marine plankton at various stages of development: barnacle larvae, crab larvae, fish larvae, etc.

During their trips to the seashore, the students observed the twice-daily rise and fall of the tide. Through directed observations they watched how seashore animals protect themselves from the drying effects of air, wind, and hot sun at low tide, and keep from being battered to death at high tide when the water comes in. To understand the situation of living organisms at low tide, the students observed ways seashore organisms keep from drying out: barnacles, mussels, and clams keep a moisture-filled shellhouse; shore crabs hide under rocks; sculpins either swim out to sea or slide into tidepools; seaweeds have water-filled bladders, etc. Students sat quietly at the tide line to hear the sounds of the incoming tide, walked barefoot and blindfolded with a partner to "feel" the drying effects of the hot sun and the cooling effects of the different types of habitats: among seaweeds, under rocks, in tidal pools, in sand and in mud. The students observed how the tidal cycle affects when and how seashore animals move about and gather their food. The students observed the behavior of common seashore animals at the seashore and in the aquarium and with microscopes at school. On the basis of numerous observations and discussions, the students recorded predator-prey relationships, sorted picture cards into food chains and food
webs, and constructed a food web bulletin board.

Students observed color patterns on beaches and learned that beaches are divided into zones or areas according to the length of time they are covered by water or exposed to air. The students marked off square-meter grids on dock pilings and identified and counted populations of plants and animals to discover that the collections differed depending on the vertical location on the dock piling. Back in the classroom, the students drew maps of zonation patterns, and discussed the relationships between zonation patterns at the seashore and the patterns of commercial or residential zones in a community such as Salmon Cove.

As the students observed, questioned, inferred, and investigated with living organisms, it was hoped they would become aware of how seashore plants and animals interact with one another, and with the type of shore, atmosphere, and sun in the vast network of complex relationships that constitute a community.

Last, the students explored their own beach to see broken glass, tin cans, rusty machine parts, styrofoam, and rubber tires. From these and other observations, the students discussed the impact of humans upon seashore communities. A local marine biologist visited the classroom to discuss the natural "balance and harmony" of the seashore, and relate conservation and management issues.
Taking Into Account the Students' Orientations

During Instruction

This section describes how the teacher and I collaborated in an attempt to "enter" the students' orientations and use of metaphor in order to increase their knowledge of specific science concepts. At a later point I will describe how the teacher incorporated the students' own metaphors into class discussions.

But first, I will attempt to establish a relationship between the students' orientations and the nature of their metaphorical reasoning: that is, the types of metaphors the students generated, the types of questions they asked, the way they generated metaphors and questions to interpret discrepant events.

On the Process of Generating Metaphors

During the first trip to the seashore all of the students engaged in vigorous play for long periods of time. At the outset, most students raced back and forth gathering their new-found animals into overflowing buckets. They appeared to compete for the weirdest, the ugliest, or the most dangerous animal: the "ugly hairy crab," the "electric eel," the "paralyzing sea urchin," the "blood sucking sea anemone." They asked simple questions that called for labels and one word answers: "What's that?" "Is this a plant or an animal?" "Will
it hurt?" Even when encouraged to slow down and observe, most students clung tenaciously to their behavior. The students spent most of their early time at the seashore within a pattern of high energy and low metaphoric thinking.

Then, as the activities switched to more sedentary inquiries in the classroom--sitting and observing a starfish turn over, watching crabs crawl sideways, watching barnacles feed in the aquarium--they gradually shifted into a more reflective mood. The students became more serious, although smiles and giggles were frequent. Occasionally, the students would generate spontaneous metaphors to describe a plant or an animal. When they began observing animals under microscopes, they seemed to drop back into low metaphoric discourse. The following discussion took place the first day the students began observing animals with microscopes:

Mary          Oh my God!
Sharon        Look at the crab. Look at its face. Yuk!
Anna          That's pretty. (red sponge)
Mary          Oh my God!
Sharon        Come! Look at the eyes. That looks disgusting. (crab)
Sally         That eel looks gross! Did you see its face! Take a look!
Sharon        This looks worse than that! (observing green sea urchin referring back to crab)
Anna          That looks like grass. (sea urchin's spines and tube feet)
Mary          It's gorgeous! (red blood starfish)
Sally         I don't want to eat today.
Sharon        Mine looks funny. It's got two little feelers sticking out. Look at its eyes! Gross! (hermit crab)
Anna          I'm afraid to touch it. You pick it up. (blood starfish)
Sally         Oh fuck! Look at that eel!
Mary          Oh my God! Will it hurt? (eel)
Sharon        Isn't he cute. (small six-rayed starfish)
Anna          This looks funny. It's like a little door to a house. (snail operculum)
Sandra: We got a momma sea anemone. It's got little babies attached to its sides. (brooding sea anemone)
Sharon: This big sea urchin looks worse than the little one. It's got all those funny little suckers sticking out. What are they doing? Oh gross!
Sandra: Look at the face on that red nudibranch!
Sally: Come! Look at the little things moving. (hairy crab)
Mary: Oh my God!

By comparison, on the third day the students worked with microscopes, this discussion took place:

Mary: There's spiral things. (chain diatoms)
Sharon: Hey! Looks like a shrimp. (copepod)
Anna: Are they worms? (chain diatoms)
Sharon: Those squiggly things look like a U, a writing U, or a W. Some are green with darker rings on it. Oh, there's a big one. (chain diatoms)
Anna: Looks like a flea. (copepod)
Sharon: What's those squiggly things? Neat-Oh! What's that thing that looks like a spring in a pen? A perfect view. Some are green or orange or yellow. (chain diatoms)
Sharon: Looks like a flea. (copepod)
Mary: Ya. It does. And it looks like he's got whiskers. Hairy poky things. Looks like needles. (copepod)
Dan: There goes a little fish. (fish larva)
Mary: That looks like neat curls. (chain diatoms)
Dan: Looks like a wood bug. Wooooooow! (copepod)
Sharon: That's a copepod.
Sharon: Looks like grass. (chain diatoms)
Sharon: Eeeeeeeeee! You can see its insides too. Isn't this funny? This one has a great big dot for an eye.
Dan: It's a copepod.
Sharon: It's funny. It has one red eye. It's eye looks like a ruby.
Dan: That looks neat. They're both together.
Sharon: Wow man! Neat-oh! They're mating!
Anna: How gross!
Mary: Hey, it's gone!

Back and forth the students went, alternating periods of low metaphorical discourse (lesser use of metaphoric images)
with periods of high metaphorical discourse (greater use of metaphorical images), fewer body movements, and more serious reflection. But gradually, it got easier for metaphorical reasoning to occur. Some students more than others worked for long periods of time on their own, observing, comparing, questioning, and problem solving using metaphorical reasoning. Gradually, individual thinking patterns began to emerge. Some students were highly metaphorical in their thinking patterns, others were not. Some students frequently asked rhetorical questions, some asked few if any questions at all, others mixed frequent questions with frequent attempts to interpret discrepant events using metaphorical reasoning. Then, as the students became satiated with observations of animals, or as the novelty of the experience diminished, or perhaps as more and more questions were answered, fewer and fewer periods of high metaphorical discourse occurred. It would appear that the students generated their own metaphors for the names and characteristics of animals that were unfamiliar.

**Individual Styles of Metaphorical Thinking**

To identify the students' patterns of metaphor use, I observed and looked for individual styles of metaphorical thinking. By allowing only two or three target students to use the microscopes at a sitting (only six dissecting microscopes were available), I was able to record their word-for-word observations. From time to time I questioned a student to
ensure that I understood his or her meaning for a metaphor. The following data were condensed from my field study notes.

Dan

When the students began observing plankton with microscopes, I was surprised that Dan appeared to generate proportionately fewer metaphors than most of the other students. During these first observations, Dan may have generated fewer metaphors because he simply had a greater familiarity and knowledge of marine life. But later, as the unit progressed, it became abundantly clear that Dan was not only generating more metaphors, but that he was using metaphors to describe his observations, to phrase his questions, and to make inferences about discrepant events:

(chain diatoms)
Looks like a log, a little tree. Looks like branches off a tree.

(barnacle molt)
I can see a molt of a barnacle. It's cool. It's got those legs on it. Is that what they use to catch plankton? All those little bugs going around in circles. Looks like little baby sand fleas.

(copepod with egg sac)
This one's got eyes too. It's orange and clear. Sort of looks like a tail. It's got feelers on top. Must be its antennae. It's orange in the middle of the body. Looks like a wood bug--its shape and two big feelers. How come it only has one eye? What are those bags? Maybe for carrying eggs. If those are eggs, it would have to be an adult. Is that all the bigger it gets? Do they get big? Some plankton must be as big as it will get. Some plankton must be just babies, baby barnacles and baby hermit crabs. Where do they go when they get big?

Recall from the pre-instructional interviews focusing on
barnacles, that Dan already knew that most seashore animals go through several planktonic stages before settling to the bottom of the ocean to live out their lives as adults. In the observations above, Dan observed a planktonic copepod with egg sacs attached to its body and questioned if it was an adult. The problem that Dan identified and solved was the distinction between "temporary plankton" and "permanent plankton." This is a complex distinction. Some animal plankton are temporary, and are the larvae or young stages of almost every kind of shoreline and shallow water animal--crabs, starfish, sea urchins, snails, clams, barnacles, worms, and many others. Other animal plankton are permanent, that is, they remain plankton all their lives, from egg throughout adulthood--copepods, amphipods, and hordes of others. Also, it is interesting to notice the types of metaphors generated by Dan during his experiences:

(operculum on a snail)
What's that hard thing on its foot? It's like a plate on the tip of its foot. It's a door. The snail uses that little plate like a door. Holy smokers! It's like a door that goes in and out, like a door to a house.

(sea urchin's tube feet)
Those black things with flattish ends look like little snorkles. Oh! This is what makes it move!

(barnacle cirri)
It looks like little feelers. The barnacle uses its feelers to collect plankton. It's like a rake. It's raking in plankton.

Dan appeared to prefer simple mechanical or household images. More than the other students (with the exception of Sharon), Dan made observations which permitted him to generate metaphors, questions, inferences, predictions, and make new discoveries
about the animals being investigated. Thus, the metaphors Dan generated came out of his own experiences, and were generally consistent with his own scientific orientation towards the seashore.

Mary

In the case of Mary, there was a strong relationship between her particular aesthetic orientation and her style of metaphorical thinking. The following observations of a purple shore crab were typical of Mary's thinking:

That looks like a potato.
It's oval shaped.
It's got bumps on its shell.
The claws are really big.
It's got joints even. Isn't that cool. I didn't know a crab had joints.
It's got a whole bunch of different colors.
Hey! Its mouth ... those little legs are where its mouth is supposed to be. Those things that are moving are looking for something to eat (mandibles).
It's such a gas!

Compared to Dan, Luke, or Sharon, Mary generated proportionately fewer metaphors and asked fewer questions. Also, it is interesting to notice the type of metaphor generated by Mary during her experiences:

A sea anemone reminds me of a dress with lots of ruffles.
Some seaweed looks like long feathers, like feathers on a hat.
Oooooooohh! That looks like neat curls. (chain diatoms under a microscope)
That red and green sea anemone looks like a red velvet hat.
It has one eye. Its eye looks like a red ruby. (copepod under a microscope)
That's pretty. That red nudibranch looks like a little red
pillow.

Mary clearly preferred "jewelry" or "clothing" or "hair" or "home" or "family" metaphors. Though such metaphors did not provide a single consistent image for looking at the seashore, they were, nonetheless, coherent and did fit together. Thus, Mary's own metaphors came out of her own social and cultural experiences, and were generally consistent with her own aesthetic orientation to the seashore.

**Luke**

Compared with all the other students, Luke generated proportionately far more metaphors and, in addition, generated the widest range of metaphors. The following observations with microscopic plankton were typical of Luke's metaphorical thought:

(diatoms)
It's a little forest.

(barnacle larvae)
What are those fuzzy seaweed-like things?
Those little bugs look like mosquitoes.
Look like sand too. Lots of footprints.
Moss on trees.

(amphipod)
Hey! One of those little bugs looks like a jellybean.

(barnacle molt)
What's that? A feather fan. Looks like a cocoon to a caterpillar.
It's all woven up. I wonder what it is?
Hey? Something down here looks like a butterfly.
It has wings spread out.
Oooooooh. That feather-fan looks like those feet.
It looks like that feather-fan of a barnacle.
It looks like a barnacle.
How did it get here?
I wonder how it got here.
Maybe it's seaweed.
It is interesting to notice that Luke called a barnacle molt a "feather-fan," a "cocoon to a caterpillar," a "butterfly," and all were viable and legitimate combinations. He made the connection that the "feather-fan" looked like the "feather-fan" of a barnacle," and even asked the question "I wonder how it got here?" Clearly, Luke was in the process of gathering comparisons and casting them into metaphorical shape to speculate about a discrepant event. But finally, unable to form patterns of meaning, he concluded "Maybe it's seaweed."

An additional set of observations from Luke's microscopic investigations with plankton gives further insights into Luke's metaphorical thought patterns. This time, Luke was drawing a picture of a cumacean (a type of permanent animal plankton):

Goodness, gracious me!
Looks like a plastic bag. A see-through plastic bag, like saran wrap.
It's got a little tail-like thing, like a fluffy dog.
Hey! There's red dots, blue dots, green dots.
Oh! Oh! Oh! It has to start up its motor. All its legs are going real, real, fast!
He must have a motor.
There he goes! Errrrrrrrrr!
Oooolooppss! It crashed. It's got a flat tire.
There's a big red thing attached to its nose.
It must be its feeding-bag.
Pass the kleenex please.
Its tail looks more like a bent needle. There's the thread and there's the eye.
I wonder why it's like a needle?
There's a big C in the middle of it.
That must be its intestine.
It's shaped like a C.
It must be breathing.
This is a funny animal.
It's a plastic animal.
It's like a see-through plastic bag.
It's a see-through plastic bag with a black pearl for an eye.
Goodness! I wonder why it looks plastic?
This is a wierd thing.
Goodness! Pass the kleenex please!

In the above observations, most metaphors are simple associations of color, or shape, or texture, or some combination: "looks like a plastic bag," "looks like a bent needle," "has a black pearl for an eye," "is shaped like a C."

Some metaphors appear to have no purpose at all: "He must have a motor. . . Errrrrrrrr . . . It's got a flat tire." Perhaps the only purpose was to generate a feeling or emotion, to generate a humorous aside, or a time for play. Nonetheless, Luke asks important questions: "I wonder why it's like a needle?" "I wonder why it looks plastic?" Moreover, if one stops to think about it, a "see-through plastic bag" is the perfect metaphor for the hordes of gelatinous planktonic animals that are perfectly camouflaged in a water environment. It follows that Luke's own metaphor could have been used in an instructional setting to increase his understanding of specific science concepts (e.g., predator-prey, protection, etc.). Although the teacher never heard and used the metaphor of a see-through plastic bag, it could have been used in specific ways.

It is useful to notice the types of metaphors generated by Luke during instruction:

A sea urchin is black like a bear, small like a mouse.

Hey! That shrimp jumping looks like a horse. It looks like a horse and it behaves like a horse.

A white sea anemone has a stem with fluffy stuff. It looks like a white flower with petals.

Looks like a little forest. Looks like moss.
A clingfish behaves like a little rock. It sticks onto rocks and doesn't move.

Barnacles are like little mountains.

A bullhead looks like a raindrop. It has a big head and small tail.

That driftwood looks like a white puffy cloud.

Luke was alert to natural metaphors, as opposed to space or mechanical metaphors, because he was linked to nature by mountains, forests, seashores, and animals. He was alert to home metaphors because he lived with his granny and was surrounded by needles and thread, plastic bags, and black pearls.

And finally, Luke constantly generated metaphors that appeared to have little purpose other than to cast a humorous aside:

A white sea cucumber looks like a worm that got shocked.

The hairy crab behaves like a child. It's always getting into trouble.

Hey! This barnacle's sticking its tongue out at me.

Luke clearly enjoyed capturing some of the paradox inherent in experiencing the world. This is important, for humorous asides, jokes, and riddles may be metaphorical constructions focusing on a slightly more bizarre or peculiar aspect of a situation. Thus, Luke's metaphors came out of his own social and cultural background, and were generally consistent with a range of orientations towards the seashore.

In sum, the students' own metaphors were effective devices for relating their present observations to their
previous experiences with similar concepts. Some of the students' metaphors conformed more closely to the sensory or physical aspects of an experience, and some conformed more closely to the social or cultural aspects of an experience. The metaphors that the students generated came out of their own experiences and were generally consistent with their own orientations towards the seashore. In other words, the students' styles of metaphorical reasoning—which included the metaphors they generated, the questions they asked, as well as the metaphors they used to interpret discrepant events—were generally consistent with their individual orientations to the seashore.

Incorporating the Students' Own Metaphors into Instruction

The students' metaphors were effective devices for relating their present observations to their previous experiences with similar concepts, and as such, were necessary communication devices. It was hoped that when the students' personal metaphors were incorporated into classroom discussions—making connections between the students' personal metaphors and science instruction—stronger understandings would be established by them. In other words, the students' own metaphors could be used to increase their understanding of specific science concepts.

To begin, I listened for metaphors that could be used during class discussion to teach specific science concepts. At first, this task proved far more difficult than I had
anticipated. Because of the cultural and age differences between myself and the Salmon Cove students, I found many of their metaphors difficult to hear, difficult to interpret, and therefore difficult to incorporate into an instructional setting. Moreover, the students at Salmon Cove generated metaphors which were different from the "war" or "machine" or "spaceage" metaphors I had experienced teaching in the city: "A crab is a robot." "A scallop is a jet rocket." "A snail is an armored tank." Also, most of their metaphors were highly textural in that they were associations of color or movement or shape or sound: "It's eye looks like a red ruby." "A crab looks like a potato with legs on it." "A sea urchin is black like a bear, small like a mouse." Although such metaphors allowed the students to relate their present observations to their previous experiences, and were necessary communication devices, they seldom led to new discoveries about the animals being investigated.

After several days of recording the students' metaphors, and after considerable reflection, certain clusters of metaphors emerged which I found more functional. For example, when observing the feeding behavior of barnacles, various students generated the metaphors "rake," "tongue," "feather-fan," "volcano," and "snake." (When submerged under seawater, barnacles rapidly thrust a group of feathery plumes in and out. The plume is made of six flexible appendages, or cirri, and strain microscopic plankton from the water.) I discussed with the teacher ways of using these metaphors as "entry points" for
learning by inviting the students to discuss their own metaphors and by incorporating these personal metaphors into the lesson to teach specific science concepts.

In the following classroom discussion, the students are nearing the completion of their plankton studies. At the seashore they had observed barnacles feeding in tidal pools and closed up tight on bare rocks when the tide had gone out to sea. In the classroom, they had observed the barnacles rapidly raking the water for plankton in the aquarium, and with dissecting microscopes. In the class discussion that follows, the teacher uses the students' own metaphors to explore the related science concepts "predator-prey," "locomotion," and "tidal cycle":

Teacher: What does a barnacle remind you of?
Walter: Like a feather.
David: That thing that sticks out, it's like a tongue.
Dan: It's like a fisherman too. Those legs are its net.*
Teacher: What would be the fisherman?
Dan: The barnacle.
Teacher: Why is it a fisherman?
Walter: It catches plankton.
Teacher: When is it a fisherman?
Walter: At high tide.
Teacher: Excellent! Excellent! What's inside the barnacle?
Linda: A moisture-filled chamber. **
Teacher: How do you think a barnacle sticks to a rock?
Walter: It's like glue.
Teacher: Why is it like glue? Have you felt it?
Teacher: Does it remind you of anything else?
Walter: It reminds me of a volcano.
Teacher: Has the volcano already erupted?
Walter: Yes. When it feeds.
Teacher: Is it dangerous like a volcano?
Walter: No. It's just the way it looks.
Teacher: What does the barnacle do at low tide?
Linda: It has to bring in lots of water into its shell.
Teacher: Why?
Linda: It creates a moisture-filled chamber.
Teacher: When does it eat?
Walter: At high tide when it's covered with water.
Teacher: Why?
Walter Because that's when the plankton is in.
Teacher So, if a barnacle were a volcano, when would it erupt,
at high tide or at low tide?
Walter At high tide.
Teacher Excellent!

* In a previous discussion at the seashore I used the images "fisherman" and "fisherman's net" to describe the feeding behavior of barnacles.

** "Moisture-filled chamber" is a quote from a reference book used during instruction. Also, the students "became" barnacles inside their moisture-filled shellhouses.

In analyzing the preceding classroom discussion, consider first what perceptions a student might have through his or her own sensory experiences: shapes, sounds, smells, textures, colors, patterns, etc. Consider second, what knowledge a student might have: calcareous shell, cirri (legs), tides, plankton, moisture-filled chamber. Consider third, what metaphors were discussed: for barnacles—fisherman, volcano, snake. For cirri: feather, tongue, fisherman's net, volcano erupting, snake's tongue. Consider fourth, what abstract concepts a student might develop through metaphoric reasoning: tidal cycle, predator-prey, locomotion, desiccation, protection, survival.

Clearly, the students' own metaphors were effective devices for moving from the abstract to the concrete, or for seeing familiar objects and events in new ways. Metaphors, such as "tongue", "feather-fan", "snake", and "volcano", allowed the students to do much more than just comment about some sensory detail, or relate a feeling about it. Such metaphors allowed the students to use one highly structured concept to structure another.
The teacher used the students' personal metaphors as effective devices for relating their present observations to their previous experiences. In doing this, the teacher could elaborate the student's own metaphors in more specific ways. It followed that the teacher and I might create new metaphors that could be elaborated in specific ways to give new understanding to a range of seashore relationships. This could be done by building up larger metaphors from smaller metaphors. Recall that the teacher did this by leading the students to study the scientific concept of community through the metaphor: "The seashore is a community." This metaphor allowed the students to conceptualize a seashore community in terms of their own community of Salmon Cove. This large metaphor included several smaller metaphors that allowed the study of several concepts.

The class studied the related science concepts: recycle, tidal cycle, locomotion, community, by exploring the metaphor of a "school janitor" for a crab and the metaphor of a "sanitation department" for the many collective scavengers at the seashore. In the following class discussion, the students had all observed crabs in the aquarium and with microscopes. Some students had used crabs as the focus for their science projects:

Teacher What else does a crab eat?
Jimmy Fish.
Linda He eats shrimp.
Jimmy One in the aquarium tore that shrimp in half.
He'll eat almost anything.
Dan He eats dead things too.
Teacher: A crab is like a sanitation department. It cleans up everything. What would happen here in Salmon Cove if the sanitation department quit working?

Sally: It would smell.

Mary: We would die.

Teacher: What would happen in the aquarium if there wasn't a sanitation department?

Mary: Everything would die.

Sandra: So, everybody in Salmon Cove would die if it wasn't for crabs? (everyone laughs)

Teacher: So crabs are very important. What other scavengers are at the seashore?

Dan: Seagulls. Crows.

Sharon: Sea urchins.

David: Eagles.

Teacher: Very good. We can compare crabs to janitors in schools and the sanitation department in Salmon Cove.

The crab metaphor provided a mental image of a real system to which the students could assign certain parts or properties that they could not see directly. It permitted them to relate their present observations with crabs to their previous experiences with school janitors and with the Salmon Cove sanitation department. The process of comparing a crab to a school janitor in order to shape abstract thought by giving it concrete form served as a key entry point to understanding. The successful instructional metaphor pointed to a possible explanation of how the system functions, but it could not give the students an accurate description of what really happens in the system. Usually the metaphor was simpler than the real system it represented. New metaphors fit a student's experiences in the same way as personal metaphors do: they provide coherent structure, highlighting some things and hiding other things. I hoped that these new instructional metaphors would have the
power to give new meaning to the students' beliefs about specific seashore relationships.

The teacher used "The seashore is a community" metaphor to help students understand their experiences at the seashore from a scientific point of view. This was possible because the community metaphor is commonly used by biologists to highlight the ecological aspects of the natural environment, and emphasizes the living together that lies behind the concept of community.

An additional attempt at increasing the students' knowledge of beach ecology involved constructing metaphors from a range of aesthetic, spiritual, or utilitarian images that took into account the students' orientations. It was hoped that by using a range of metaphors, we could present ideas in harmony with the students' preferred orientations, and that this instructional input would be sufficiently strong to increase their understanding and experiencing of certain science concepts. For example, we thought that, when discussing barnacles, the image of a fisherman for a "barnacle" would appeal to "utilitarian" students living in a coastal fishing community. In other words, the metaphor "A barnacle is a fisherman" was viewed loosely as a "utilitarian" metaphor designed to teach the concept of predator-prey relationships. In order to teach science concepts I devised aesthetic, spiritual, and utilitarian, etc. metaphors.
Aesthetic Metaphors to Teach Science Concepts.

The following discussion focused the students' attention on the aesthetic metaphor: "The seashore is a musical production." The metaphor was intended to increase the students' awareness of the aesthetic aspects of the seashore and, in addition, to explore the scientific concept of tidal cycle. In other words, it was hoped that by elaborating the metaphors in specific ways, we would create a system of aesthetic and scientific entailments. The discussion below took place after the students had several opportunities to increase their sensory awareness at the seashore, to sit quietly and observe a tidal pool, to walk barefoot along the tide line looking for patterns in nature, and to look, smell, touch, and listen.

Teacher If the seashore were a musical production, what would be its instruments?
Sally Birds singing.
David Whales would be making sounds too.
Teacher What would be the drums?
Mark The water. Waves making splashing sounds.
Sally The rocks would be drums. The water and the cobblestones.
Teacher What about violins?
Linda The seagulls.
David Whales, because they make squeaky sounds.
Teacher What would be the trumpets?
Jane Sea lions.
Teacher Who is the conductor?
Luke God.
David The killer whale. He's bigger.
Sharon Mother nature.
Teacher Who is mother nature?
Sharon The tide. The sun. The ocean. Everything that makes up the ocean.
Teacher What would be the voices?
Sally The sea. The wind and waves.
Linda  Crows.
Teacher What would be the theatre?
Sally  The sand.
Mary  Under the rocks. The water making sounds under the cobblestones.
David  The seashore.
Teacher Who would be the audience?
Mark  The fish.
Luke  The killer whale.
Sharon  Us.
Teacher Would the music be the same all the time?
Sally  The same.
Mary  No. It would be different when the tide changes.
Teacher When would the music sound low?
Mary  When the tide was low.
Teacher When would the music sound high?
Beth  At high tide because the water would be closer.
Teacher Would the feeling change?
Sharon  Yes. If it were a storm it would feel angry.
Teacher Good. Very, very good.

To explore what is being communicated, first consider the perceptions a student might have through sensory experience: shapes, sounds, smells, colors, textures, patterns, etc. Consider what prior knowledge about the seashore a student might bring to instruction: killer whales, eagles, seagulls, sun, wind, waves, storms, high tide, low tide, sand, cobblestones, etc. Consider what aesthetic concepts might be elaborated: beauty, ugliness, feeling, emotion, mood, change, etc. Consider what ecological concepts might be elaborated: high tide, low tide, ebb tide, change, etc.

"The seashore is a musical production" discussion comprises a range of possible aspects of an experience: aesthetic, scientific, spiritual, recreational, even health and safety. This ability of metaphor to allow movement between orientations has potential for educational applications because metaphors can be elaborated to allow individuals to explore
their own experiences from a variety of orientations, and from a range of previous experiences.

The students were able to elaborate their own beliefs about specific seashore relationships in terms of "The seashore is a musical production" metaphor. This process of comparing the "seashore" to a "musical production" or a "community," or of comparing a "barnacle" to a "volcano" or a "fisherman" in order to shape abstract thought by giving it more concrete forms, provided a key to entering the students' systems of meaning. The teacher created a lively classroom atmosphere by juxtaposing dissimilar elements, by presenting the "old" and the "new," the "commonplace" and the "bizarre."

**Spiritual Metaphors to Teach Science Concepts**

In describing the "spiritual" metaphors used in instruction, it should be acknowledged that neither the teacher nor myself attempted to encourage or discourage a spiritual orientation towards the seashore. We felt that by making connections between the spiritual beliefs of the traditional native people of Salmon Cove and specific science concepts during certain activities, the instruction would appeal to students with a spiritual orientation.

Towards the completion of the seashore unit, the students were invited to the cultural language class for two half day sessions portraying the spiritual stories, songs and dances of the native people of Salmon Cove. In order to get a clearer idea of the type of instruction that occurred, I include
several statements made by the four cultural teachers:

Many of our people's legends, especially about the killer whale and the wolf, come from preparing for the flood. White man calls Bible stories the gospel truth. Our stories he calls myths. They are not myths. They are spiritual stories. This is our religion.

If you talk to the animals, they will talk to you. Chief Henry Walker said, "If you talk to one another, you will know each other."

Everything has a spirit. My grandfather told me, "When I die, I'm going to come back as a killer whale. You will know me because I'll be big, I'll have a big dorsal fin, and I'll glide by higher in the water" . . . Chief Henry Walker said, "When I die, I want to be an eagle." When he died, a big eagle flew over his service. Burt Small, a great Indian artist from Salmon Cove, came back as a porpoise.

Our dances are a gift, not a sin. They were given to us by the transformer. Our dances are important to us. We become those animals when we dance. . . The Salmon Dance is important to the Salmon Cove people. We must not forget to dance the Salmon Dance.

Indian people made use of everything. If they wasted food, they were punished. Everything has a right to be here. Everything has a spirit. Our people believe that all animals have souls, rights, feelings. We must respect every living thing.

To take into account the students' spiritual orientations I looked for stories which could be used to give the students a general understanding of beach ecology. The following story portrays an acceptance, at least in part, of the science concepts community, interdependence, and conservation:

I'm going to tell you a story of two greedy brothers who live right here in Salmon Cove. This story took place only a few years ago, so I'm not going to tell you their names. Everytime the two brothers went seal hunting they killed more seals than they could eat. They would take what they wanted, and leave the rest. About three years ago the wife of one of the hunters got pregnant and had twins. The twins were both very sick and cried all the time. Everyone said
they sounded just like baby seals crying because they cried with such loud high pitched squeals. Some people even say they looked like baby seals. After a long sickness both of the babies died. That's because the two brothers were greedy and they wasted food. They didn't respect the seals and so they were punished.

During the session with the cultural teachers we made connections between the stories and the concepts interdependence, community, and conservation. Back in the classroom the teacher read several stories from a book of Salmon Cove legends. The students discussed the stories, made connections between the stories and the above concepts, and wrote their own legends about the seashore.

In a further attempt to take into account Luke's particular spiritual orientation, I looked for connections in his pre-instructional spiritual responses and the science concepts. Eventually, two responses indicated that Luke had at least an awareness of the concepts tidal cycle and habitat and that his understanding was grounded in the spiritual aspects of an experience at the seashore:

I would be a high tide. If it's summer, sometimes the water goes out too far. I would be kind. I would put food higher on the beach.

The tide is a legend. The wolves looked after the tide long before anyone was born.

After reading a book of Salmon Cove Legends, I found that such responses are similar in tone to the story known locally as "Turning the Tide." I have condensed the following version from the book:

It was winter and the people were hungry because there was no food. The wolf had control of the tides. He
always kept it at high water mark. The deer pretended he was dead and stole the wolf's tail. The deer held the wolf's tail over a fire until the wolf promised to let the tide go out so the people could get mussels. But the people were still hungry. They wanted clams. So the deer stole the wolf's tail again and held it over a fire. This time the wolf let the tide out further, and the people could get clams. From that day on the wolf let the tide out twice a day. Every six hours it changed. After that there was plenty of food in the village.

This story expresses an understanding of a particular relationship between the tide and the location of specific plants and animals and habitats on a shore. The scientific notion of zonation is quite similar: mussels live in the high tide zone, clams live in the middle and low tide zones, abalone live in the low tide zone, and so on.

In an attempt to develop teaching strategies which would appeal to Luke's particular spiritual orientation, I had the teacher read the story "Turning the Tide" to the class and discuss the connection between the story and the scientific concepts tidal cycle, habitat, and zonation. Then, during our sessions with the Salmon Cove cultural teachers, I had this connection reinforced.

Utilitarian Metaphors to Teach Science Concepts

In describing the utilitarian metaphors, it should be acknowledged that some activities were highly metaphorical, others were not. To give the students an awareness of the utilitarian aspects of the seashore a local marine biologist was invited into the classroom to discuss his attempts at culturing oysters and developing an oyster farm near Salmon Cove. The
students visited the docks and were invited onto seine boats to see halibut and salmon being unloaded from the boats and crab traps being stacked up on the docks. The students interviewed various fishermen regarding the type of fish caught, life on a fishing boat, how much money a fisherman makes, what a fisherman needs to know to catch fish. In this sense, we used "utilitarian" activities to reinforce the concepts habitat, predator-prey, food chain, community, and interdependence.

When the students visited the cultural teachers, several references were made to the native Indian's harvest of the sea, especially the salmon, but also seals, halibut, herring, seaweeds, abalone, scallops, clams, chitons, and sea urchins. Last, the teacher, the students, and parents collected and prepared an elaborate seafood dinner to celebrate the annual harvest of the sea: baked and smoked salmon, baked halibut, curried shark, oolichans, dried seaweeds, sauteed limpets, curried shrimp, oyster rolls, and seaweed salad. Throughout, connections were made between the utilitarian activities and the science concepts food chain, interdependence, community, and conservation.

**Health and Safety Activities to Teach Science Concepts**

The teacher and I never encouraged or discouraged a health and safety orientation *per se*. Some concern for health and safety at the seashore was inevitable, even desirable, depending on the situation. We discussed the hazards of becoming trapped by the incoming tide or getting caught in
offshore currents, or falling off the docks into deep water. We discussed falling on barnacles and slippery seaweeds. But throughout, we discouraged misconceptions about the "poisonous" or "paralyzing" or "blood sucking" seashore animals. For example, many students used the word "blood sucker" to refer to any animal they didn't know about, especially sea urchins, sea anemones, sea squirts and blennies. Some students thought that blennies (harmless eel-like fish) could deliver a powerful electric shock, or that sea anemones and sea urchins could throw paralyzing darts. In other words, we encouraged an awareness of health and safety at the seashore, and endeavored to provide students with accurate information about the potential dangers or lack thereof associated with some of the less-well known marine organisms.
The Relationships Between the Students' Orientations and Beliefs, and Their Behavior During Instruction

Consistency could be seen to exist between the students' orientations and their behavior during instruction.

The Students' Behavior During Science Instruction

Briefly described here are the individual students' behavior during the various science activities.

The Fieldtrips to the Seashore

From the outset, it was obvious that Dan was no newcomer to the seashore. He arrived at the beach appropriately dressed in rain gear and knee-high rubber boots, plastic bucket in hand. When the class was asked to sit and observe the upper tidal pools, Dan was immediately focused and relaxed. When the class collected seashore animals for the aquarium at school, Dan busily walked back and forth from the lower tidal pools to the upper tidal pools collecting animals. His painstaking handling of the animals was striking. When exploring the beach he was careful to gently turn the rocks back over, otherwise the sun would dry them out. At his own suggestion, Dan collected all the sculpins and blennies into plastic bags and floated them in tidal pools. He changed the water several times because "the temperature would get too high and the oxygen would be all used up." Towards mid-day, I noticed that several buckets of animals
had been left in the sun to bake. I suggested to the owners that they should take their animals back to the lower tidal area and let them go. Dan smiled, he had already emptied the buckets of the other students, without them even knowing it.

By comparison, Jimmy arrived at the seashore wearing fisherman's waist-high rubber pants, with shovel, bucket and fishing knife in hand. At first, Jimmy explored the upper pools looking for bullheads, eels and shore crabs; he then spent most of the day exploring the lower tidal pools or wading out into deeper water. He occasionally whipped out his long sharp knife and cut animals open to see "what kind of meat" was inside. This was not cruel behavior, simply a practical way of finding out about an animal. Although he explored everywhere, and collected numbers of animals into overflowing buckets to take back to the aquarium, he never stopped to sit quietly or to observe carefully, or to care for the animals he had collected.

Mary and Anna arrived inappropriately dressed in running shoes and wind breakers. They stayed on the upper part of the beach and refused to enter the "yucky" seaweed covered lower beach. They clung tenaciously together with three other girls and frequently screamed, swore, and had fits of nervous laughter. They spent the entire day exploring the upper tidepools and they appeared fascinated with new-found creatures. It was obvious they were seeing the great majority of organisms for the first time. As with most of our field trips, they spent much of the afternoon sitting on the beach and suntanning.

Luke arrived appropriately dressed in rain gear and
knee-high rubber boots. For most of the day, Luke stayed in the upper tide zones, only occasionally wandering down to the lower zones. For long periods of time Luke sat on a boulder with his bucket half filled with seawater and enticed Billy, Joan, Mark, and Don to bring him animals. Although he appeared to enjoy the animals, and used his binoculars to watch shorebirds, he spent more time sitting than he spent exploring the beach.

Sharon arrived with Mary and Anna and spent the first part of the day racing back and forth and screaming with the girls. Later in the day, she began to calm down and explore the lower tidal pools with Dan, Jimmy, and some of the other boys. At the outset, Sharon's curiosity and her desire to learn were extraordinary. She incessantly asked questions: "What's this? What's its name? Why is it doing that? Is this related to that?" When the class was asked to observe a tidal pool, Sharon was immediately focused and relaxed. More than the other students, Sharon brought to school prized possessions that she wanted identified: living animals, seashells, old bones, dried seaweeds. On one such occasion, Sharon brought a jar half-filled with what looked like tiny pieces of transparent confetti, 1 to 2 mm in length. After observing several pieces under a microscope, I was amazed to learn that they were the cast-off molts of thousands and thousands of planktonic crab larvae. This was a surprising discovery, for I had never in all my trips to the seashore discovered the hordes of tiny planktonic molts that are seasonally washed ashore and stranded by the outgoing tide.
In sum, the students' behavior at the seashore was consistent with their orientations. Whether they explored independently or in groups, the questions they asked, how they cared for the animals, the way they continued their investigations or sat on the beach to suntan—all were consistent with their orientations generally.

The Science Projects

In choosing organisms for their science projects, the students made choices from the following pre-selected types of seashore animals: fish, starfish, sea urchins, crabs, clams, sea anemones, and barnacles. The students were asked to observe the animals in the aquarium and with dissecting microscopes. They were asked to make a list of observations, inferences and predictions, and set up simple investigations to find out the answers to some of their questions. For the sake of brevity, I describe the science projects of four students: Jimmy, Mary, Anna, and Sharon.

Jimmy's science project was a series of investigations with clams. After observing several species of clams in the aquarium he asked a number of rhetorical questions: "Do clams dig? Are clams white? Do clams have a siphon? Do clams hide in sand? Do clams have a foot?" Jimmy asked only one question which could not be immediately answered by observation—"Do clams eat plankton?"—but obviously he knew the answer before he wrote down the question. After considerable help from both the teacher and myself, Jimmy decided to draw a series of sketches
"to identify the parts of the clam that I can see," to dissect a clam and label the parts using a book.

Anna and Mary worked together on a series of investigations with crabs. After making very few observations, they asked "How many different colors are crabs? How are crabs born? How big can crabs grow to?" and immediately went to the library to find the answers in books. When I banned library research, both students protested loudly. It was only after I assured them they could go back to the library towards the end of the week, that they returned to the classroom. After considerable help getting started, they set up some simple investigations to "see how the crabs use their feelers and their eyes," and "tested to see if the crabs would eat some frozen fish." Although much of their final report was copied from books, both students appeared to enjoy their investigations with living organisms.

Sharon worked independently on a series of investigations with sea urchins. After observing sea urchins and making very detailed drawings, Sharon asked many good questions: "What are the sea urchin's enemies? Does the sea urchin have any relatives besides different types of sea urchins? What do sea urchins eat? Does the sea urchin protect other animals? Do they have eyes? Does it have a mouth? If they do bleed, what color is it? What are all the different spines for?" After making more observations and conducting several simple investigations, Sharon concluded: "The sea urchin's relatives are the sea cucumber, starfish, and sand
They all have a five-star pattern. I was right, I gave the sea urchin some food and it eats seaweed. No, it doesn't protect any other animals. They don't have eyes. They can sense light and dark. They use their sense cells. I turned it over on its back and they do turn themselves over with the long skinny pipe-like feet. I found out it has five teeth and its mouth is on the bottom.

Dan and Sharon were clearly the most independent investigators, as evidenced by the questions they asked, the detailed sketches of organisms they made, the inferences and predictions they generated, and the interpretations they gave to their inquiries. By contrast, Jimmy, Luke, Mary, and Anna required considerably more help, generated lower level questions, and conducted simpler inquiries.

Preferred Animals

An additional way of assessing the interaction between the students' orientations and their experiences during instruction involved looking at the types of seashore animals preferred during instruction. I describe the preferred animals of Jimmy, Mary, and Luke.

When the students were given the chance to complete a science project with one of several common seashore animals, Jimmy chose "clams" as his first choice, and "fish" as his second choice. Later, when asked to construct a food chain with a set of picture cards, Jimmy's food chain included the following: herring ———> salmon ———> seal ———> killer
whale. Jimmy's food chain is interesting because it makes use of salmon and the salmon fishery is the most valuable on the west coast. This and Jimmy's choice of a science project animal is consistent with data gathered in a later interview where students were asked to list seashore animals, starting from their favorite and ending with their least favorite. Jimmy listed salmon first, crabs second, and clams third, all because "I catch them" and "eat them." He listed starfish and sea anemones last, because "I don't see them. I can't get them." When asked to write a legend, Jimmy chose the title "How the Bullhead Came to Have a Big Head," but because of Jimmy's poor writing skills, the legend was never completed. During our day-long trip to Bear Island, Jimmy discovered clams. To Jimmy, this was significant, because clams are extremely scarce on Salmon Cove beaches. In spite of frequent efforts by the teacher and by myself to encourage Jimmy to slow down and participate in the science inquiries and to explore for other animals, he spent the entire day happily digging butter clams, horse clams, and littleneck clams to take home for dinner. He wouldn't even donate a single clam for the aquarium! Whether conducting science investigations or writing stories, or exploring the seashore for animals, Jimmy clearly preferred edible or "utilitarian" animals.

Mary listed "starfish" as her first choice for a science project, and "sea urchins" as her second choice. When the students were asked to write a legend about any seashore animal they wished, Mary chose "How the Starfish Got It's Name."
Mary's food chain, not surprisingly, included a starfish: animal plankton ———> clam ———> starfish ———> seagull. Mary's preference for starfish is consistent with her prioritized list of seashore animals—she listed "sea urchin" first because it "Looks really neat: all its tentacles, its colors, the way it moves." She listed "starfish" second and gave "same reason" as her explanation. She listed "eels" (or blennies) as her least favorite animal because "I don't like eels. I hate eels. I won't touch them. It's black. Its colors. They're wicked looking." By way of a brief comparison, Anna's choices and her explanations were remarkably similar to Mary's. Both students clearly preferred brightly colored animals—those orange, red, or purple; and disliked dark colored ones—those black, dark brown, and dark green. The connection between aesthetics and the types of animals preferred is clear here.

By comparison, in choosing animals for the science inquiries, Luke chose "crabs" as his first choice, and "starfish" as his second choice. However, when asked to make a prioritized list of marine animals, Luke listed the "eagle" first and the "killer whale" second, then wrote "Thunderbird" above the eagle as his overall favorite. In other words, Luke chose "crabs" and "starfish" because his preferred animals were impossible choices for conducting classroom science inquiries. When asked to write a legend from a list of pre-selected animals, Luke chose the title "How the Eagle Came to Live in the Tallest Trees." However, because of his poor writing skills and in spite of constant encouragement, Luke never completed the
legend. Finally, I asked Luke to tell me the story he had been trying to write:

It's a story about the eagle. Why it lives in the tallest trees. How it got sharp eyes. The eagle and its friend the slug traded eyes. The eagle didn't have good eyesight. He had to watch the war canoes. The slug had good eyes, so he traded eyes.

Last, it is interesting to notice that Luke included the salmon, seal, and killer whale in his food chain: sun ---> plant plankton ---> isopods ---> herring ---> salmon ---> seal ---> killer whale. In interpreting the above data, it is important to know that among the traditional Indian people in Salmon Cove, the eagle, salmon, killer whale and Thunderbird all hold significant spiritual power. This clearly illustrates a relationship between Luke's preferred animals and his dominant spiritual orientation to the seashore.

In sum, Sharon and Dan seemed to be aware of a larger range of seashore animals and, in addition, preferred a wider range of seashore animals, regardless of their scientific or aesthetic or spiritual or utilitarian or health and safety aspects. By contrast, Jimmy, Luke, Mary, and Anna clearly preferred animals that were consistent with their own orientations to the seashore.

Pollution Study

One other science activity is worthy of discussion. It was an attempt to look at the relationships between the student's beliefs about the concepts pollution and conservation, and their behavior during a garbage pick-up day. Recall from
the metaphor interviews that Sharon, Luke, Anna, and Mary all stressed a concern about pollution and the conservation and preservation of the seashore; Dan expressed a deep emotional commitment to conservation, but never mentioned pollution; while Jimmy never expressed an awareness of pollution or a concern about conservation.

During instruction, the teacher and the students discussed the effects of pollution on the marine environment. Then, on the final trip to the seashore, the students were asked to work in pairs and collect a garbage bag full of beach junk—beer cans, broken bottles, rusty car parts, etc. Dan immediately took a bag and went off by himself to collect garbage. Mary and Anna slowly collected garbage, but when the bag was half filled declared they were finished. Luke held a garbage bag open, and ordered Mark and Bill to fill it. Sharon fell off a log and scrapped her leg on barnacles, and spent the afternoon sitting under a tree. This was unfortunate not only because of the severity of the wound, but because Sharon had made such strong emotional statements regarding pollution and conservation. Jimmy delivered a loud protest: "It's not my junk! I didn't put it here and I'm not going to pick it up! I'm going home! I said, I'm going home!" It was only after the teacher managed to turn the task into a race that resembled a sports event that Jimmy decided to participate. In fact, Jimmy's team won the race.

This type of datum is important. It emphasizes that for most students, there was a connection between their beliefs
about the concepts pollution and conservation and their behavior during instruction. At the one extreme, Dan's behavior is consistent with metaphor constructions which stress a strong emotional commitment to the conservation of living things. At the other extreme, Jimmy's behavior is consistent with an absence of metaphor constructions which emphasize a concern about conservation. Although Mary and Anna both mentioned pollution and conservation, their lackadaisical behavior at the seashore would indicate a certain lack of commitment to the care and preservation of seashore life. Luke's behavior was remarkably consistent with his metaphor constructions:

I would be a fishing boat. The fishing boat would be the seashore. I would boss people around. Keep the boat going. Keep it clean. Tell people to pick up garbage at the seashore and broken glass.

The Students' Behavior During Aesthetic Instruction

In general, there was a certain consistency between the students' particular aesthetic orientations and their behavior during instruction; that is, during instruction that focused on the aesthetic aspects of the seashore and involved art, music, dance, and drama activities. For illustration, when the students were asked to look for "natural pictures" in the jetsam and flotsam at the tide line, and for interesting colors, textures, shapes, and designs on pieces of seaweeds, beach pebbles, driftwood, feathers, etc., Jimmy refused, declaring, "It's stupid! I'm not going to do it!" On the second trip, however, Jimmy found a nice piece of driftwood, although not
without protest. He also protested during every sensory awareness activity, except for the "blind walk" on the final trip to the seashore. By sharp contrast, Mary, Anna, Sharon, Luke, and Dan appeared to enjoy all of the sensory awareness activities, and happily collected pieces of driftwood, polished beach pebbles, and seashells.

When the students painted seascapes with water colors and tempera paint, Sharon, Anna, Mary, Luke, and Dan participated fully, even enjoyed the activities. Jimmy, on the other hand, appeared afraid to paint ("I'm not good at drawing"), then went on to paint a beautiful blenny in the stylized form of Indian art. When the students made driftwood and seashell collages, Jimmy was the only target student who didn't complete his collage.

When the class dramatized the behavior of seashore animals at high tide and at low tide, several students complained that they didn't want to participate. As usual, Jimmy was the loudest protestor of all: "I won't do it. I'll go home!" At first, even the girls didn't want to join the activity. On the other hand, Dan and Luke were the stars of the show. While the teacher and I tried to organize the class (which wasn't easy) Luke and Dan delighted in "becoming" the killer whale, the salmon, and the seagull and spontaneously slithered and slid and fluttered about, and encouraged the others to join in. It was only after considerable persuasive discussion, that all of the students finally participated.

At first, the uncooperative behavior of the girls seemed
surprising as well as disappointing. I had been used to working with many other groups of grade six students at the seashore, and usually found the girls to thoroughly enjoy the drama activities. In a later discussion with Anna, however, I learned that she didn't associate the seashore drama or creative movement activities with music, dance, or even drama at all: "It's not like dancing to music. It's just moving around." To understand Anna's thinking, it is important to know that her particular aesthetic orientation was grounded in a rather narrow concept of the creative arts: the Polynesian Tinkling Dance, the singing of Olivia Newton-John, piano lessons, ballet, the classical music of her father. Hence, the uncooperative behavior of Anna can be interpreted as a reflection of the type of instruction that occurred on that particular day, and her particular aesthetic orientation to the seashore.

Last, when the class explored the "The seashore is a musical production" metaphor, it is interesting to notice that Mary, Sharon, and Luke actively participated in the discussion, while Jimmy never volunteered a single response. Considering Jimmy's low usage of an aesthetic orientation, and the other students' aesthetic orientations, this type of behavior is not surprising. It illustrates a relationship for all of the students between their aesthetic orientations, how they perceived a particular activity, and their behavior during instruction.
The Students' Behavior During Spiritual Instruction

In general, a certain consistency could be seen to exist between the students' particular spiritual orientations, and their behavior during instruction that focused on the more spiritual aspects of the seashore. For illustration, when the students were first invited to visit the Salmon Cove cultural teachers, Mary and Anna acted as if they didn't want to be associated with the native Indian program at all; Sharon seemed non-committal; Luke, Dan, and Jimmy looked forward with enthusiasm to their visit. However, during the first session, the students gradually became quite interested in the stories and discussions. Prior to the second session with the cultural teachers, the general mood of the class was one of enthusiastic anticipation. Nonetheless, at the end of the second session, when the students were asked to dance the Salmon Dance and Luke and Dan enthusiastically volunteered, Mary refused at first, and only took part when Anna and Sharon reluctantly joined the group. Once again, when the students finally participated, they appeared to enjoy the activity. Anna's participation was particularly striking. Although she had not danced the Salmon Dance since the primary grades, her recollection of the finer details of the dance was exceptional: the undulating swimming movements of the salmon, from the dip of the head to the splash of the tail, all performed with extraordinary grace and poise.

Last, in an attempt to describe the relationships between the students' spiritual orientations and their behavior
during instruction, I describe in more detail the behavior of Luke, the student with a preferred spiritual orientation to the seashore.

Recall that Luke's particular spiritual orientation was grounded in both the spiritual beliefs of the traditional native Indian people of Salmon Cove and in the fundamentalist beliefs of the Pentecostal Church. The following excerpt from the class discussion of "The seashore is the musical production" metaphor illustrates an interaction between Luke's spiritual beliefs and his behavior:

Teacher: What would be the trumpets?
Luke: Killer whales
Teacher: Who is the conductor?
Luke: God
Teacher: What would be the voices?
Teacher: Who would be the audience?

Similarly, when the teacher used the metaphor "The seashore is a battleground" to discuss a story about the changing coastlines, notice Luke's usage of biblical imagery:

Teacher: What would be the battleline between the land and the sea? The line between the two armies?
Sally: Where the water attacks the homeland.
Teacher: In the story, it says that a big battle takes place, and then there is a calm. What is the calm?
Luke: Jesus Christ is coming.
Mark: The storm is over. The tide is out.
Teacher: O.K. Good. The storm is over.

This type of biblical imagery illustrates the relationship between Luke's particular spiritual orientation and his behavior during instruction. He may have made a connection between the metaphorical instruction that occurred: "battleground,"
"armies," "homeland," and certain biblical metaphors. It shows how a student's behavior, which might be annoying in an instructional setting, may be interpreted as appropriate given a different frame of reference.

In sum, the students' behavior during instruction was generally consistent with their preferred orientations towards the seashore. The types of metaphors they generated, the types of questions they asked, the way they explored the seashore and conducted their science investigations, the animals they preferred for their science inquiries and their creative writing, the way they volunteered or protested during drama activities or the sessions with the Salmon Cove cultural teachers, or the fact that Dan independently filled his garbage bag while Jimmy attempted to go home—-all of this suggests that the students' behavior during instruction was generally consistent with their preferred orientations and their specific beliefs about seashore relationships.
Summary

On the basis of these examples, I am suggesting the following conclusions about the relationships between the students' orientations and beliefs and their behavior during instruction:

1. The data suggest a relationship for all of the students between the type of orientations held and their behavior during certain types of instruction. Complete consistency between the students' orientations and behavior was rare; a general consistency was typical.

2. The data suggest a relationship for all of the students between the type of orientations held and their individual metaphorical thinking (e.g., the types of metaphors generated, the types of questions asked, the way they mixed metaphors with questions to interpret discrepant events).
This chapter describes and analyzes the students' orientations and beliefs after instruction, and relates the changes in beliefs to the students' initial orientations and to the type of instruction that occurred. Recall that the primary purpose of instruction was to increase the students' knowledge of the basic ecological relationships. A secondary purpose of instruction was to enhance the students' ability to view the seashore from a variety of different orientations.

To begin this chapter, I describe in some detail the students' beliefs about specific seashore relationships after instruction. Then, I describe the orientations that the students used to describe the seashore. For each student there was a complex relationship between the student's preferred orientations, the instructional input, and his or her beliefs about seashore relationships after instruction. The orientations that the students brought to instruction helped shape the ways they responded to and interpreted science instruction. These relationships then, are described and documented in the third section of this chapter. Fourth, I describe and analyze the stability of the students' orientations and beliefs six months after instruction. Last, I discuss the potential effect of an increase in knowledge of science concepts on the students' preferred orientations towards the seashore.
The Students' Beliefs After Instruction

In an attempt to describe in detail the nature and dynamics of the students' beliefs after instruction, I begin by reviewing the types of data which can be taken as support for an increased knowledge of basic ecological concepts:

1. the elaboration of an existing belief (the belief was identified prior to instruction, but it now is more intelligible, it possesses more explanatory power, and there are additional examples);

2. the appearance of new beliefs about seashore relationships (the belief was not identified prior to instruction);

3. an increased awareness of the complex relationships among concepts (e.g., the relationship of tidal cycle, habitat, desiccation, and protection);

4. the decrease of alternate beliefs (beliefs inconsistent with accepted science ideas).

For the sake of brevity, the beliefs described in the next few pages are summaries of the above types of data. I begin with a general summary of the students' awareness of seashore phenomena and their beliefs about seashore relationships. Then, I include the critical metaphor choices and the responses that represent the type of data taken as support for the change. At a later point, I provide a more detailed analysis of individual students' beliefs. These data are taken from both the metaphor and the literal interviews. Last, I analyze all the data to describe a relationship between
the students' orientations and beliefs.

The results of the post-instructional interviews show that all of the students expressed a much greater awareness of seashore phenomena, as evidenced by a much longer set of spontaneously generated names of seashore plants, animals, objects, and events than in the pre-instructional interviews (Appendix D). Instead of listing prototypes such as crabs or clams or seaweeds, all of the students listed specific species of animals: for example, different species of crabs (purple shore crab, decorator crab, hermit crab, oregon rock crab, edible crab, mud crab, spider crab, king crab, porcelain crab) and different species of seaweeds (kelp, sea lettuce, rockweed, rainbow seaweed). Additionally, more students listed different types of habitats (mud, sand, cobblestone, gravel, tidal pools), different types of seashores (sandy beach, rocky beach, cobblestone beach, mudflat), and different types of objects and conditions (sun, air, wind, tides, storms, oxygen, salt, currents, high tide, low tide). All of the students listed plankton, some distinguished between plant plankton and animal plankton, and some listed specific families of plankton (copepods, isopods, amphipods).

To varying degrees, all of the students used a more elaborated scientific vocabulary to describe the seashore: "energy," "predator-prey," "habitat," "protection," "food chain," "zonation," and "community." Also, all of the students used a greater repertoire of explicit terminology: "tube feet," "siphon," "tentacle," "camouflage," "carnivore," "herbivore,"
"scavenger," "plant plankton," "animal plankton," "high tide zone," and "low tide zone."

The Elaboration of Existing Beliefs

Recall from the pre-instructional metaphor interviews, that all of the students expressed at least an awareness of the concept of habitat—generally "on rocks" and "under rocks." By comparison, after instruction all of the students expressed a more elaborated awareness of the concept of habitat:

Mud is a tunnel. There's tunnels in the sand from worms and clams. . . The animals go in them and through them. They travel around hunting and making tunnels as they go.

Dan

Sand is a sandcastle. All the different kinds of animals that hide in the sand. All the different animals have private places, private homes, like a castle does.

Luke

Similarly, while all of the students expressed at least an awareness of predator-prey relationships in the pre-instructional interviews, all of the students expressed an awareness of additional predator-prey relationships after instruction. For example:

A starfish is a can-opener. This is just imagination. This is just like how it opens the clam. The clam's the can and the starfish is the opener.

Anna

A sea anemone is a mouse trap. The tentacles are like teasing, moving around, calling the fish. Some fish might be curious to see what it is. The sea anemone grasps it and stings it to death.

Sharon
A sea urchin is a lawn mower. It might seem like a lawn mower because the sea urchin eats seaweed and it just comes and chomps up the seaweed as it goes along with its five teeth on the bottom where its mouth is.

Dan

A clam is a vacuum cleaner. All the clam has to do is open its mouth and it's got some food and it's like it's sucking it out with a siphon. A vacuum cleaner sucks the dirt for food, that's his food, and then it throws it away after. But that's what a clam does too. It sucks it's food in and it doesn't eat the whole thing.

Anna

The clam response is particularly interesting because it illustrates an awareness of some of the more subtle aspects of food relationships. During instruction, the clam was portrayed as a "sloppy eater." It filters in plankton through its siphons, but loses much of its food through the mantle cavity, whereupon sculpins and other scavengers gobble up the rest.

For all of the students, there was a more elaborated awareness of the concept of protection. For example:

I would be a purple starfish. It's not as bright as the other two. With the Sun Star and the Sunflower Star . . . their color is a traitor to them.

Sharon

A crab is a mobile house. It could be a mobile house because its shell is its house. It's for protection. Our house is for protection from rain, snow, wind. The crab's house provides protection from other animals.

Luke

Although all of the students had at least a concept of birth, growth, and death prior to instruction, several students expressed a more elaborated awareness of the concept of life cycles with reference to the larval stages of planktonic animals. For example:
The tide is a legend. The tide brings in and out new lives. It brings in animals at different stages in their lives, like little animals that are just born, some are half grown like little plankton.

Sharon

The Emergence of New Beliefs

In addition to more elaborated beliefs, a number of new beliefs were identified in the post-instructional interviews. For example, while two students had expressed an awareness of animals that recycle the remains and wastes of other animals (Dan and Sharon), most students had not. For some the concept of recycle was completely new (Mary and Anna):

A seagull is a janitor. It cleans up the garbage on the beach. It's a scavenger. A janitor cleans up places.

Mary

A crab is a garbage collector. It's sort of like a scavenger too. It cleans up animals that are dead.

Mary

A bullhead is a vacuum cleaner. The motor can be its big head and the rest can be the tail. It seems like when it swims along it gets food to eat. It's just like a vacuum cleaner, as it goes on the carpet it gets dirt. Like the vacuum cleaner, the bullhead cleans the tidepool.

Anna

Several students expressed a new awareness of types of seashores. For example:

The seashore is a patchwork quilt. All the different types of beaches: sandy beach, pebble beach, cobblestone beach, mudflat.

Luke

The tide is music. When the tide's coming in, it makes splashing sounds. It can sound like music. It depends on the type of beach. You have different sounds for rocks, sandy and cobblestone beaches.

Anna
For most students, an understanding of the sun as a source of energy was a new concept. For example:

The sun is a factory. It's an energy factory for plants, giving them what they need to grow.

Sharon

I would be a sunny day. I would be "Klisila" and make things grow: trees, and grass, and seaweed.

Luke

I would be a sunny day. . . I could help things grow: seaweeds and plants.

Mary

Several students expressed a new understanding of the concept of zonation. For example:

The seashore is a totem pole. It's a totem pole because of the tide zones. A totem pole has different animal designs that tell different stories along the pole. There's different animal designs going up and down the pole: like a bear, then an eagle, and a man. That's like low tide, middle tide, high tide, and spray zone.

Dan

I would be a boulder. I would be a boulder and be a hotel for animals. . . the different zones of the animals that had a place for a starfish, sea anemone, and a place for sea urchins and barnacles.

Luke

A new awareness of the concept of interdependence and conservation were also evident, as for Mary:

The seashore is a totem pole. They all depend on one another to live. Like on a totem pole, there's a picture, then another and another one, going on up to the top. The seashore seems like that to me.

I'd be the flower and the seashore would be the blackberry bush. A flower grows on a blackberry bush. When I was little I used to go to the seashore a lot. I used to go looking for crabs. I usually brought them home, and they would die. I was really stupid.
Complex Relationships Among Beliefs

For all of the students there was a new awareness of the complex relationships among the concepts tidal cycle, desiccation, habitat, and protection:

Seaweed is a curtain. It makes it so you can't see the rocks underneath. It keeps the sun out. It keeps the light from hitting the rocks for the animals that have to keep moist.

Dan

I would be a gentle breeze. I would be a shade and make it cool so people wouldn't get sunburned and animals wouldn't dry out.

Luke

Some students expressed a new awareness of the complex relationship of tidal cycle, habitat, predator-prey, and locomotion on a beach:

A cobblestone is a hotel. Animals come and go. In a hotel they either check in or check out. Some crabs or starfish move around, they go to different rocks. Like, if a crab goes out, he doesn't go back to the same rock. He goes to another rock. At high tide the crab goes out for food, then at low tide he would go back under a different rock.

Sharon

Although Sharon had at least a simple awareness of a cobblestone as a type of habitat in the pre-instructional interviews, she showed a greater understanding of a cobblestone as a type of habitat by connecting the concept to several related concepts, for example, to the concept of locomotion: "Like if a crab goes out, he doesn't go back to the same rock, he goes to another rock." The concept of habitat is also connected to the concepts tidal cycle and predator-prey: "At high tide the crab goes out for food, then at low tide he would go back under a different
Several students expressed a new awareness of the complex relationship of predator-prey, food chain, and interdependence:

The seashore is a patchwork quilt. If one piece goes missing, the whole thing falls apart, meaning the food chain. Like, if clams were to disappear, lots of other animals would suffer from it, gradually something would disappear.

Mary

The seashore is a necklace. All the animals are like a necklace. When one dies, that's one bead from the necklace gone. But usually, another one grows up to take its place. They're all linked together through the food chain. And that's like a necklace too.

Sharon

Last, some students expressed a new awareness of the complex relationship of types of seashores, types of habitats, predator-prey, community, and interdependence:

Mud is a pot-luck dinner. All the little mudflat animals like mud-shrimps and worms are a pot-luck dinner for the sandpipers.

Sharon

Mud is a tunnel. It would be a tunnel because there's tunnels in the sand from worms and clams; the animals go in them and through them. They have two ends to move from one spot to another. They travel around hunting and making tunnels as they go.

Dan

In the above metaphor responses, Sharon and Dan showed a more elaborate understanding of the mudflat as a type of community by connecting the concept to several related concepts. Sharon noted that certain collections of organisms live in mudflats and that mudflats support predator-prey relationships. Dan, too, recognized the relationship of community and predator-prey when he said the mudflat animals "travel around hunting and making
tunnels as they go."

**The Decrease of Alternate Beliefs**

For some students there was a marked decrease of beliefs inconsistent with accepted science ideas. For example, Mary and Anna no longer exclusively stressed the "peaceful" and "cooperative" aspects of the seashore, but were able and willing to stress the harsher aspects:

**The seashore is a graveyard. Sometimes there's lots of crabs or other animals dead.**

Mary

The seashore is a battleground. If two animals at the seashore have a fight, like a clam and a starfish, it would be just like a battleground. The water can be the battleground where they hold their battle.

Anna

I would be a gentle breeze. A hurricane would wreck houses. It could push all the logs and rocks around and crush barnacles and crabs. It's like that war between the land and the sea.

Anna

Also, Mary and Anna no longer constructed predator-prey relationships from common household pets and pests such as dogs, cats and flies, but correctly identified predator-prey relationships:

A barnacle is a fisherman. Its legs on the inside pull things inside, like a fisherman does with his net. It's pulling in food, its plankton.

Mary

A starfish is a burglar. When it sucks up the clam, it's like stealing from the clam, its body. It's actually eating to survive.

Anna

Quite unlike the pre-instructional interviews when all of the
students gave confused descriptions of the organism-tidal cycle relationship, most students correctly described this relationship:

A barnacle is a rock. It just sits there doing nothing—just like a rock. It fishes and opens its front doors and fishes at high tide and eats its food. When its low tide it sits on a rock and its doors close.

Luke

A clam is a vacuum cleaner. Its siphon comes out at high tide and it gets plankton. A vacuum cleaner sucks up dust.

Jimmy

What this means is that after instruction, all of the students had begun to give back metaphor responses showing a more sophisticated and scientifically acceptable view of the relationships among seashore organisms and natural phenomena (sun, tidal cycle, type of seashore, etc.).

Summary

1. For all of the students, there was an increased knowledge of basic ecological relationships. All of the students expressed a much greater awareness of the existence of seashore plants, animals, objects, etc. All of the students showed a marked increase in the relative proportion of beliefs consistent with accepted science ideas, and a marked decrease of alternate beliefs.

2. It would appear that the primary purpose of instruction, which was to increase the students' knowledge of specific science concepts, was achieved.
To begin this second section, I provide a brief summary of the use that each student made of various orientations to describe the seashore after instruction. Then, I provide a description of the student's willingness to view the seashore from a variety of orientations. At a later point, I provide a detailed description of Jimmy's use of orientations after instruction. For the sake of brevity, I describe only orientations used by Jimmy, but at many points I have included critical metaphor responses which enhance an appreciation of Jimmy's understanding and are generally illustrative of the other students' use of orientations.

After instruction, all of the students showed a shift towards more scientific responses. For most students, there was an increase in the proportion of scientific responses, and a decrease in the proportion of aesthetic, utilitarian, spiritual, or recreational responses (Mary, Jimmy, Luke, Anna, Sharon). For some students there was a decrease in the proportion of health and safety responses (Luke and Jimmy).

The Diversity of Orientations

As I discussed previously, a second purpose of instruction was to enhance the students' willingness to view the seashore from a variety of different orientations. That is, it was hoped that there would be a more detailed and clearly
delineated awareness of some of the more subtle aspects of, for example, the aesthetic, utilitarian, spiritual, etc., aspects of the seashore.

As seen in Chapter IV, some students more than others used several orientations to describe the seashore. After instruction, there was a greater tendency for all of the students to display a diversity of orientations with a single metaphor:

The seashore is a gift. It was given to us to use, and we use it. We're supposed to use it properly. It's like a special gift that was given to us to use. The fisherman use it for fish, people use it to learn about it, and for fun too.

Sharon

I would be the team and the seashore would be the hockey puck. The team uses the puck and we use the beach. We use the seashore for learning and collecting things for art. Song writers write poems about it, and about the many people that use the beach, or just to have fun.

Sharon

I would be the thorn and the seashore would be the blackberry bush. I would be the thorn to protect the berries. Some blackberries are hard to pick off the bush, so you have to use gloves. The gloves protect your hands. I would be a thorn protecting the seashore from people throwing garbage on the beach. There would be no place to swim, no place for children to play, no place to dig clams.

Luke

More than the other students, Sharon consistently responded to a metaphor with a much more complex concept of the seashore. She was alert to the multiple uses of the seashore and quick to weave this broad knowledge into numerous metaphor responses. At the other extreme, Jimmy consistently responded to a metaphor
with a much simpler concept of the seashore. Hence, this tendency to establish multiple orientations clearly depends upon the complexity of thought that the metaphor stimulates in revealing the students' understanding of the seashore.

The best examples of a more explicit knowledge of the aesthetic aspects of the seashore also come from Sharon. For illustration, in the pre-instructional interviews Sharon didn't choose the metaphor "A tidal pool is a painting," but in the post-instructional interviews she gave the following response:

A tidal pool is a painting. Sometimes the animals, they're really still and sometimes they're really changing. In a painting, sometimes things are really still and sometimes they're really changing. You see things moving. The ocean itself is like a painting because of all the bright colors and because of all the colorful animals and seaweeds. The shades of the colors really change. In the ocean, it changes with the sky color. If the sky is gray or silver the ocean is gray or silver too.

Notice the attention paid to the quality of sensory impressions: the constantly changing colors, textures, and movements which capture the general on-goingness of the seashore. The fact that Sharon had a strong aesthetic orientation that was based largely on painting and drawing suggests a relationship between her previous experiences with art, a readiness to take in the aesthetic details of an experience at the seashore, and an ability to creatively extend certain types of metaphors.

Some students mentioned the traditional spiritual stories of Salmon Cove for the first time:

A clam is a legend. There is a story to the clam. There is a legend, but I don't know it.

Mary
The seashore is a legend. If you look at the rocks or cliffs around seashores, you can see how the land has changed. You can see what happened long ago, what the earth's crust was like, or fossils. As well, there's many legends that are about the seashore animals: about salmon and how the salmon came from the shore. There's a lot of legends associated with the sea in the Salmon Cove legends.

Dan

The seashore is a totem pole. It's like a totem pole to the Indians. Each carving on it is like a story. The sea is like that too. It goes on and on from when the sea began life, from the beginning until now. Before there probably weren't many animals. And now there's more.

Sharon

The seashore is a legend. Like the totem pole, it's a legend of the sea. There's a legend in Salmon Cove telling about it, like a story. That's like fossils and rocks and scrapes. Like a totem pole, it's like the story of life repeating itself over and over, birth and death and animals living, repeating itself over and over.

Sharon

What this means is that students continued to use a variety of orientations to view the seashore, and for some students there is evidence of willingness to use new orientations. They can begin to understand the interdependence of organisms both upon each other and upon natural phenomena (tides, nature of the beach, etc.). Hence, one can say that their ability to use a scientific orientation to describe the seashore has been enhanced. However, the fact that many of the students continued to use other orientations, and in some cases to use new orientations, is important in that it provides evidence that the second objective was also achieved. Students are able and willing to view the seashore from multiple orientations.
Coherences Across Orientations

The data suggest a certain internal coherence for each student among their orientations, and a certain external coherence between each student's set of orientations and the type of perceived physical and cultural environment. I chose to document the case of Jimmy in detail because his responses nicely illustrate the changes which occurred between the interpretation of the word "seashore" prior to and after instruction, and in particular, the relationships between these changes and his use of orientations before and after instruction.

The results of Jimmy's post-instructional interviews pointed towards a predominant proportion of scientific responses. First, there was an increased awareness of many seashore relationships which were identified in the pre-instructional interviews. Several responses expressed an awareness of additional predator-prey relationships:

A barnacle is a fisherman. When it's high tide there's something that comes out the top to catch the plankton. It's like a fishing net.

A starfish is a can-opener. When it finds clams, it just puts a clam underneath it, and cracks it open and eats it.

A sea anemone is a mouse trap. It traps little animals with its tentacles.

In addition to the two types of habitats identified in the pre-instructional interviews (under rocks and on rocks), two new types of habitats were identified (in tidal pools and on dock
Several new beliefs were identified which were not identified in the pre-instructional interviews. For example, in relation to the concept of protection:

A crab is a robot. It moves its legs really slow. It just can't move that fast. A robot can't move fast either. It has a hard shell that protects it like a robot.

There was a new awareness of the relationships among the concepts tidal cycle, desiccation, habitat and protection:

I would be a roof to a house. It protects people from rain, snow, and sun. That's like at low tide a rock protects all the animals from drying out.

Although there was an increased awareness in Jimmy's responses about seashore relationships, there continued to be a conspicuous absence of several of the more abstract relationships associated with beach ecology.

Jimmy still exhibited many aspects of a utilitarian orientation, but there was a marked decrease in the number of utilitarian responses. Quite unlike most pre-instructional responses, which suggested an emotional attachment to commercial fishing from a boat, most post-instructional responses expressed concern with the utilitarian aspects of the seashore:

The seashore is a farm. You could eat the edible crabs if you could find them.

I would be cloth to a curtain. You need cloth to put on a window. You could put curtains on a window and you could put crabs and clams in buckets. You could take them home, if you could find them.

Interestingly, some metaphor responses stressed fishing from a line on the beach:
The tide is a gift. When the tide is in, it's easier to get fish and when it's out, it's harder to get fish. The tide is like a gift because you can get fish.

Similarly, a health and safety orientation continued to be evident, but was markedly decreased. Quite unlike most pre-instructional responses which stressed the hazards of commercial fishing while at sea, most post-instructional responses stressed hazardous animals and conditions at the seashore:

A barnacle is a thumb tack. When you step on it you can get hurt, cut.

I would be a lock to a necklace. A lock could pinch, just like a crab could pinch. Like that clam closing on my fingers or how that big red crab can cut you open with its pinchers. Some of them really hurt.

The seashore would be the thorn to a blackberry bush. . . because of all the broken glass and rocks and stuff that could cut you.

There continued to be responses in Jimmy's post-instructional interviews that were suggestive of a recreational orientation:

I would be a sunny day. All the people go on the beach and go swimming. You can walk around in your shorts.

I would be a high tide. At low tide you can't jump off the dock and go swimming or take your boat out and ride around and look at stuff.

The sun is a furnace. . . When the sun is out it heats up the whole beach so you can go swimming and have a picnic on the beach.

Only three of Jimmy's post-instructional metaphor responses expressed an aesthetic orientation to the seashore, although Jimmy is not very convincing as an admirer of natural
beauty:

A sea anemone is like a flower. Those white tentacles come out and it looks like a flower. It's kind of pretty.

A sea urchin is a sunburst. It's round and those poky things could be the sun's rays. It's sort of pretty.

A tidal pool is a painting. When the tide goes out, it leaves a pool and it looks like a painting when you look at it from far away. It's got rocks and water.

Jimmy's reference to "It's kind of pretty" and "It's sort of pretty", and the low proportion of aesthetic responses, suggests that within a schooling context he does not prefer to see the seashore as a place of natural beauty.

In the context of this study, Jimmy has changed from using a predominant number of utilitarian responses to describe the seashore, to one using a predominant number of scientific responses. Although Jimmy continued to use a utilitarian orientation, he used it less frequently, and there was a shift in emphasis from commercial fishing to edible seashore plants and animals. Jimmy continued to exhibit a health and safety orientation, but the emphasis was on hazardous seashore animals and conditions rather than on the hazards of commercial fishing. Several responses also continued to stress the recreational aspects of the seashore. A spiritual orientation to the seashore was still absent. Although Jimmy made some mention of the aesthetic aspects of the seashore, the number of responses was small.

In explaining a shift in the use of orientations, recall that prior to instruction Jimmy interpreted the word "seashore"
broadly as the offshore water and open ocean; after instruction he interpreted the word "seashore" more specifically as the inter-tidal region between the land and the sea. The fact that Jimmy interpreted the word "seashore" as two different physical environments affected the system of metaphorical connections he chose to stress. Prior to instruction, there was a certain external coherence between Jimmy's particular set of orientations—his almost equally predominant utilitarian and health and safety responses—and the type of physical environment that is frequently associated with commercial fishing. After instruction, there was a certain external coherence between Jimmy's decreased utilitarian and health and safety responses. Although Jimmy's utilitarian responses continued to be associated with commercial fishing and making money, there was a much greater stress on edible seashore plants and animals: clams, crabs, seaweeds. His health and safety orientation was no longer associated with the hazards of commercial fishing, but with hazardous seashore animals and conditions. So it seems that the effect of instruction was to allow a shift in Jimmy's thinking from the ocean to the seashore which resulted in changes in the orientations he used.
Summary

On the basis of these examples, I am suggesting the following conclusions about the nature of the students' orientations after instruction:

1. All of the students showed a shift towards more scientific responses. For most students, there was an increase in the proportion of scientific responses, and a decrease in the proportion of aesthetic, utilitarian, spiritual, or health and safety responses.

2. To varying degrees all of the students were able and willing to view the seashore from several more elaborated orientations. Hence, the second purpose of instruction, which was to enhance the students' willingness to view the seashore from a variety of orientations was achieved.

3. The data suggest a relationship between the students' interpretation of the word "seashore" and their set of responses to the seashore. A shift in a student's thinking from the "ocean" to the "seashore," for example, results in changes in the students' use of orientations.

4. For all of the students, there continued to be an internal coherence among their orientations, and an external coherence between their orientations and the type of perceived physical, social, and cultural environment.
The Relationship Between the Students' Orientations and Their Beliefs After Instruction

In this section, I show the relationship between the students' preferred orientations, their awareness of certain types of seashore phenomena, and their set of beliefs about specific seashore relationships. I show that after instruction, there continued to be a relationship for some students between their preferred orientations, and the particular beliefs they chose to stress.

The Students' Orientations and Their Awareness of Seashore Phenomena

It is clear that all of the students expressed a greater awareness of the existence of seashore phenomena after instruction. The particular characteristics of each students' awareness continued to be related to their preferred orientations. For example, Luke's list of seashore phenomena has the eagle first, the raven second, the killer whale seventh, the seal eighth, and mink ninth—all important supernatural powers in Salmon Cove mythology. Mary listed four species of starfish (blood star, sun starfish, sunflower starfish, six-rayed starfish), more than any other family of organisms, suggesting a continued relationship between Mary's particular fascination with starfish and her aesthetic orientation.

On the other hand, it is interesting to notice that
Jimmy began listing seashore animals (clams, sea anemones, sea urchins, crabs), before listing a great number of commercial fish as well as seals, dolphins, and killer whales. These data suggest a relationship between Jimmy's prior interpretation of the word "seashore," the type of instruction that occurred, and Jimmy's interpretation of the word "seashore" after instruction. And while it suggests a relationship between instructional input and the priority of items on the list, it also illustrates the continued importance of certain edible or commercial animals to Jimmy's thinking about the seashore.

The Students' Orientations and Their Beliefs About Specific Seashore Relationships

In order to see, in some detail, the relationship between the students' orientations and beliefs after instruction, I discuss the case of each student.

Dan

Although Dan expressed a remarkable knowledge of seashore relationships prior to instruction, he expressed an even more detailed knowledge of seashore relationships after instruction. First, a number of beliefs identified in the pre-instructional interviews were more elaborated in the post-instructional interviews: diversity of organisms, habitat, tidal cycle, locomotion, predator-prey, protection, recycle, life cycle, energy from the sun, and conservation. For example,
after instruction Dan identified twenty-seven predator-prey relationships and no incorrect predator-prey relationships. In addition to the three types of habitats identified in the pre-instructional interviews (under rocks, in tidal pools, and in mud), Dan identified two new types of habitats (among seaweeds and in sand). Second, Dan expressed beliefs about several new concepts: types of coastlines, types of seashores, desiccation, food chain, zonation, interdependence, and community. Third, there was an increased awareness of the complex relationships among concepts: the relationship of tidal cycle, desiccation, predator-prey, habitat, and protection; the relationship of habitat, types of coastlines, types of seashores, protection, and community; and the relationship of predator-prey, food chain, interdependence, and community.

The depth and complexity of Dan's increased knowledge of the scientific aspects of the seashore is worth noting. For illustration, when asked to group his list of seashore phenomena into categories, Dan used his knowledge of ecology as the major criterion for grouping. For the sake of brevity, I illustrate only the first seven of fourteen categories:
<table>
<thead>
<tr>
<th>Table 7</th>
<th>Dan's Category System After Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. sand</td>
<td>4. acorn barnacle</td>
</tr>
<tr>
<td>sun</td>
<td>barnacle</td>
</tr>
<tr>
<td>mud</td>
<td>sea anemone</td>
</tr>
<tr>
<td>air</td>
<td>sponge</td>
</tr>
<tr>
<td>current</td>
<td>green anemone</td>
</tr>
<tr>
<td>tide</td>
<td>- all attached</td>
</tr>
<tr>
<td>salt</td>
<td>- all have holdfasts</td>
</tr>
<tr>
<td>logs</td>
<td>- all eat plankton or tiny</td>
</tr>
<tr>
<td>oxygen</td>
<td>food particles</td>
</tr>
<tr>
<td>rocks</td>
<td>- green anemones eat snails</td>
</tr>
<tr>
<td>tidepools</td>
<td>white anemones eat plankton</td>
</tr>
<tr>
<td>water</td>
<td>- sponge eats plankton</td>
</tr>
<tr>
<td>trees</td>
<td>- they all make up the base of the shore</td>
</tr>
<tr>
<td></td>
<td>- you have to have most of them there for the animals to live</td>
</tr>
<tr>
<td>2. periwinkles</td>
<td>5. red sea urchin</td>
</tr>
<tr>
<td>lined chiton</td>
<td>purple sea urchin</td>
</tr>
<tr>
<td>moon snail</td>
<td>sea urchin</td>
</tr>
<tr>
<td>whelks</td>
<td>green sea urchin</td>
</tr>
<tr>
<td>black chiton</td>
<td>- all sea urchins</td>
</tr>
<tr>
<td></td>
<td>- all herbivores</td>
</tr>
<tr>
<td></td>
<td>- all eat small plants and animals that fall on them</td>
</tr>
<tr>
<td>3. crabs</td>
<td>6. kelp</td>
</tr>
<tr>
<td>purple shore crab</td>
<td>rockweed</td>
</tr>
<tr>
<td>decorator crab</td>
<td>- make their own energy</td>
</tr>
<tr>
<td>edible crab</td>
<td>from the sun and water</td>
</tr>
<tr>
<td>hermit crab</td>
<td>- they need sun and water</td>
</tr>
<tr>
<td>shrimp</td>
<td>to survive</td>
</tr>
<tr>
<td>spider crab</td>
<td>- both have holdfasts</td>
</tr>
<tr>
<td>king crab</td>
<td>- they're the beginning</td>
</tr>
<tr>
<td></td>
<td>of the food chain</td>
</tr>
<tr>
<td></td>
<td>7. plant plankton</td>
</tr>
<tr>
<td></td>
<td>animal plankton</td>
</tr>
<tr>
<td></td>
<td>isopods</td>
</tr>
<tr>
<td></td>
<td>copepods</td>
</tr>
<tr>
<td></td>
<td>- they're the beginning</td>
</tr>
<tr>
<td></td>
<td>of the food chain</td>
</tr>
</tbody>
</table>
Notice that in his first category Dan grouped air, water, salt, sun, tide, tidepools, mud, currents, etc., because "They all make up the base of the shore" and "You have to have most of them there for the animals to live." More than any other student, Dan used ecological concepts as the main criterion for grouping. Additionally, Dan was aware of the intimate details of specific food relationships: that among snails, periwinkles are herbivores and whelks are carnivores; that among sea anemones, green sea anemones eat snails and white sea anemones filter plankton from the water, and so on. The presence of complex ecological relationships suggests the importance of previous experience. It would appear that Dan's scientific orientation enabled him to develop a more detailed knowledge of ecological relationships after instruction.

Jimmy

Jimmy's post-instructional interviews show an increased proportion of beliefs consistent with accepted science ideas, and a decreased proportion of alternate beliefs.

Many beliefs identified in the pre-instructional interviews were more elaborated in the post-instructional interviews: diversity of organisms, tidal cycle, habitat, predator-prey, recycle. In addition to the two types of habitats identified in the pre-instructional interviews (under rocks and on rocks), Jimmy identified two new habitat (in tidal pools and on dock pilings). He identified seven new predator-prey relationships and no incorrect predator-prey
relationships. In addition, Jimmy expressed an explicit understanding of the organism-tidal cycle relationship, that is, the complex relationship of tidal cycle, predator-prey, habitat, and protection; and the relationship of tidal cycle, desiccation, habitat, protection.

Jimmy also continued to have many ideas about seashore relationships which were quite different from accepted science ideas. For example, his beliefs about the concept of tidal cycle:

The tide is a mop. A mop goes up and down. When the sun comes up the tide goes out, and when the sun goes down the tide goes out.

Still, there was a marked decrease in the number of alternate descriptions of specific seashore relationships. For example, Jimmy no longer generalized using his knowledge of the feeding behavior of offshore commercial fish to describe the feeding behavior of inter-tidal barnacles and tidepool sculpins.

Although Jimmy expressed many beliefs consistent with accepted science ideas, he continued to stress beliefs which are important to fishing, crabbing, and hunting. This is seen in the utilitarian orientation of Jimmy's category system:
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. dogfish</td>
<td>steelhead, sockeye salmon, pink salmon, hump salmon, spring salmon (they all stick together)</td>
</tr>
<tr>
<td>2. geese</td>
<td>geese, ducks (shoot at them for food)</td>
</tr>
<tr>
<td>3. kingfisher</td>
<td>crows, eagle, blue jay, seagull (pigeon, you can't eat them)</td>
</tr>
<tr>
<td>4. killer whale</td>
<td>blue whale, seal, dolphin (porpoise, all swim around together)</td>
</tr>
<tr>
<td>5. eel</td>
<td>eel, bullhead, clingfish, starfish, chinese hat, chinese shoe, limpet, kelp, dock piling, seaweed, rocks, sea urchin, sea anemone, barnacles, plankton, clams, clamshells, tubeworm, glass sandworm (all live on the beach)</td>
</tr>
<tr>
<td>6. ling cod</td>
<td>ling cod, whisker cod, red snapper (all live by rocks)</td>
</tr>
<tr>
<td>7. rock crab</td>
<td>rock crab, hermit crab, red rock crab (all live under rocks, all eat meat, when the bullheads die, they all eat dead animals)</td>
</tr>
</tbody>
</table>
What is important to notice is that when asked to list seashore phenomena, Jimmy listed seashore phenomena first, then gradually listed more and more commercial fish as well as seals, porpoises, killer whales, etc. But when asked to categorize phenomena into groups, Jimmy created a category for commercial fish first, ducks and geese second, mammals that are frequently spotted when commercial fishing third, and seashore animals fifth. Quite unlike Dan's interest in details, Jimmy grouped seashore animals together in one large group, and categorized generally according to edibility, habitats, feeding behavior, and fishing methods.

It is important to acknowledge the conspicuous absence of concepts like types of seashores, energy from the sun, food chain, zonation, interdependence, community, pollution, and conservation. It clearly shows a lack of emphasis on the more important concepts associated with beach ecology. The absence of concepts like pollution and conservation reflects Jimmy's dislike of fisheries officers, and an inability or unwillingness to accept conservation and management regulations. Compared to the other students, Jimmy's post-instructional interviews show the most limited knowledge of science concepts. If would appear that the near absence of a scientific orientation prior to instruction did not encourage an understanding of the ecological aspects of the seashore. Hence, Jimmy's pre-instructional preferred utilitarian orientation continued to influence the particular beliefs he chose to stress.
Mary

More than any other student, Mary's post-instructional interviews show the greatest increase in beliefs consistent with accepted science ideas, and the greatest decrease in alternate beliefs. First, there was a much more elaborated awareness of concepts (diversity of organisms, tidal cycle, life cycle, habitat, predator-prey, locomotion, and conservation) by the addition of new examples. From both the metaphor and the literal interviews, Mary significantly increased her awareness of specific predator-prey relationships by correctly identifying sixteen predator-prey relationships and incorrectly identifying only one. Second, there was an awareness of several new concepts: desiccation, protection, recycle, energy from the sun, food chain, interdependence, and community. Third, there was an awareness of the complex relationships among concepts: the relationship of tidal cycle, predator-prey, desiccation, habitat, and protection; the relationship of energy from the sun, predator-prey, food chain, and interdependence; and the relationship of food chain, interdependence, and community.

Especially striking was a decrease in alternate beliefs. Quite unlike the pre-instructional interviews which stressed the "quiet" and "peaceful" and "cooperative" aspects of the seashore, Mary's post-instructional interviews focused on the harsher aspects of life at the seashore: death, predator-prey, desiccation, protection, the constant struggle for survival. Interestingly, Mary, more than any other student stressed over
and over the related concepts energy, food chain, and interdependence. Compared to all of the other students, Mary showed the greatest increase in an ecological view of the seashore. What is important to this study, is that Mary's pre-instructional aesthetic orientation no longer significantly influenced the particular beliefs she chose to stress.

**Luke**

Compared to the pre-instructional interviews, Luke's post-instructional interviews showed a greater proportion of beliefs which were consistent with accepted science ideas, and a decreased proportion of beliefs which were quite different. First, a number of concepts which were identified in the pre-instructional interviews were more elaborated after instruction: diversity of organisms, tidal cycle, locomotion, predator-prey, protection, recycle, energy from the sun, pollution, and conservation. In addition to the two types of habitats identified prior to instruction (under rocks and in tidal pools), four new types of habitats were identified (on rocks, among seaweeds, in sand, and in mud). Luke correctly identified twenty-four predator-prey relationships and only one incorrect predator-prey relationship—altogether twelve new predator-prey relationships. There was a new awareness of some of the concepts: types of seashores, desiccation, zonation, interdependence, and community. Also, several metaphor responses expressed an awareness of the complex relationships among concepts: the relationship of tidal cycle, predator-prey,
desiccation, habitat, and protection; and the relationship of tidal cycle, predator-prey, habitat, zonation, and community.

Also, many of Luke's beliefs continued to express a traditional spiritual view of the seashore. For example, Luke continued to have different ideas about the concept of tidal cycle: "The wolf had control of the tides." And different ideas about predator-prey relationships, food chains, and food webs: "Only the Thunderbird can catch the killer whale." Some metaphor responses are poignant examples of traditional native Indian beliefs:

I would be a raven. It's bigger than the eagle and flies faster. It's strong. It can talk. If you really listen they talk. They tell you things; what's going to happen to you or your family.

I would be a salmon. You could let people catch you. I was fishing off my Uncle Jimmy's boat. The salmon came up and just bit my hook. He started giving little jerks on my line. He never even struggled when I pulled him in.

Again, the supernatural animals have two forms - one animal, the other human - so that animals can talk, give people advice, and aid in solving human problems.

Once more, it is important to notice that when asked which animal, object, or event at the seashore he would most like to be, Luke chose the Thunderbird:

I would be a Thunderbird. It's bigger than the raven. And it could cause storms, but I don't want to cause storms. And it's my family crest.

Additionally, Luke continued to express many beliefs about the seashore which reflect the fundamental beliefs of the Pentecostal Church:
The seashore is a painting. The water and the seashore are rocks. The rocks draw a picture. When you look out the window it looks like a great big painting. When the water's all calm it's like a painting an artist would paint. God would be the artist.

Clearly, in some of Luke's responses the animals, objects, and events in nature "become" human: and in other responses Luke "becomes" the different animals, objects, and events at the seashore. After instruction, Luke continued to have many ideas and beliefs about seashore relationships consistent with a spiritual view of the seashore, and many ideas and beliefs consistent with an ecological view of the seashore.

Anna

Anna's post-instructional interviews showed an increased proportion of beliefs consistent with accepted science ideas, and a decreased proportion of alternate beliefs. First, a number of concepts were more elaborated: tidal cycle, predator-prey, locomotion, habitat, protection. Anna correctly identified twenty-three predator-prey relationships and only two incorrect predator-prey relationships—an increase of nineteen new predator-prey relationships. In addition to the one type of habitat that was identified prior to instruction (under rocks), three new types of habitats were identified (on rocks, in tidal pools, on dock pilings). Second, there was an explicit understanding of several new concepts: types of seashores, recycle, energy from the sun, desiccation, and at least an implicit awareness of the concept of interdependence. There was an explicit understanding of the relationship of tidal cycle,
predator-prey, desiccation, habitat, and protection; and at least an implicit understanding of the relationship of predator-prey, food chain, and interdependence.

Although there was a marked decrease in the proportion of alternate beliefs to explain the seashore, Anna continued to generate new ones:

The seashore is a graveyard. In the sea, when the fish dies, it stays there, or it goes away like a molt. All the other fish get together and dig a hole, or they eat it.

Such metaphor responses illustrate how Anna continued occasionally to emphasize the "cooperative" aspects of life at the seashore: "All the other fish get together and dig a hole."

Although she had a clearer idea of the organism-tidal cycle relationship, notice how she generated alternate beliefs about the concepts tidal cycle and locomotion:

I would be an ebb tide. If you would be high tide or low tide all the time, it would be too hard on the barnacles... If the barnacles on a dock piling get stuck on one dock piling they need another high tide to get back to another dock piling. They float in the water and go from one dock piling to another. Get me?

Although a marked decrease in the number of alternate beliefs was evident, Anna continued to make wild guesses more than any other student.

Last, far more than any other student, Anna continued a monotonous repetition of the diversity of organisms. For example:

The seashore is a pin cushion. Usually a pin cushion has lots of pins in it. If you pretend the sea is a pin cushion, the animals can be the pins. There's so many different kinds of animals, like all the different pins.
The seashore is a town. A town can have lots of people. Salmon Cove has about 2500 people, but it doesn't seem like it. There's a lot of animals in the ocean. Of course there's more than 2500 in the sea, there's more like 25 million or something like that. There's a lot more than you would think.

Such data are important. The emphasis on simple concepts like the diversity of organisms, and the near absence of more complex concepts like energy, food chain, interdependence, zonation and community, portray a limited knowledge of beach ecology. The absence of some of the more abstract ecological responses from Anna's post-instructional interviews confirms the importance of previous experience, and suggests the difficulties of encouraging an awareness of the ecological aspects of the seashore in a student who brought to instruction a near absence of a scientific orientation. Hence, Anna's recreational and aesthetic orientations continued to influence the particular beliefs she chose to stress.

Sharon

The results of Sharon's post-instructional interviews show an increased understanding of specific seashore relationships consistent with accepted science ideas. For brevity, I describe this increased understanding as similar to the depth and complexity of Dan's increased knowledge of ecology. In addition, Sharon continued to show an emotional commitment to the conservation and preservation of living things more than any other student. It would appear that Sharon's scientific orientation enabled her to develop a more clearly
delineated knowledge of ecology after instruction.

Although all of the students have increased their knowledge of basic ecological relationships, the specific areas of increased knowledge for individual students varies. For most students, the way in which this varies can be understood, in part, in terms of their preferred orientations expressed prior to instruction.

Summary

1. For most students, a reasonably strong relationship continued to exist between their preferred orientations prior to instruction and the way they perceived certain seashore phenomena as aesthetic, utilitarian, spiritual, etc., after instruction.

2. For most students, a relationship continued to exist between their preferred orientations and the specific beliefs they chose to stress, although this relationship was not as strong as in the pre-instructional interviews.
The Relationship Between Instructional Metaphors and Students' Orientations and Beliefs

One way of looking at the relationship between the students' preferred orientations and the type of beliefs most easily learned, is to compare the specific beliefs that individual students chose to stress on the post-instructional interviews. The fact that some students chose to stress certain concepts over others raises a question. Why did Dan stress the concept of community, when Mary stressed the concept of food chain, and Luke stressed the concept of zonation? Why did Anna stress the diversity of organisms, and not stress the more abstract concepts that are more commonly associated with beach ecology?

To give some idea of the complex interactions between the students' orientations and beliefs, and instructional input, I document in some detail the relationships between the beliefs that individual students chose to stress, the student's orientations, and instructional input. I show that for some students, there was a connection between certain beliefs they chose to stress, certain types of instruction, and their preferred orientations towards the seashore. To do this, I compare the cases of four students: Dan, Mary, Luke, and Anna.

Dan

To give some idea of the interactions between Dan's orientations and beliefs, and instructional input, I describe
the introduction of the concept of community into Dan's belief system. Recall that the concept of community refers to a group of interrelated plants and animals living in the same area and dependent on one another for food and other requirements. At the seashore, the interrelated plants and animals, tide, sun, air, and type of shore constitute a community.

To see the connection between instructional input and the emergence of the concept of community, recall that the teacher used two language metaphors "The seashore is a community" and "The seashore is a town" to compare the seashore community to a community inhabited by humans.

Prior to instruction, Dan chose the metaphor "The seashore is a town" and gave the following response:

The seashore is a town. All the animals live at the seashore. They all grow up there. The rocks being like houses for the animals to hide under.

The above metaphor response (and other responses) shows that Dan was aware of at least some of the concepts essential to an ecological understanding of community—diversity of organisms, habitat, predator-prey, and tidal cycle—but lacked an explicit awareness of the complex relationships of tidal cycle, types of seashores, desiccation, food chain, energy, and interdependence. By contrast, after instruction, Dan again chose "The seashore is a town" metaphor and gave the following response:

The seashore is a town. All the different animals are gathered up in one spot. It's sort of like a town. Like on some cobblestone beaches the rocks are moving around. Nothing can live there because the rocks are moving and shifting by the tide. But in tidepools, where it's calm, it seems like a town because lots of animals live there.
The above metaphor response illustrates a more elaborated awareness of the complex relationships among concepts: the relationship of tidal cycle, protected and exposed coastlines, types of seashores, types of habitats, and survival.

In an additional post-instructional interview, I asked all of the students to invent three metaphors for the seashore and to choose one to illustrate with a drawing. When Dan gave the metaphor "community," I said he couldn't choose community because it had been used as an instructional metaphor. When he chose "town," I said he couldn't choose town for the same reason. I wanted him to think of a metaphor that had not been used during instruction or as a choice on the metaphor interviews. Dan thought for a long time, then chose "neighborhood". He drew a picture (Figure 1), and gave the following response:

The seashore is a neighborhood. They're all on the seashore or close to the shore. They're all part of my life. It's like the seashore sort of covers my mind. I always think about the killer whale and eagle as being near the shore, not far away. The purple shore crab, swimming crab, sculpin, eel, purple starfish, kingfisher, butterflies and dragonflies all live close to the shore near my house. The different tidezones might be like different streets in a neighborhood. All the many different animals just make my life so much neater. Sometimes I see me as part of the seashore. I don't know if I'm part of their life, but they're part of my life.

In the neighborhood response, Dan relates the concept of community to the concepts tidal cycle and zonation: "All the different tide zones might be like different streets in a neighborhood." Although the concept of interdependence is never explicitly stated in either the "town" or "neighborhood"
Figure 2
Dan's "The Seashore is a Neighborhood."
responses, the concept of interdependence was clearly stated in similar responses:

I could be the house and the seashore could be the window. It sort of opens something for me. I can see things different after I've had an experience at the seashore. . . how the seashore works, how everything has to work together to survive, and not just the seashore, everything. There's the seashore and there's all the things that eat things from the seashore, it goes on down the line. . . I would know more about the food chain.

It is clear from these and other metaphor responses that after instruction, Dan had a more elaborated knowledge of how seashore plants and animals interact with one another in the network of relations that constitute a seashore community: the type of coastline, the type of seashore, the type of habitat, tide, air, and sun. The fact that Dan chose the "community," "town," and "neighborhood" metaphors seems no small coincidence, since Dan had a preferred scientific orientation in both the pre-instructional and post-instructional interviews, and marine biologists regularly use the community metaphor to talk about the seashore. It suggests a reasonably strong interaction between instructional input and Dan's emerging understanding of a seashore as an ecological community.

Mary

To give some idea of the interactions between Mary's prior orientations, her beliefs about seashore relationships after instruction, and the instructional input, I document in some detail the introduction of the concept of food chain into Mary's belief system. I have chosen the concept of food chain
because Mary repeated the concept more than any other student, and because it illustrates the use of an aesthetic metaphor to teach an ecological view of the seashore.

Recall in the pre-instructional interviews that Mary stressed the aesthetic aspects of the seashore by suggesting that the animals were there to "decorate" the seashore and "make it nice." Mary's strong sense of the "peace" and "quiet" at the seashore suggests that it was difficult for her to speak of the harsher aspects of the seashore: specifically, predator-prey, death, competition for food, the constant struggle for survival. Moreover, she had little or no awareness of the more complex concepts such as the transfer of energy from the sun, food chain, interdependence, and community.

To take advantage of Mary's particular aesthetic orientation during instruction, I attempted to enter into Mary's thinking. At first, this proved far more difficult than I had anticipated. I interviewed various teachers and community members looking for evidence of an artistic background in the home or in Mary's early school experiences. I simply couldn't find sufficient data to account for a talent, or interest in the fine arts: painting, poetry, sculpture, drama, dance. This was puzzling. How could Mary, who had a preferred aesthetic orientation to the seashore, not have a strong artistic background?

Finally, during the later stages of instruction, I began to notice a pattern emerging in the types of metaphors Mary generated during her classroom experiences with living seashore
plants and animals. Recall Mary's personal metaphors: "A sea anemone reminds me of a dress with lots of ruffles." "It's eye looks like a red ruby." "Ooookkkkoooh! That looks like neat curls". To gain further insights into Mary's particular aesthetic orientation, I analyzed her pre-instructional metaphor interviews, looking for preferred metaphor choices and particular types of images:

(first choice) The seashore is a playground. Seems quiet, peaceful to find seashells and things.
(second choice) The seashore is a necklace. Finding and making things from seashells.
(third choice) The seashore is a jewel. Looking for shells on the beach, making things from the shells, like jewelry.

During my classroom observations I noticed that Mary clearly preferred jewelry, clothing, and cosmetic metaphors to describe seashore organisms. Therefore, in attempting to take into account Mary's particular metaphor preferences to increase her knowledge of seashore relationships, I instructed the teacher to explore with the class the instructional metaphor: "The food chain is a necklace". As a follow-up, the students used picture cards to describe predator-prey relationships, food chains, and food webs, and they constructed a food web bulletin board.

In the post-instructional interviews, Mary chose the following metaphors:

(first choice) The seashore is a family. All of the animals all over the seashore seem like one big family living together. Some of the animals are related, or they look alike.
(second choice) The seashore is a necklace. It seems like a necklace because of the food chain. If one latch falls off, the rest of the necklace just falls right apart, or breaks in half.

In addition, I asked all the students to generate two or three personal metaphors for the seashore and to illustrate a favorite metaphor with a drawing. Mary chose "necklace." When I said she couldn't choose necklace because it had been used in the metaphor interviews, Mary thought a while, then chose "bracelet." She drew a picture (Figure 2), and gave the following response:

The seashore is a bracelet. The seashore is long like a bracelet. The seashore would be the string. All the crabs, starfish, seaweeds, sea urchins, sea otters and killer whales would be all the beads, and the sun would be the lock. The sun is the most important part.

Quite unlike Mary's pre-instructional interviews, which stressed the peaceful and quiet aspects of the seashore, Mary's post-instructional interviews stressed the ecological aspects of the seashore (e.g., "If one latch falls off, the rest of the necklace falls right apart.") and an understanding of a hierarchical system of energy: "The sun would be the lock. The most important part."
Figure 3
Anna's "The Seashore is a Bracelet."
In several post-instructional responses, the concepts of food chain and interdependence were abundantly clear. For example:

The seashore is a patchwork quilt. If one piece goes missing the whole thing falls apart, meaning the food chain . . . Like, if clams were to disappear, lots of other animals would suffer from it, gradually something would disappear.

I'd be the curtain and the seashore would be the stitches. It holds me together. It's like the food chain. The food chain is all hooked together. Without the stitches everything would fall apart and die. The stitches are all hooked together.

On the basis of the above responses (as well as other metaphor responses), I believe there is a connection between the instructional metaphor "The food chain is a necklace" and the successful introduction of the concept of food chain into Mary's belief system. The fact that Mary, more than any other student, wove the concept of food chain into more metaphor responses suggests an interaction between Mary's particular aesthetic orientation and the necklace metaphor. It would appear connections such as this one can be used to teach about abstract science concepts.

Luke

A description of Luke's references to the concept zonation will provide insights into the dynamics of how Luke's prior orientations interacted with the type of instruction and influenced the beliefs he chose to stress. I illustrate the introduction of the concept of zonation because after instruction Luke repeated the concept more than any other
Recall that zonation involves the relationship between tidal cycle, habitat and the location of plants and animals on a beach. Prior to instruction, Luke had at least an awareness of the concepts of tidal cycle and habitat, and his understanding was partially grounded in the spiritual aspects of an experience at the seashore:

I would be a high tide. If it's summer, sometimes the water goes out too far. I would be kind. I would put food higher on the beach.

The tide is a legend. The wolves looked after the tide long before anyone was born.

Because such responses are similar in tone to the story known in Salmon Cove as "Turning the Tide" (Chapter 5), I developed a teaching strategy whereby the teacher read the story "Turning the Tide" to the class and discussed the connection between the story and the scientific concepts tidal cycle, habitat, and zonation. Then, during our sessions with the Salmon Cove cultural teachers, this connection was reinforced.

To see a relationship between Luke's emerging beliefs about the concept of zonation and this type of instruction, I compared his pre- and post-instructional responses, looking for evidence of change. In the post-instructional interviews, Luke again chose "The tide is a legend" metaphor, but this time made a more obvious connection to the story "Turning the Tide":

The tide is a legend. It's like the legend of the tides. The wolves looked after the tide a long time ago. The wolves wouldn't let the tide out. Then some
people got mad, so they tricked the wolves into letting the tide out. The deer pretended he was dead, so the wolves would let the tide out. He had no food, so the wolves let the tide out. And then the people could get mussels and clams and crabs and seaweed.

Although the concept of zonation is not explicit, the availability of plants and animals on a shore depends on the tide level. In other post-instructional responses, the concept of zonation is clear. For example:

A tidal pool is a painting. All the different colors: black, white, blue, orange, and purple. The different sections or parts of the seashore would be like a painting. The different places and the different parts of the tidepool. The different zones of the tidepool look like a painting.

The seashore is a cannery. Because of all the animals looking for food. They all have different sections to look for food. At the seashore, the fish have a section to look for food, the barnacles have a section to look for plankton, and it's the same with crabs and other animals. A cannery has different sections where you wash the fish, cut the fish up, and then you put them in cans, then you put the lids on them.

In "The tidal pool is a painting" response, Luke expressed an awareness that different collections of plants and animals seen from a distance appear as distinct color patterns on a shore: "All the different colors--black and white, blue, orange and purple." In addition, different collections of plants and animals occupy different types of habitats or zones on the beach: "The different sections or parts of the seashore... the different parts of the tidepool". In "The seashore is a cannery" metaphor, Luke was aware of animals living together in different tidal zones, and in addition, connected different predator-prey relationships to the various tidal zones: "They all have different sections where to look for food--the
barnacles have a section to look for food, and it's the same with crabs and other animals."

On the basis of these and other metaphor responses, I believe Luke made a connection between the spiritual story "Turning the Tide" and the concept of zonation. Although the concept of zonation was not explicitly stated in the "The tide is a legend" response, the fact that he repeated the concept of zonation more than any other student in both the post-instructional metaphor interviews, and again in the long-term interviews, suggests a connection between Luke's beliefs about the concept of zonation, his particular spiritual orientation, and the type of instruction that occurred.

Anna

To give some idea of the relationship between Anna's orientations and beliefs, and instructional input, I document in some detail her references to the diversity of organisms. I chose to illustrate Anna's striking and monotonous repetition of this concept because it illustrates a certain disparity between Anna's preferred orientations, the absence of important concepts such as food chain, zonation, and community, and the absence of the type of instruction that would have been appealing to a student with Anna's particular orientations.

"Diversity of organisms" refers simply to the different kinds of plants and animals. Because diversity at the seashore was almost taken for granted, and because it is not central to an understanding of ecological relationships, the concept was
never stressed during instruction. Nonetheless, in both the
pre- and post-instructional metaphor interviews, Anna's
fascination with the different kinds of plants and animals
surfaced again and again; no other student expressed this same
degree of fascination. Then, after the post-instructional
interviews, when I asked Anna to invent three metaphors for the
seashore, she invented only two metaphors, "store" and
"school"—and gave the following responses:

The seashore is a store. There's lots of dried goods
in a store. In the Salmon Cove Store there's lots of
different sizes of groceries. There's different
animals and different sizes, and different ages.
Like, if the sunflower starfish was tooth paste, it
would be the 150 ml size because that would be the
large size.

The seashore is a school. There's lots of animals at
the beach, and a lot of kids at school. There's lots
of interesting things about lots of animals and lots
of things to learn.

And finally, when I asked Anna to illustrate one of the above
metaphors with a picture, she chose the "store" metaphor, but
said she couldn't draw the seashore like a store. She then
added that she could draw the seashore as a garden. Anna drew a
picture (Figure 3), and gave the response below:

The seashore is a garden. A garden usually has lots
of things, like flowers and vegetables that have to
grow. A seashore has plants and animals that have to
grow too. There's lots of animals and seaweeds in the
ocean, and on land there's so many different kinds of
flowers. The sea can be a giant underwater garden and
the animals can pretend they're flowers and
vegetables: like the sea anemone, sea urchin,
blowfish, jellyfish, starfish, seaweed, octopus can
pretend they're the flowers. And the other animals
can pretend they're the vegetables: the killer whale,
the fish, seaweed, barnacles, serpent, sea cucumber,
lobster, crab, clam, and seagulls. And there's a man
fishing for fish and other animals. All the different
animals and all the different sizes and shapes.
Figure 4
Anna's "The Seashore is a Garden."
In the garden response, the concept of diversity of organisms is related to the concepts of size, number and growth. But overall, Anna's comparatively simple elaboration of the concept of diversity parallels a lack of emphasis on more complex concepts such as food chain, zonation, interdependence, and community. This raises the question: Why did Anna stress the concept of diversity when important concepts associated with beach ecology received considerably more class time?

Recognizing a lack of substantive data, I offer some speculative thoughts. One possible explanation is that Anna simply had a greater awareness of the different marine plants and animals than any of the other students. There were some data from both the metaphor and literal interviews to support this notion. For example, in "The seashore is a garden" response, notice the richness of previous experiences: the killer whale from the Pacific Coast, the lobster from the Atlantic Coast, the blowfish from the South Pacific Ocean, even an imaginary animal, the serpent. From the literal interviews, Anna was the only student to mention exotic animals: piranhas, parrots, swallows, mukkas, Alaska King Crab, zebra fish, tuna, guppies. In the post-instructional interviews, Anna listed seventy seashore plants, animals, objects and events—the greatest proportional increase in any students' list of seashore phenomena. These data suggests links between Anna's previous experiences in the physical world, and the beliefs she chose to stress. She may have stressed the concept of diversity, at least in part, because she simply had a greater exposure to a
wide range of marine plants and animals from different regions of the world.

Another possible explanation for stressing the concept of diversity touches on the role of mental capacities. Does Anna have the intellectual ability to understand some of the more complex aspects of beach ecology? An interview with the teacher revealed the following:

Anna is above average in all subjects, the second best student in the class behind Sharon. She is very neat, hands in all assignments on time, always does her homework, very competitive. Very good at math. At times, a little weak in language skills. Winning and being at the top of the class is very important. If there's a test, she goes home and studies. If we had given a test on the seashore unit, she would have gotten an A+.

Clearly, Anna was quite capable of understanding basic ecological concepts. Considering her competitive nature and willingness to work hard, it seems likely that she would have volunteered more knowledgeable responses had she been clearer about what concepts to stress.

The fact that Anna is "at times weak in language skills" is an important clue to an analysis of Anna's metaphor responses, because the metaphor interview is based on linguistic constructions, and requires a knowledge of language. Again, I gathered data from the primary teachers:

Anna came to Salmon Cove from the Solomon Islands in grade two. At first, she couldn't speak the language. She learned fairly fast, but is still a little weak.

Although a quick glance through Anna's metaphor responses reveal a greater proportion of short choppy sentences and sentence fragments than the average grade 6 student, it is insufficient
to account for a lack of ecological concepts. The fact is, when stressing the recreational or aesthetic aspects of the seashore, Anna was quite capable of generating complex responses.

A last possible explanation for Anna's stressing the concept of diversity touches on the relationship between Anna's particular recreational and aesthetic orientations, and the lack of certain types of instructional input. During the Salmon Cove study, the teacher and the students never explored language metaphors or non-verbal metaphors that focused on dance, music, drama, or playground images in order to explore the more abstract concepts such as food chain, or zonation, or interdependence and community. For example, although "The tide is music" metaphor was never used to increase the students' understanding of seashore ecology, Anna was one of two students to choose the metaphor, and the only student to connect the metaphor to a key concept of instruction:

The tide is music. When the tide's coming in, it makes splashing sounds. It can sound like music. It depends on the type of beach. You have different sounds for rocky, sandy, and cobblestone beaches.

Clearly, Anna used her own creative imagination to make a connection between the concept of tidal cycle and the concept of types of seashores. This is important. The fact that Anna went further than any other student to extend a musical metaphor to experience and understand a seashore relationship, suggests that it may have been useful to employ instructional metaphors that stressed the musical or dramatic or dance aspects of an experience. Although speculative, one potential explanation of Anna's rather limited responses is that there simply may not
have been an instructional activity that matched Anna's preferred orientations.

One final question is worthy of discussion. If Anna didn't acquire an ecological understanding of the seashore, what aspects of the seashore did she stress? Not surprisingly, Anna continued to stress playing, music, dance and drama. Some of Anna's post-instructional responses demonstrate a more elaborated awareness of the musical aspects of the seashore:

The seashore is a song. A song needs lyrics and music. The barlines, they can be the sea. That can be water. The notes can be the animals. And the waves sound like music too.

Mud is a piano. A piano has white and black keys. The mudflat goes straight and up a bit, then straight and up a bit. Those can be like the keys.

There were also interesting associations of the seashore and dance:

A sea anemone is a dance. By the way they move, it looks like a dance, they dance curvey. The sea anemone opens and closes like a dance.

A seagull is a dance. When they fly they swoop down. There's a dance called "The Bird." That's probably where it got its name, from the birds that swoop down, because they look like they're dancing.

There were several associations of the seashore and creative drama:

I would be an animal and the seashore would be the story. The whole seashore is like a book divided in two and you have the writing. You put a fish and a frog in the story, they're friends. I'd be one of the animals in the story and pretend I was an octopus grabbing a salmon and eating it. Instead of just listening, I want to be in the story. I usually want to play more at the seashore.

Last, notice the references to pretending in the garden metaphor: "The sea can be a giant underwater garden and the
animals can pretend they're flowers and vegetables." The fact that Anna had an aesthetic orientation based largely on music, dance and drama suggests a relationship between her previous experiences with certain art forms, a readiness to take in the aesthetic details of an experience at the seashore, and an ability to creatively extend certain types of metaphors.

Anna's repetition of simple concepts such as the diversity of organisms and the elaboration of certain aesthetic aspects of the seashore, is at least as important for understanding the relationships between Anna's preferred orientations to the seashore and instructional input, as is the near absence of certain more complex concepts.

Thus, the instructional intent of talking about the seashore and carrying out activities illustrating a diversity of orientations was twofold: to try and make serious contact with students who held different orientations about the seashore so as to enable them to relate events and ideas to something that was already important to them, and to try and legitimate different students' preferred orientations as being valid ways of looking at the seashore.
Summary

1. The data suggest a relationship for most students between their preferred orientations, the type of instructional metaphors, and the specific beliefs they chose to stress.

2. There was a relationship for most students between the type of orientations held and preferred types of instructional metaphors. The student with a preferred scientific orientation used the scientific metaphor "The seashore is a community" to understand the concept of community. The student with a preferred spiritual orientation used a spiritual metaphor "The tide is a legend" to understand the concept of zonation. The student with a preferred aesthetic orientation used an aesthetic metaphor "The food chain is a necklace" to understand the concept of food chain.
The Elaboration of a Variety of Orientations

Although metaphors constructed with images representing preferred orientations are most easily taken up, other metaphors also have an impact and help the students in viewing the seashore from a variety of orientations. As I discussed previously, a second purpose of instruction was to enhance the students' ability to view the seashore from a variety of orientations. That is, it was hoped that there would be a more detailed and clearly delineated awareness of some of the more subtle aspects of the aesthetic, utilitarian, spiritual, recreational, etc. aspects of the seashore.

To give a better idea of how instructional metaphors were used to increase the students' ability to view the seashore from an aesthetic orientation, for example, I explore for all of the students the effectiveness of the aesthetic metaphors "The seashore is a musical production" and "The seashore is a song." I compare for all of the students their pre- and post-instructional responses to "The seashore is a song," looking for evidence of change.

Recall that the strategy of instruction called for the students to explore the seashore first--to sit quietly at the tideline and hear waves striking the shore at high tide, to hear seagulls picking and probing for any edible items to eat at low tide, to feel wet squishy mud--all in order to increase their sensory-imbedded impressions of the seashore. It was felt that these sensory experiences would help the students to take in new
information and see things in new ways. Once back in the classroom, these experiences would provide the students with the raw data to creatively extend the various instructional metaphors.

Prior to instruction, Anna was the only student to choose the song metaphor:

The seashore is a song. When the waves are splashing on the beach, or when the waves are blowing real hard, it's like a song.

Anna

By comparison, after instruction, all of the six students except Jimmy chose the song metaphor:

The seashore is a song. A song needs lyrics and music. The barlines, they can be the sea. That can be the water. The notes can be the animals. And the waves sound like notes too.

Anna

The seashore is a song. The many different sounds on the beach: when they're all put together they sound neat—the birds and waves lapping against the shore. Sometimes you can hear the rocks moving.

Dan

The seashore is a song. People write songs about the seashore. It just seems like a song: the way the waves move, the sounds it makes. And some of the animals, like when the whales blow through their blowholes, or when the seagulls make noises.

Mary

The seashore is a song. All the different sounds: the waves, the wind, the rocks, the trees, the boats. They all make nature's music.

Luke

The seashore is a song. The sounds that the animals make. On a windy day the ocean really makes a lot of sounds: roaring sounds like a big choir. The seagulls are like instruments of a song. The wind sometimes makes a big sound like wind through the trees.

Sharon
And finally, notice that when asked to generate three metaphors for the seashore and draw a picture of his first choice, Luke provided "The seashore is a happy song." He drew a picture (Figure 4), and gave the response below:

The seashore is a happy song. All the sounds at the seashore make a happy song. All the different sounds make nature's music. The killer whale when he blows his water out, it makes a squeaking noise. The seagulls making squeaking noise. The rocks falling into the water . . . splaaaaaasssh! The sand moving makes sounds like a sponge washing the bathtub . . . rough! The yellow is the wind going woooooosh! And the wind growls and crashes against the cliff.

The above metaphor responses make it clear that sensory impressions and emotions form an important basis of the students' understanding and experiencing of the seashore. In all of these metaphor responses, notice the attention paid to the quality of sensory impressions. Also, notice that several responses are similar in tone to the classroom discussion of "The seashore is a musical production" metaphor: "The roaring sounds like a big choir." "The seagulls are like instruments in a song." "The killer whale when he blows his water out." For some students, the data suggest a strong relationship between the particular aesthetic aspects they chose to stress, and the use of certain aesthetic metaphors as instructional devices.

The data also give insights into the interactional properties of the students' orientations. The fact that all of the above students had an aesthetic orientation prior to instruction, and that all of the above students have played a musical instrument, suggests a relationship between their
Figure 5
Luke's "The Seashore is a Happy Song."
previous experiences with music, a readiness to accept musical images as instructional metaphors, and an ability to extend certain types of metaphor questions. Confirming the importance of previous experience is the conspicuous absence of aesthetic responses from Jimmy's interviews, his lack of responses to this and similar metaphor questions suggests the difficulty in encouraging an awareness of the aesthetic aspects of the seashore in a student who brought to instruction a seeming absence of an aesthetic orientation. Such data suggest a relationship, for most students, between their more elaborated awareness of the "musical" aspects of the seashore and the type of instructional input that occurred.

What this means is that students could "see" the seashore from multiple orientations. The fact that many of the students still used orientations which they possessed prior to instruction is important in that it provides evidence that the second objective was achieved. That is, students are able and willing to use more than one orientation to view the seashore in spite of the tendency to simply give back school-related (e.g., scientific) responses to the interview questions. The effect of instruction, then, was to develop a more sophisticated and diverse knowledge base. This is clear from the elaboration of beliefs in the post-instructional responses. So in this sense the students' orientations became more extensive in scope and nature.
Summary

1. To varying degrees all of the students were able to view the seashore from multiple orientations. It would appear that the use of metaphors to help the students view the seashore from a more extensive knowledge base was successful.

2. For most students, there was a reasonably strong relationship between their previous experiences with music, or painting, or dramatics, for example, and their willingness to elaborate certain types of aesthetic metaphors.
The Stability of the Students' Orientations and Beliefs

To determine the stability of the students' orientations and beliefs over time, I returned to Salmon Cove six months after instruction to conduct the long-term interviews. These data provide insights into the effectiveness of the major intents of instruction by distinguishing between the students' orientations and beliefs prior to instruction, and their orientations and beliefs after instruction.

The Students' Long-term Beliefs

To varying degrees, all of the students continued to use a greater proportion of scientific responses to describe the seashore. In the long-term interviews, all of the students continued to express a greater proportion of beliefs about seashore relationships consistent with accepted science ideas, but there was a decrease in these when compared with the post-instructional interviews. More specifically, Dan and Sharon continued to express an awareness of the widest range of seashore relationships, followed closely by Luke and Mary. Luke continued to express an explicit awareness of the concept of zonation, and an implicit awareness of the concept of food chain. Mary continued to express an explicit awareness of the concept of food chain, but not even an implicit awareness of the concept of zonation. Anna continued to repeat the concept of the
diversity of organisms, and never explicitly mentioned the concepts food chain, zonation, community, or interdependence. Jimmy continued to express a more elaborated awareness of concepts like predator-prey, habitat, desiccation, protection, etc., but never expressed even an implicit awareness of concepts like food chain, zonation, interdependence, or community. While Sharon, Mary, Anna, and Luke continued to express a strong concern about pollution and the conservation of the seashore, Dan continued to express an emotional attachment to animals and a concern for the care and preservation of the seashore while never mentioning pollution. Jimmy never expressed a concern about conservation or even an awareness of pollution.

Compared with the post-instructional interviews, all of the long-term interviews showed a decline in the use of a scientific vocabulary, as evidenced by the students' implicit references to specific concepts. Despite these losses, all of the students continued to show stability in their use of a scientific framework to understand and experience the relationships associated with beach ecology. The students' retention of specific science concepts is important because it provides evidence that the instructional strategies were effective.
The Students' Long-term Orientations

The fact that all of the students were willing to give back a majority of scientific responses in both the post-instructional and the long-term interviews raises an important question. What is the potential effect of an increase in knowledge of science concepts on the students' preferred orientations towards the seashore? Or, more specifically, to what extent have the students shifted their preferred orientations, for example, from an aesthetic or spiritual orientation towards the seashore to a scientific orientation?

Answers were obtained from an analysis of the students' preferred metaphor choices in the pre-, post-, and long-term metaphor interviews. Recall that after each interview set, I asked each student to choose the metaphor responses which best described how he or she viewed the seashore. It was hoped that by comparing the students' preferred responses (their first-, second-, and third choice responses), a distinction could be made between the students' preferred orientations prior to instruction, and the effect of instruction on the students' preferred orientations after instruction. To make a clearer distinction between the students' orientations before and after instruction, I compare the cases of Luke, Mary, Jimmy, Sharon, and Anna. I chose not to document the case of Dan because he used a great proportion of scientific responses (as well as preferred scientific responses) in all three sets of interviews indicating that a shift in orientations had not occurred.
Luke

In the pre-instructional interviews, Luke chose "battleground" as his first metaphor, and gave a spiritual and scientific response:

The seashore is a battleground. If the sharks attacked the killer whales, the dolphins will come and save the killer whales.

He chose "legend" as his second metaphor, and gave a spiritual response:

The seashore is a legend. There's a legend about this man who became wild and he went down to the beach every day and he ate mussels, clams, and abalone ... He was wild and he lived in a tree stump.

He chose "painting" as his third metaphor, and gave an aesthetic response:

The seashore is a painting. If it was blue sky, it would look like a painting. And if the water was real calm, it would be a nice painting.

When asked what animal, object or event at the seashore he would most like to be, Luke chose "Thunderbird," and gave a spiritual response:

The Thunderbird can make thunder and lightening from its eyes. The Thunderbird is the ruler of the sky.

The results of Luke's pre-instructional interviews clearly indicate that he brought to his curricular experiences a preferred spiritual orientation to the seashore, as evidenced by the first-, second-, and third-choice responses, as well as the number of composite spiritual responses.
By comparison, in the post-instructional interviews Luke chose "painting" as his first metaphor from among those provided in the interviews, and gave a spiritual and aesthetic response:

The seashore is a painting. The water and the seashore are rocks. The rocks draw a picture. When you look out the window it looks like a great big painting. When the water's all calm, it's like a painting an artist would paint. God would be the artist.

He chose "song" as his second metaphor, and gave an aesthetic response:

The seashore is a song. All the different sounds: the waves, the wind, the rocks, the trees, the boats. They all make nature's music.

He chose "totem pole" as his third metaphor, and gave a spiritual response:

The seashore is a totem pole. It's like all the different kinds of animals: crabs, halibut, killer whale, mink. They all have a story, like a totem pole. Legends like the killer whale.

When asked what animal, object, or event at the seashore he would most like to be, Luke chose "eagle" and gave a spiritual response:

The eagle. It's strong. It's better than the seagull because it's bigger and more colorful, and there's more stories about it.

Recall also, that when asked to invent his own metaphor for the seashore, Luke invented the metaphors "park," "bathtub," and "blanket," and gave recreational responses for all three metaphors. And last, when asked to draw a picture of his favorite metaphor, Luke drew a picture of the seashore as a
"happy song," and gave an aesthetic response. Such data suggest that even after instruction, and in spite of his many more scientific responses, the spiritual, aesthetic, and recreational aspects of the seashore continued to play an important role in Luke's thinking.

By way of further comparison, in the long-term interviews, Luke chose "playground" as his first choice and gave a recreational response, "gift" as his second choice and gave a recreational and utilitarian response, "town" as his third choice and gave a scientific response, and "Thunderbird" as the animal he would most like to be and gave a spiritual response. More than any other student, with the possible exception of Sharon, Luke continued to view and describe the seashore in terms of a combination of orientations, and with a spiritual orientation predominating.

Mary

In the pre-instructional interviews Mary first chose "playground" from among the metaphors provided and gave an aesthetic and recreational response:

The seashore is a playground. Seems quiet, peaceful to find seashells and things.

She chose "necklace" as her second metaphor and gave an aesthetic, recreational, and utilitarian response:

The seashore is a necklace. Finding and making things from seashells.

She chose "family" as her third metaphor and gave an aesthetic response:
The seashore is a family. All the animals sharing the same place. Getting along. It's peaceful.

When asked what animal, object or event at the seashore she would most like to be, Mary chose "starfish" and gave an aesthetic response:

I would be a starfish. I wouldn't have to go fast. I like their colors and all their legs.

Prior to instruction, Mary clearly preferred to use an aesthetic as well as a recreational orientation to describe the seashore, as evidenced by the first, second, and third metaphor choices and accompanying explanations.

By sharp contrast, in the post-instructional interviews, Mary chose "family" as her first metaphor, and gave a scientific response:

The seashore is a family. All the animals all over the seashore seem like one big family living together. Some of the animals are related, or they look alike.

She chose "necklace" as her second metaphor and gave a scientific response:

The seashore is a necklace. It seems like a necklace because of the food chain. If one latch falls off, the rest of the necklace just falls right apart, or breaks in half.

She chose "totem pole" as her third metaphor and gave a scientific response:

The seashore is a totem pole. They all depend on one another to live. Like on a totem pole, there's a picture, then another and another one, going on up to the top. The seashore seems like that to me.

She chose "sailboat" as the animal or object she would most like to be, and gave an aesthetic and recreational response:

I would be a sailboat. I could go nice and slow, look at lots of things and be calm. I wouldn't be a
fishing boat because they're always rushing around and they kill all those fish and get money for them.

Recall that she invented "bracelet" as her own metaphor for the seashore and gave a scientific response:

The seashore is a bracelet because of the food chain.

After instruction, Mary clearly preferred to use a scientific response to describe the seashore, as evidenced by her first, second, and third metaphor choices and explanations. More than any other student, Mary seemed to make a shift towards a preferred scientific orientation.

To see if the scientific aspects of an experience were sufficiently strong to persist over time, I asked the same set of questions in the long-term interviews. Mary chose "town" as her first metaphor and gave a scientific response, "family" as her second metaphor and gave a scientific response, and "farm" as her third metaphor and gave a scientific response. When asked what animal or object she would most like to be, she chose "killer whale" and gave an aesthetic response. One interpretation is that there was an interaction between Mary's particular aesthetic orientation prior to instruction and the use of the aesthetic metaphor "The food chain is a necklace" during instruction. This preference for an aesthetic metaphor accounts, at least in part, for the apparent shift towards a scientific orientation.
In attempting to describe the nature and dynamics of changes that occurred as a result of instruction, this section will focus upon Jimmy's preferred metaphor responses and the shift in his thinking from the ocean to the seashore.

In the pre-instructional interviews, Jimmy chose "The seashore is a farm" as his first metaphor and gave a utilitarian response:

The seashore is a farm. It's got lots of animals. You look after them, feed them, raise them to be big. Sell them to people for meat.

He chose "playground" as his second metaphor and gave a recreational, utilitarian, and spiritual response:

The seashore is a playground. All the kids play on the beach: find crabs, make stuff, teeter totter, make masks from wood, sticks to hold fish.

He chose "edible crab" as the animal he would most like to be and gave a utilitarian response:

Edible crab. Because you could eat them. Boil them and eat them.

In general, the above data suggest that the utilitarian aspects of an experience at the seashore were sufficiently strong to dominate Jimmy's thinking in the pre-instructional interviews.

By contrast, in the post-instructional interviews, Jimmy chose "town" as his first metaphor and gave a scientific response:

The seashore is a town. The eels, bullheads, crabs, and hermit crabs all live there. They all stay under rocks and the rocks could be their homes.

He chose "battleground" as his second metaphor, and gave a scientific response:
The seashore is a battleground. The animals like crabs and eels and bullheads fight each other for food, for getting something to eat. When a crab finds something to eat, other crabs try to eat it too.

When asked what animal, object, or event he would most like to be, Jimmy chose "bullhead" and gave a scientific response:

I would be a bullhead. When the tide is just coming up you can just high-ball it out and swim out to the ocean. I'd stay underwater and go underneath a rock if a seagull came.

At first, these data suggest that an increase in knowledge of ecological relationships resulted in a shift from a preferred utilitarian orientation to a preferred scientific orientation. However, additional data lead me to believe otherwise. When I asked Jimmy to invent three metaphors for the seashore, Jimmy couldn't think of a single one. I re-phrased the question, even gave examples of metaphors that other students had generated. Jimmy simply couldn't invent a single metaphor for the seashore. Finally, I asked Jimmy "If he could draw a picture of the seashore, what would be in the picture?" Jimmy said he couldn't draw a picture of the seashore, but he could draw a picture of a fishing boat. Jimmy drew a picture (Figure 5), and gave this response:

There would be salmon, killer whales, and fishing boats. I'd be on a seine boat with my dad, my mom, and Richard, Wooley, and Burt (my brother-in laws). My dad would be the captain. My mom would be cooking. Wooley and Burt would be in the skiff and I'd be running the drum. My dad would say "Let it go!" Then I'd hit this thing on the side that makes the skiff let go. Burt and Wooley would throw this round thing that lets the net go out. Then we just sit and wait and my dad drives the seiner around to close the net. Then, when my dad stops the propeller we pull the winch and drum it in.
Figure 6
Jimmy's "A Fishing Boat."
Finally, I asked Jimmy if he had been thinking about the seashore or the ocean during the post-instructional interviews:

I was thinking of the seashore most of the time, not fishing in the seiners.

In this case, an increase in knowledge of ecological relationships contributed, at least in part, to a shift in Jimmy's thinking from the ocean to the seashore. This shift in the focus of his thinking allowed Jimmy in the post-instructional interviews to select choices that he could explain in terms of the information that he obtained from instruction. Although this increased scientific knowledge allowed Jimmy to view seashore phenomena from more of a scientific orientation than before instruction, it is clear that a strong utilitarian orientation was still present.

Further evidence of this propensity to view the seashore from both a scientific and a utilitarian orientation comes from the long-term interviews. Jimmy chose "battleground" as his first metaphor and he gave a scientific response, "house" was his second metaphor and he gave a scientific response, and "edible crab" was the animal he would most like to be and he gave a utilitarian response. These data suggest that a knowledge of scientific relationships, which was sufficiently strong to persist long after instruction, allowed Jimmy to think about the seashore in more diverse ways than was the case prior to instruction.
Sharon

Prior to instruction Sharon chose "gift" as her first metaphor and gave a utilitarian response, "garden" was her second metaphor and she gave an aesthetic response, and "sea urchin" was the animal she would most like to be and she gave an aesthetic response. After instruction, Sharon chose "totem pole" as her first metaphor and gave a scientific response, "legend" was her second metaphor and she gave a scientific response, and "polished beach pebble" was the object she would most like to be and she gave an aesthetic response. In the long-term interviews Sharon chose "town" as her first metaphor and gave a scientific response, "painting" was her second metaphor and she gave an aesthetic response, and "sunny day" was the event she would most like to be and gave a recreational response. These data suggest that after instruction a knowledge of scientific relationships was sufficiently strong to allow Sharon to think about the seashore in more scientific ways, but she continued to view the seashore from a variety of orientations.

Anna

Last, a brief description of Anna's preferred metaphors provides additional insights into the dynamics of how a students' prior orientations interacted with and were influenced by instruction. In the pre-instructional interviews, Anna's first, second, and third-choice metaphors involved recreational and aesthetic responses. But after instruction, there appeared
to be a change, as evidenced by a greater proportion of preferred metaphor responses that expressed an awareness of the scientific aspects of the seashore. However, as discussed earlier, a more detailed analysis of Anna's word-for-word responses revealed a monotonous repetition of the relatively simple concept of the diversity of organisms. Although a shift in the priority and the proportion of scientific responses did occur, the shift did not seem to represent a change in the complexity of thought that the metaphor questions stimulated. Compared with the responses of Dan, Sharon, Luke, or Mary, there simply was not a major change in relation to her understanding of some of the more abstract concepts associated with beach ecology.

In sum, a careful analysis of the students' metaphor responses revealed that for most students their increased knowledge of seashore phenomena and their understanding of some of the ecological relationships associated with these phenomena enabled them to provide richer and more diverse explanations of their metaphor choices. In the language of orientations, it would seem reasonable to claim that instruction has served to increase most of the students' ability 'to see' the seashore from several points of view. In particular, this increased knowledge and understanding meant that for most students they could adopt a scientific orientation in explaining their preferred choices. Given the school context of this study and the focus of the instruction, these results are not totally unexpected. The fact that this knowledge appeared to be
relatively stable six months after instruction does imply that it was integrated into the students' cognitive systems and hence the instructional techniques can be judged to be effective.

However, we still need to be cautious in concluding that the instruction resulted in a shift in preferred orientations to the seashore. Even in the case of Mary, it is hard to document a relationship between her increased knowledge of science concepts and her apparent shift to a preferred scientific orientation, since the use of orientations would have to carry over into other non-school events. Nonetheless, the question of a shift in preferred orientations is an interesting one to speculate about.

Summary

1. For all of the students, the increased proportion of scientific responses after instruction was sustained in the long-term interviews. Thus, the instructional objectives were met.

2. A shift towards a greater proportion of scientific responses can be interpreted as evidence of an increased knowledge of science concepts. For most of the students, with the possible exception of Mary, an increased knowledge of science concepts did not result in a shift in preferred orientations.
Chapter 7

IMPLICATIONS FOR SCIENCE INSTRUCTION AND FUTURE RESEARCH

This last chapter summarizes the study, describes some implications of the research for addressing problems of learning and instruction, and identifies some possibilities for future research. In particular, I explore the implications of the results for analyzing students' interpretive frameworks embodying both the affective and cognitive domains.

Summary of the Study

An assumption of the present study is that students of different social and cultural backgrounds bring to their classroom experiences, beliefs and values which may have a significant impact upon the way they respond to and interpret instruction. One way to examine some of the more complex aspects of a student's cognitive organization is through the construct of an orientation. "Orientation" here has been used to refer to an individual's tendency to understand and experience the world through an interpretive framework embodying a coherent set of beliefs and values. If a student interprets new science concepts as being in harmony with his or her orientations, then learning those concepts may be a fairly straightforward task. But if a conflict exists between the beliefs and values held by a student and those presented by the
curriculum, then a given instructional encounter may result in the student constructing a version of the concept quite different from that being taught.

Teachers need to know more about the nature and variability of students' beliefs and values prior to instruction. Therefore, the study addressed the following research questions:

1. What is the nature of the students' orientations towards the seashore prior to instruction?
   1.1 What is the nature of the students' beliefs about specific seashore relationships prior to instruction?
   1.2 How are the students' beliefs about specific seashore relationships related to their orientations?

2. What interactions occur between the students' orientations towards the seashore and their experiences during instruction?

3. How effective were the strategies of instruction?
   3.1 What is the nature of the students' beliefs about specific seashore relationships after instruction?
   3.2 To what extent are the students' able to view the seashore from a variety of orientations?
   3.3 What is the relationship between instruction and the students' orientations and beliefs?
   3.4 How stable are the students' post-instructional orientations and beliefs?

Results of the pre-instructional interviews show that
while all of the students used several orientations to describe the seashore, some students used one orientation predominantly, as evidenced by the great proportion of responses which could be interpreted in terms of that particular orientation. For most students, there was a reasonably strong relationship between their orientations and their specific beliefs about seashore relationships. For example, the student with a preferred scientific orientation brought to instruction many beliefs consistent with accepted science ideas. The student with a preferred spiritual orientation brought to instruction many beliefs consistent with the traditional native Indian beliefs of Salmon Cove. The student with a preferred utilitarian orientation tended to stress the concepts predator-prey and habitat specifically in relation to edible organisms. The student with a preferred aesthetic orientation tended to stress the peaceful and cooperative aspects of the seashore, rather than the harsher aspects.

During instruction, there appeared to be an interaction between the students' orientations and their curricular experiences. For example, there was a relationship between students' orientations and their individual metaphorical thinking processes: the types of metaphors they generated, the types of questions they asked, the way they mixed metaphors with questions to interpret discrepant events. The data also show a relationship between the students' beliefs and orientations and their behavior during certain instructional activities. For example, students who indicated a concern and awareness of
pollution and conservation during the interviews actively participated in the garbage pick-up day, whereas the students who didn't mention pollution or conservation issues tended not to participate. In general, the data show that when the students' orientations were in harmony with the instruction, the students' behavior better conformed to desired classroom behavior. But if a conflict existed between the students' orientations and instruction, then the students' behavior was more often unrelated or at odds with instruction.

Results of the post-instructional interviews show that for all of the target students there was a shift towards a greater proportion of scientific responses, and a decrease in alternate beliefs (beliefs inconsistent with accepted science ideas). In general, this increase of science responses was sustained in the long-term interviews. Hence, the primary purpose of instruction, which was to increase the number of students who could be said to possess a better scientific understanding of the seashore, was achieved. However, most of the students still maintained their preferred orientations in the post-instructional interviews, and most students gave more elaborated responses. Hence, the second purpose of instruction, which was to enhance the students' ability and willingness to view the seashore from a new orientation, or from a variety of orientations was also achieved. The data suggest that a shift towards a greater proportion of scientific responses can be interpreted as an increase in knowledge of science concepts. Although the research results suggest that after instruction
many of the students were aware of complex ecological relationships, a significant result in itself, the students' underlying values regarding beach ecology were not likely changed to any significant degree.

For some students there was a strong relationship between their use of orientations after instruction and the type of instructional input that occurred. The data suggest a relationship between the students' previous experiences and a readiness to accept certain images as instructional metaphors. The data also suggest that the students' orientations may have had an effect on the students' capacity to understand and recall science concepts.

One of the more important findings of this study is that all of the students showed an increase in the number of scientific responses. It shows that scientific beliefs can be learned and retained over time, even though a given student's preferred orientation may not be scientific. Another important finding is that an increase in knowledge of science concepts did not result in a significant shift in the students' preferred orientations, except possibly for Mary. It shows that the effect of instruction was to develop a more sophisticated and diverse knowledge base. So the students' orientations are changing, but in the sense of becoming more extensive.
Contributions to Education

This study has made contributions to the field of education in three areas:
1. an elaboration of the nature of student orientations;
2. the application of metaphor interview techniques to the study of orientations and beliefs;
3. the development of instructional strategies using both verbal and non-verbal instructional metaphors to significantly increase the students' comprehension and retention of specific science concepts.

The Nature of Student Orientations

The typology of orientations consisting of scientific, aesthetic, spiritual, utilitarian, recreational, and health and safety contributes insights over and above those to be obtained by studying only students' beliefs. In this study, the typology was useful in three ways: (1) in developing instructional metaphors that were interesting and appealing to students with different preferred orientations, (2) in describing and interpreting the students' behavior during instruction, and (3) in assessing the effectiveness of instruction.

With knowledge of the students' orientations, it was possible to develop instructional metaphors that were interesting and appealing to the various students involved. The students' preferred orientations were used in many instances to
develop and plan a variety of activities with the expectation that they would serve as a bridge for the instructional knowledge that was being conveyed. The fact that Mary used the "necklace" metaphor to describe the concept of food chain, Luke used the "legend" metaphor to describe the concept of zonation, or that Dan used the "town" metaphor to describe the concept of community—all suggest links between the beliefs the students chose to describe metaphorically, the students' particular orientations, and the type of instruction that occurred.

The typology of orientations was also useful in describing and interpreting how students adapt to instructional experiences. The fact that Dan stressed conservation in the metaphor interviews and independently collected garbage during our garbage pick-up day, while Jimmy never mentioned conservation in the metaphor interviews and threatened to go home, suggests links between the students' orientations, their beliefs about specific science concepts, and their behavior during instruction. When problems of behavior arose during instruction, my immediate reaction was concern that the instructional activities were not working. But later, when I looked for patterns in the students' behavior, I was frequently able to understand their behavior in light of their orientations.

Knowledge of the students' orientations also gave insights into the effectiveness of the strategies of instruction. The typology of orientations was useful in accounting for those beliefs which were retained and which
disappeared, the connections among beliefs, and changes in beliefs as a result of instruction.

The data suggest that prior to instruction, in the absence of specific knowledge, the students' orientations helped shape their responses to questions about seashore relationships. In both the pre-instructional metaphor and literal interviews, when the students were presented with questions they could not answer, information from the various utilitarian, or aesthetic, or spiritual orientations were used to help construct their explanations. Hence, Jimmy generalized his knowledge of the feeding behavior of certain nearshore edible fish to the feeding behavior of seashore organisms, so that barnacles and tidepool sculpins "feed just before low tide." Similarly, Mary generalized her knowledge of the aesthetic aspects of the seashore to the feeding behavior of seashore organisms: "The animals all share the same food. They all get along. It's peaceful." The fact that a three-week instructional unit brought about changes in the students' beliefs about specific seashore relationships suggests the relative fluidity of certain beliefs. By contrast, the instruction did little to alter the students' metaphor preferences, suggesting the stability of the students' orientations towards the seashore generally.

To varying degrees, the students' orientations include beliefs that may be easily changed, as well as beliefs to which the individual exhibits some commitment. Some beliefs appear to be unrelated or less connected to an orientation—"dogs and cats eat barnacles," "barnacles eat flies," and "sea urchins have a
head, they just tuck it under themselves." Indeed these may well represent random guesses (Piaget, 1929) to satisfy the interviewer's request for their beliefs. Other beliefs are inextricably connected to an orientation: Luke's ideas about the "Thunderbird" being "the ruler of the sky" or "God" being "the artist" or creator of the seashore. The data indicate that beliefs which are not related to an orientation are easily changed, but beliefs which are connected to an orientation are not easily changed. It seems likely that Mary's beliefs about barnacles eating flies at low tide were easily changed by simply observing the evidence— that is, barnacles raking the water for plankton at high tide, or observing barnacles feeding in tidal pools and in the aquarium, and with microscopes. By contrast, it seems unlikely that an attempt to change Luke's ideas about "the Thunderbird breathing thunder and lightning from its eyes" would have been successful because such beliefs could scarcely be affected by external empirical evidence.

Closely related to the findings that some beliefs are more connected to an orientation than other beliefs, are the findings that students showed an increased proportion of scientific beliefs for different reasons. Dan and Sharon had scientific orientations prior to instruction, and showed an increased number of scientific responses after instruction. This finding is consistent with research indicating that people generally seem to prefer beliefs which are congruent with their own value systems (Borheke & Curtis, 1975; Rokeach, 1960, 1968). The fact that Jimmy stressed the concepts habitat and
predator-prey and not the concepts pollution and conservation before and after instruction may be congruent with his particular utilitarian orientation. But what about Mary, Anna, and Luke? Mary's set of orientations did not strongly conflict with a scientific view of the seashore. She simply didn't have a knowledge of beach ecology. Hence, it was a comparatively simple task to increase Mary's knowledge of beach ecology. In the case of Anna, an increased proportion of scientific responses was not viewed as a significant change in her thinking because of the repetition of the comparatively simple concept of the diversity of organisms. A more detailed analysis of the data suggests that Anna may have learned more than I had previously thought. The fact that Anna held far more beliefs inconsistent with accepted science ideas than any of the other students prior to instruction, and that there was a marked decrease of these beliefs after instruction, suggests that new information was learned which required synthesizing. It suggests the difficulties in "unlearning" a repertoire of alternate beliefs, and changing a style of thinking which encouraged imaginative associations. In the case of Luke, a shift to a predominant proportion of scientific responses was viewed as an increase in knowledge of science concepts, but he continued to prefer a spiritual view of the seashore. It seems quite likely that, had the situation been more threatening to this orientation, Luke may have rejected many scientific beliefs presented during instruction. However, in this study the instruction took into account the students' orientations and
this rejection was not observed.

Another way the identification of orientations was useful in assessing the effectiveness of instruction, was in documenting the elaboration of a variety of orientations. Prior to instruction, the students differed in their relative knowledge about seashore ecology. For some students, their information was great, in others it was less so. After instruction, all of the students showed an increase in the relative knowledge of seashore ecology. The students also differed in the degree to which they elaborated the quality of an aesthetic, or utilitarian, or spiritual experience at the seashore. So after instruction, the students' knowledge of the various orientations could be said to be more clearly delineated and with a more extensive range of examples.

The students' orientations seemed to be relatively enduring, thereby accounting for many of the uniformities I observed in their actions. But this does not mean that new instructional experiences could not influence the students' orientations, or that the students' orientations are completely solidified. Orientations seem to be relatively stable, but also possessing some plasticity in response to instruction.

Sometimes an existing orientation may act as a barrier, at other times it may form a bridge to new ideas. It seems likely that in order for students to make sense of the new ideas they encounter during instruction, they must reinterpret that knowledge in light of their own orientations. This analysis is consistent with previous research suggesting that students must
"reconstruct" the new knowledge they encounter in their own way (Nussbaum & Novick, 1981; Osborne & Wittrock, 1983).

Thus, the typology of orientations could be important to science educators wishing to monitor the ways in which any student will approach and interpret new curricular situations. Through knowledge of the students' orientations it may be possible for teachers to understand more fully why students think and behave the way they do, and then to develop instructional strategies which are more effective in teaching specific concepts.

Orientations and Future Research

Still, this work leaves obvious and important issues unanswered. To what extent are the students' orientations to the seashore specific to Salmon Cove? To what extent can the students' orientations to the seashore be applied to other environments: e.g., the forest, the pond, the urban environment? To what extent can students' orientations be used to interpret and understand their behavior? What kinds of questions need to be pursued in classroom settings?

It is clear that all of the students used a recreational orientation to the seashore, that girls more than boys preferred an aesthetic orientation to the seashore, and that students from a traditional native Indian culture favor a spiritual orientation over others. From the five pilot studies it is clear that young students (age 6-10) more than older students (age 11-13) favored a health and safety orientation. Yet, when
Considering the students' orientations to the seashore, we must be cautious in generalizing to other situations. Though one would expect evidence of shared orientations among the students towards the seashore and the forest and the city, the proportion of aesthetic, or utilitarian, or spiritual responses may vary depending on the students' perception of the environment in question. The students' knowledge and experience of the "seashore," or "forest," or "city" are important. What this means is that while students' orientations seem to be relatively stable, there may be variations in their orientations, depending on the context of the physical and cultural environment in question.

If we are going to explore the use of orientations in different settings, then we must work towards developing metaphors which are appropriate for a particular setting, but which elicit equivalent orientations. There are likely additional orientations which have yet to be identified. For illustration, I recently gave a workshop on the metaphor interview at an international curriculum development meeting in Hawaii. Not surprisingly, many of the participants' metaphor responses reflect the international and political aspects of the seashore:

The seashore is a painting. Like a mosaic of many nations and cultures trading with one another.

The seashore is a battleground. It's a battleground to fight wars and for power--like the war in the Pacific, Pearl Harbour, World War I and World War II.

In my view, the above metaphor responses represent a "political
orientation" towards the seashore. In identifying and analyzing responses, then, we must be prepared to consider a wide range of experiences that individuals will choose to stress. There may well be ten to twelve broad orientations to the seashore. We are not likely to get a firm set of orientations, but rather a series of situationally specific ones related to age, physical environment, and social and cultural background.

In looking for orientational preferences cross-culturally, we need to single out those orientations which are likely to hold up in most social and cultural situations, contrasting these with those which are likely to show considerable variation. The closer we get to culturally specific contexts and values, the more culturally unique orientations are likely to become. Differences in the relative emphasis on one orientation or another in such settings would be interesting to explore. Orientations would be useful in understanding cultural preferences for certain instructional metaphors.

This raises a number of questions which need to be pursued in classroom settings. Are teachers aware of student frameworks, or orientations? If so, do they see them as an obstacle to learning? To what extent are students aware of their own beliefs and orientations? To what extent do teachers take into account students' orientations during instruction? Is conventional science instruction (i.e., that based on teaching materials that ignore students' orientations) effective in altering students' orientations, or do such orientations persist?
Clearly, there is still much work required to clarify the nature of students' beliefs and orientations, and the extent to which they interact with the students' experiences during instruction. If we are to make informed decisions about the most effective forms of instruction, then we must devote some of our research efforts to systematically studying the ways in which this interaction occurs, since such factors are of concern in developing any theory of learning and instruction.

The Metaphor Interview as a Research Tool

Metaphor interviews allow us to examine aspects of the cognitive system which are often relatively inaccessible. In this study, the metaphor interview allowed an analysis of the students' beliefs and orientations to the seashore. To show how the metaphor interview allowed me to study ways of thinking that are often masked by more conventional approaches, I compare and contrast the salient features of metaphor and literal interviews.

The literal interviews probed what the students believed about specific seashore relationships: what happens at high tide and at low tide, what a plant or an animal can do, how it protects itself and why. The literal interviews allowed me to probe the students' knowledge of specific seashore relationships, and to compare this with concepts identified in the metaphor interviews. Because I was probing for factual
data, the students often appeared nervous about the interviews. The students assumed that for every question, there was a "right" answer.

In addition to probing for beliefs, the metaphor interviews probed what the students think is desirable and how they felt. The metaphor interviews did more than probe for single beliefs or single values or single emotions. By asking the students to project responses onto metaphors in an imaginative way, the students were less likely to be consciously aware of the beliefs and values that they were communicating. The metaphor interviews allowed me to study how, in most situations, a complex cluster of beliefs, values and feelings influenced the formation of the students' response. One of the more useful features of the metaphor interview is that it allowed an analysis of "preferred" beliefs and "preferred" orientations. The fact that Mary stressed the concept of the food chain but not the concept of zonation, and Luke stressed the concept of zonation but not the concept of food chain, allowed me to study what beliefs the students viewed as the "most" important. It allowed me to describe and analyze a relationship between the students' beliefs about the seashore, their broad orientations, and the type of instruction that occurred.

What characteristics of the metaphor interview allowed me to uncover beliefs and orientations? One of the most important characteristics of the metaphor interview is that it is non-directive. The metaphor question suggests, it doesn't
define. Hence, the students have to define their preferred relationship to the seashore. There is a connection between the characteristics of metaphorical thinking, which are essentially relational in nature, and the responses obtained by metaphor interviews. The metaphor interview allowed me to analyze such relationships as: 1) a student's comprehension of the relationships among concepts, 2) a student's own relationship to the phenomenon under study, and 3) a student's relationship with others in social and cultural situations.

The essence of beach ecology is the study of relationships: tidal cycle, habitat, predator-prey, interdependence, community, pollution, conservation, and so on. The meaning stems from a relationship among animals, objects, events and conditions at the seashore. For example, the concept of food chain cannot be understood unless something about its relationship to other concepts is known: energy, predator-prey, interdependence, and so on. The concept of desiccation cannot be understood unless something is known about an organism's relationship to its habitat, the tidal cycle, the way it protects itself from loss of moisture. Similarly, one cannot tell if something is polluted unless it can be compared to something else. Metaphor questions such as "A seagull is a robber," "A cobblestone is a hotel," and "A tidal pool is a city" help one to explore the student's understanding of relationships among ecological concepts.

Similarly, the students' own relationship to the seashore cannot be understood unless something about the
students' perceptions, feelings, knowledge, and values of the seashore are known. For example, the metaphor question, "I am to the seashore as: a driver is to a car, a passenger is to a car, a mechanic is to a car", allows researchers to analyze student - seashore relationships. The students' metaphor responses illuminate whether the relationship is passive, active, dominating, positive, negative, and so on.

Analysis of the students' pre- and post-metaphor interviews allowed some understanding of complex interactions between the students' previous experiences and their present instructional experiences. The meaning that the students weave into their pre-instructional metaphor responses may stem from their previous personal experiences with multiple physical, social and cultural objects and events. The meaning that the students weave into the post-instructional interviews stems from an interaction between their previous experiences and their recent instructional experiences: the various observations and inquiries with the seashore phenomena under study (plants, animals, tides, wind, and sun); their experiences with others during instruction (peers, teachers, resource persons); and their experiences with classroom materials (textbooks, library books, salt water aquaria, microscopes). These objects, events, and experiences of students in classroom settings continuously vary. The students' metaphor responses allow researchers to get at modes of thinking that are grounded in the students' experience. Also, they enable communication of the students' ideas, beliefs and experiences with a richness of detail.
The students' metaphor responses express the particular qualities of experience. What are the particular qualities of Dan's scientific mode of inquiry and his intimate relationship with the seashore? What are the particular qualities of Mary's detached relationship with the seashore? What are the particular qualities of Jimmy's fear of fishing boats sinking during storms at sea? How do Sharon's perceptions about seashore animals' capacity to feel pain and have feelings interact with her attitudes towards science? In revealing these expressive qualities through metaphor interviews, educators have the opportunity to participate vicariously in the lives of students, to acquire an empathetic understanding of these situations that are important in the lives of their students.

Moreover, metaphor interviews may have implications for multi-cultural education by allowing researchers to understand the thinking of students with different social and cultural backgrounds. In this study, both Jimmy and Luke are full-status native Indians. Both students have writing, reading, mathematics, and science skills which are well below grade level, as evidenced by their report card grades and achievement test scores. Yet both students gave responses which allowed an analysis of their beliefs and orientations. In the case of Luke, there is a connection between his fluid usage of metaphor and his performance on the metaphor interviews. The fact that Luke's preferred spiritual orientation is grounded in highly metaphorical forms of expression (native Indian oral legends and Pentecostal biblical stories) provides insights into Luke's
performance. Given a means of analysis based on verbal metaphorical skills and a sensitivity to his social and cultural environment, Luke's knowledge of science concepts can be described as average to good from the pre-instructional interviews and excellent from the post-instructional and long-term interviews. The metaphor interview is one possible assessment tool that takes into account the linguistic and socio-cultural background of the child.

Metaphor interviews could be used in large urban centers, in rural settings, and in isolated coastal fishing or native communities. They can be linked to a sampling strategy to provide important qualitative data that is holistic and episodic. The discourse of students struggling to increase their understanding of science concepts adds humanistic understanding to quantitative research.

Finally, metaphor interviews allow educators to study the impact of instruction among students with different starting points, and hence trace paths of learning much richer than we may have heretofore been allowed.

Metaphor Interviews and Future Research

A variety of questions about metaphor interviews needs to be explored. How can metaphor interviews take into account linguistic differences? Do we need a different set of metaphors for students of different ages and developmental levels? Should metaphor interviews be quantified?

Clearly, some students may have more ability than others
in responding to metaphor questions about particular aspects of reality. Luke clearly enjoyed the metaphor interviews and gave thoughtful responses to almost every metaphor choice. By contrast, Jimmy preferred to avoid the metaphor interviews altogether and gave short responses. One reason for Jimmy's behavior could be that he found the metaphor interviews difficult. We need to develop metaphor interviews for students with different metaphorical abilities and experiences. To do this, the abilities and preferences to express ideas in metaphorical fashion need to be explored for students of different ages, sexes, and social and cultural groups. For example, in the present study, a single metaphor question such as: "I would be an eagle, a raven or seagull" appealed to students of all ages, especially to primary children, whereas a double metaphor question: "I am to the seashore as a driver is to a car, a passenger is to a car, a mechanic is to a car", seemed to be difficult for students under grade five. There are metaphor interview techniques which seem to be more appropriate for students at different developmental levels. This finding is consistent with other research indicating that children's ability to handle more demanding metaphor comprehension tasks increases with age (Johnson, 1983; Marschark & Nall, 1983; Vasniadou & Ortony, 1984). In addition to exploring a wider range of language metaphor questions, we need to explore a range of non-verbal metaphor formats as well--the use of pictures and role-playing in probing for preferences. Such research is currently lacking in science education.
In spite of the apparent desire of many researchers to try and assign numbers to any construct, we need to be cautious in attempting to quantify the students' metaphor responses. Because orientations have a certain stability and coherence, they appear easy to classify into categories. In reality, orientations seem to be quite context dependent and the researcher must have appropriate knowledge and experience with the contexts to categorize the students' responses. Hence, the task of simply counting responses in a given category will be neither very informative nor particularly valid. The richness of the metaphor interview is its potential to illuminate personal perceptions, feelings, and value preferences.

The development of a sensitive metaphor interview and the analysis of responses depend on an understanding of the respondent's physical, social and cultural experiences, the curriculum as presented, and so on. For instance, in the present study, this analysis requires knowledge of the social and cultural milieu of Salmon Cove, as well as fishing methods and the state of commercial fishing in British Columbia, the instructional concepts of interest, and knowledge and experience of the seashore. This suggests that the analysis of data is not a simple coding schedule which can be picked up in a 30 minute training session. An inter-rater reliability category system may be possible and desirable in some future studies, if it presupposes a holistic understanding of complex situations. A sensitive coding schedule would require a careful examination of the contributions of context to the students' metaphor response.
Instructional Metaphors

This study indicated that instructional metaphors contributed significantly to the comprehension of science concepts. The data reveal that several criteria could be utilized for creating verbal and non-verbal instructional metaphors for increasing the students' comprehension of specific science concepts:

1. Conceptual Fit There is a close connection between the metaphor and the science concept of interest.

2. Perceptual Fit The metaphor relates to perceived experience: color, shape, texture, sound, activity, etc.

3. Orientational Fit The metaphor appeals to the students' preferred orientation.

4. Social and Cultural Fit The metaphor is sensitive to the social and cultural background of the student.

It is interesting to notice that in the post-instructional interviews all of the students chose a high proportion of metaphors that had been used as instructional metaphors, and stressed the specific concepts which were associated with the metaphor during instruction. For example, most of the students chose the instructional metaphors "A barnacle is a fisherman" and "A seagull is a robber" to discuss the concept of predator-prey, "A crab is a garbage collector" to discuss the concept of recycle, "A barnacle is a house" and "A cobblestone is a hotel" to discuss the related concepts of tidal cycle, habitat, desiccation, and protection. Such metaphors have a conceptual fit with the science concept of interest. For
example, the fisherman metaphor may be successful because there are obvious connections between the predator-prey aspect of a human catching a fish and a barnacle feeding on plankton. In the words of Lakoff and Johnson (1980), the metaphor "highlights" the predator-prey concept by bringing into the foreground the notion of fishing. The metaphor is a way of comparing the food relationships of animals in terms of a human food activity. In asking the students to focus on the concept of predator-prey relationships the metaphor can keep the students from focusing on other aspects of the seashore that are inconsistent with the concept. In this sense, metaphors such as "A barnacle is a fisherman" involve fewer interpretations and seem to be remembered best (Marschark & Hunt, 1983).

Also, there needs to be a perceptual fit between the metaphors and the concepts of interest. For example, in "The barnacle is a fisherman" metaphor there is a perceptual fit between the metaphor and the concept of predator-prey, the visual image of a fisherman throwing a fishing net and the activity of the barnacle with its cirri raking the water for planktonic food. Such metaphors enable the communication of concepts with a richness of detail because the sensory aspects are more highlighted.

Successful instructional metaphors may need to satisfy several of the above criteria. In the Salmon Cove study, the students preferred the "A barnacle is a fisherman" metaphor over the "A sea urchin is a spaceship" metaphor in the post-instructional interviews. At first, such data suggest that
the fisherman metaphor was more perceptually appropriate. But
the spaceship metaphor also allows a good visual and conceptual
fit between the image of a spaceship with its robot-like sensors
and probes and the sea urchin with its long sharp spines on
movable ball-and-socket joints, its long tube-feet with suction
cups, and its tiny plier-like pedicellaria. It seems likely
that the Salmon Cove students didn't prefer the spaceship
metaphor because it was not as culturally appropriate.

In looking for instructional metaphors that appeal to
students' preferred orientations, we need to single out those
metaphors which are more likely to appeal to individual students
with specific orientations, as well as those metaphors that
appeal to a wide range of students possessing different
orientations. The fact that girls may favor an aesthetic
orientation gives insights into the types of imagery girls
likely prefer. The use of more aesthetic metaphors—for
example, the necklace metaphor—is probably a useful teaching
strategy. When teaching in a fishing community, the use of the
"A barnacle is a fisherman" metaphor to teach the concept of
predator-prey and "The food web is a fishing net" to teach the
concepts of food web and interdependence may prove to be
effective. The fact that all the students favored a
recreational orientation to the seashore suggests that "The
seashore is a playground" could be used successfully to teach
the concepts pollution and conservation. This is important.
Even in the Salmon Cove study, the teacher taught the concepts
pollution and conservation by referring to the fact that
degradation of the environment would diminish the productivity of the seashore; that is, the teacher used a utilitarian approach. The fact that all the students exhibited a recreational orientation suggests that the teacher also could have taught pollution and conservation using a recreational approach: degradation of the environment would diminish the recreational possibilities at the seashore. In other words, the use of recreational metaphors to teach science concepts may be more effective with younger age groups. Still, we need to be cautious when making such assumptions. For example, many younger children may not see the beach in recreational terms and many girls may not favor jewelry imagery. There will always be differences among individuals.

In this study science concepts were reinforced at the verbal and non-verbal level. Recall that the teacher used both language metaphors ("A barnacle is a house," "A cobblestone is a hotel," "The sun is a factory") and non-language metaphors (the dramatization activities) to teach the relationships of the tidal cycle, desiccation, habitat, and protection. We have here a whole cluster of verbal and non-verbal images which reinforces relationships. One of the more interesting findings from the Salmon Cove study was that after instruction, all of the students stressed a new understanding of the concept of desiccation. This 'acting out' of the "hot sun burning bright," a "barnacle closed up tight inside its moisture-filled shellhouse at low tide" or a "starfish prying open a clam at high tide" gives students encounters with the physical world and
may help them comprehend some of the concepts associated with these events. Such clusters of verbal and non-verbal metaphors may be mutually reinforcing when applied together, rather than singularly. There may be more support for comprehension and recall when both verbal and non-verbal metaphors are provided.

As revealed in this study, there appear to be times when a "typical" metaphor such as "A barnacle is a fisherman" seems to work best in moving students from the abstract to the concrete, or for making the strange seem familiar. The metaphor "highlights" the predator-prey concept by bringing into the foreground the notion of fishing, and "masks" other aspects of the seashore that are inconsistent with the concept. In this sense, metaphors involving fewer interpretations seem to work well in teaching specific science concepts and seem to be remembered best. At other times, "atypical" metaphors such as "A sea urchin is a spaceship" or "The seashore is a symphony orchestra" seem to work well in moving students from the concrete to the abstract, or from the familiar to the strange. In this sense, the introduction of apparent contradiction and complexity may stimulate the students to invent imaginative and novel associations. In this instance, a more ambiguous or multi-faceted metaphor may have opened up a new range of entry points, thus allowing more students to participate.

The data in this study indicate that in the post-instructional interviews some students more than others were able to elaborate metaphors that were not used during instruction. For example, "A sea anemone is a mouse trap" was
used to describe the concept of predator-prey, "The seashore is a totem pole" to describe the concept of food chain", "Seaweed is a curtain" to describe the related concepts tidal cycle, desiccation, habitat, and protection. By contrast, some students were much less likely to elaborate such metaphors.

Metaphors are important as teaching devices because they allow the transfer of coherent information in a flexible way. This view dominates the thinking of writers such as Beck (1978, 1980), Lakoff and Johnson (1980), Ortony (1975, 1979), and Paivio (1979). Controlled experiments have shown, for example, that the more ambiguity a metaphor provides, the better it serves basic thought processes (Johnson & Malagady, 1980). It seems likely that in the Salmon Cove study, the use of instructional metaphors saved the teacher from specifying one by one each of the often innumerable relationships between the instructional metaphor and the concept of interest. Metaphor rescued the students from complicated and boring explanations because the metaphor was always simpler than the abstract concept it represented. Because the metaphors allowed for greater flexibility, the transfer of information was more vivid and memorable.

This research helps explain the pedagogic value of metaphor. Educators need to recognize the role of metaphors in concept formation and in stimulating innovative and expressive thought. Metaphors encourage students to ask a range of questions, to see things in new light—and thus are useful tools for inquiry.
Instructional Metaphors and Future Research

The results of this study raise some interesting issues for metaphorical teaching. What are the dangers involved in using metaphors to teach science concepts? How much guidance should teachers give students when using metaphorical teaching?

From an instructional point of view it becomes important to recognize how much guidance the teacher needs to give to students when using metaphors to elaborate a concept—a consideration which grows in importance as the audience becomes larger and more heterogeneous. The teacher who uses metaphors needs to know how much she can assume about the students' prior knowledge of the concept. If she makes an incorrect judgement in this respect a situation may arise in which the students cannot elaborate the metaphor because they simply don't know enough about the concept. There might be two consequences: the students may simply fail to grasp the concept, or they may attribute inappropriate characteristics to the metaphor and hence be misled.

Closely related to the idea that students may fail to recognize the concept is the idea that the teacher needs to know when the metaphor "highlights" and "hides" some aspects of an experience that may be inappropriate. When the metaphor entails very specific aspects of a concept, it suppresses other aspects of the concept. The effect could be a narrow or incorrect interpretation of the concept. "A seagull is a robber" may highlight certain negative qualities that are viewed in our
culture as bad, or dangerous, or immoral. Teachers need to discuss the usage of metaphor openly with their students. That is, to discuss the metaphorical and literal aspects of the "A seagull is a robber" metaphor. In the Salmon Cove study, the teacher discussed "The seashore is a battleground" metaphor with the students the first day of class. After the students elaborated the metaphor, they discussed the idea that the seashore doesn't really carry on a "battle," the land and the sea are not "armies," and the water, rocks and sand are not "weapons." The author of the story used metaphors as a literary device to dramatize the concept of tidal cycle and erosion. Teachers need to encourage students to view animals, objects and events from different angles. For example, to explore the seagull as a "janitor," "dance," "song," "jewel," and "gift." How many different ways can they see the pattern? The fact that all of the students in the Salmon Cove study had fewer incorrect beliefs about seashore relationships after instruction suggests that students at the grade 6 level are able to distinguish between appropriate and inappropriate usages of metaphor. Nonetheless, we need to be cautious in attempting to use metaphors during instruction. The potential negative effects of instructional metaphors are still largely unknown.

Another consideration is to recognize how much sensory experience the students need in order to elaborate the metaphor. In the Salmon Cove study, the teacher introduced "The seashore is a symphony orchestra" metaphor after the students had ample unstructured explorations at the seashore, and after they had
completed several sensory-awareness activities: sitting and listening at the tideline, a blind walk, and so on. The teacher introduced the "A sea urchin is a spaceship" metaphor after the students had observed sea urchins in the aquarium, used microscopes, and completed their science inquiries. The teacher who uses the metaphor needs to know how much first-hand experience is required to elaborate the concept, and when the metaphor is effective in moving the students from the familiar to the unfamiliar, or vice versa. A metaphor used successfully can give insight and comprehension, used unsuccessfully it can generate confusion and even anger.

From my own observations, teachers are unaware how much they and their students use metaphors in the classroom. Classrooms are exceedingly busy places. While instructing, teachers have little time to reflect upon what they are doing because they are so busy reacting to the present situation. Thus, unless teachers are listening for student metaphors, or looking for ways to incorporate metaphors into instruction, they will not see opportunities to use metaphors in their teaching. This problem can be solved in part, but not completely through training. Even after teachers conceptualize a metaphorical approach to teaching, awareness of the students' metaphors, or even constructing effective metaphors for particular students, is still difficult.

The use of instructional metaphors extends beyond the brief descriptions provided here. We need to identify and describe what teachers do when they use metaphors for
instruction. We need to identify and describe what teachers do when they engage students in metaphorical thinking, how students respond, what type of learning takes place, how the students interpret the concepts of interest, what types of metaphors are more memorable, when the use of metaphor results in inappropriate or inaccurate conclusions. We need to develop curriculum materials and ways of evaluating curricula employing metaphors. To be effective, we also need pre and inservice training to help teachers develop strategies of instruction conducive to metaphorical thinking. Thus, the use of metaphor for increasing comprehension and retention of any set of concepts of interest holds promise. Furthermore, the range of educational applications of metaphors is largely unexplored and ought to be the focus of continued inquiry.

Diversity of Orientations and Science Instruction

To what extent should teachers value one orientation over another? Should science educators attempt to change students' orientations, for example, from a spiritual orientation to a scientific orientation? What are the ethics involved?

The results of this study help explain why some students reject science as it is frequently taught in schools. In the Salmon Cove study, the marine biologist's portrayal of the "lower animals" as "incapable of detecting pain" or of "having feelings and emotions" provides insights into why girls (as well
as many boys) may reject standard science. Discussions involving issues of this sort are important and even necessary under certain circumstances, but must be approached with sensitivity, especially with young students. Students with a spiritual orientation would have rejected such claims altogether. Recall that Luke believes in supernatural animals that "can talk" and "give people advice." Luke's family crest is the Thunderbird, which means that after death Luke's relatives can "become" a killer whale or the Thunderbird. Given such fundamental differences in beliefs and values, it seems likely that many of the students would simply recognize a difference in values and reject the concept outright. Or worse, they may feel frustrated and angry, fail to grasp the intended meaning of the concept, and interpret the concept quite inappropriately.

An important finding of this research is that it is possible to increase a student's knowledge of science concepts without altering substantially his or her preferred orientation. In the case of Luke, an increased knowledge of beach ecology was achieved, yet he continued to prefer a spiritual orientation to the seashore. What this means is that we can increase a student's scientific knowledge so that it can be utilized in appropriate situations. It makes sense to talk about increasing a student's knowledge and changing certain alternate beliefs about science concepts. It makes sense to talk about using the students' preferred orientations as bridges to teach science concepts. But it doesn't make sense to talk about changing (in
the sense of replacing) students' orientations. Since the students' orientations are a complex cluster of interrelated beliefs and values, we can teach in order to increase the students' understanding of various seashore organisms and relationships (and so increase the likelihood that they may use more of a scientific orientation to the seashore). But this instruction should always recognize that there are many interpretations of scientific phenomena, just as there are many interpretations of religion, politics, economics, or art. Therefore, we teach that: "There are many different ways that I can see patterns in seashore life."

This leads to practical implications for science teaching. The current research provides some examples, but not prescriptions about how this might occur. It should be part of science teaching that students be given the opportunity to re-interpret new information in light of their own orientations. Students should be given opportunities to identify and articulate their own orientations with each other. In this way pupils are encouraged to defend their own ideas, have a personal interest in the discussion, and focus on the relevant issues.

Thus, science teaching strategies cannot be the same for each school or classroom. The strategies must be modified to take into account the social and cultural qualities of the community. In some classroom situations the teacher might avoid certain conflicting beliefs and values altogether, in other classrooms the teacher might encourage the students to explore conflicting beliefs and values. But always, the teacher
encourages the students to allow for the possibility of differing orientations.

As science educators we must not forget that our overall task is not simply to present science concepts—as if this were a detached task—but to present an authentic view of science, emphasizing the connection between personal knowledge and science, and setting science education in a social and cultural context. Individual differences must be understood, respected, and provided for. This means a science education for all students: girls as well as boys, those with a special interest in science and science careers, those with different career aspirations, and those of different religious and cultural perspectives.

To negotiate meaning with others, students with different orientations have to become aware of differences in meaning in their own backgrounds and when these differences are important. Metaphorical imagery can be useful in creating rapport and in attempting to communicate the nature of experiences which the students have not shared. This strategy consists, in large measure, of the ability to bend your own view and adjust the way you categorize your experiences. When conflicts occur during instruction, or when the teacher or person of authority transmits a fixed proposition by means of "force," meaning is almost never communicated. Students need to slowly figure out what they have in common, what is safe to talk about and question, and how they can communicate personal experiences to create a shared vision. With enough flexibility,
some mutual understanding might be achieved. Through metaphor, it may be possible to teach each group that certain kinds of behavior, previously annoying, can be interpreted as "reasonable," given a different set of orientations.

It is easy to ignore the fact that students have emotional needs that must be met through teaching. When an approach which focuses upon learning a set body of science "facts" dominates classroom practice, opportunities to gain satisfaction from learning and a better understanding of science as a human activity can be seriously diminished. The human need for pride in accomplishing the task and being able to feel comfortable during the learning process is still very great for most of us. The science classroom should provide optimal conditions where such needs can be met.

As the findings described in this study rest on data collected through the use of a small interview sample, the need for more extensive research is obvious. By discovering some of the ways students' orientations interact with different types of instruction, educators and curriculum developers could plan programs appropriate to students with a range of different orientations. Such programs could provide teachers with resource materials about students' orientations, scientists' views, and differences between them.

The research described here is a first step. As such, it suggests that educators in all subject areas need to explore this frontier. The identification of orientations is one important way educators can monitor and resolve conflict between
the beliefs and values that students bring to instruction, and the concepts taught in the classroom.
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APPENDIX A
THE METAPHOR INTERVIEWS
Set A: The Students' Metaphors for the Seashore

Metaphor question: If the seashore were one or more of the following six images, which one or ones, would it be? WHY?

Set of Images:

(a) ______ factory          (g) ______ farm
(b) ______ painting         (h) ______ dance
(c) ______ house**         (i) ______ graveyard**
(d) ______ battleground**  (j) ______ blackberry bush
(e) ______ legend**        (k) ______ totem pole
(f) ______ gift**          (l) ______ hotel**

(m) ______ cannery          (s) ______ pot-luck dinner**
(n) ______ necklace**      (t) ______ patchwork quilt
(o) ______ town**          (u) ______ family
(p) ______ pin cushion      (v) ______ jewel
(q) ______ playground      (w) ______ spaceship
(r) ______ song**          (x) ______ garden

** Images used as "instructional metaphors".
<table>
<thead>
<tr>
<th>Set B: The Students' Metaphors for the Animals, Objects and Events at the Seashore</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Barnacle</strong></td>
</tr>
<tr>
<td>___ thumb tack</td>
</tr>
<tr>
<td>___ fisherman**</td>
</tr>
<tr>
<td>___ song</td>
</tr>
<tr>
<td>___ house**</td>
</tr>
<tr>
<td>___ rock</td>
</tr>
</tbody>
</table>

| **4. Crab** | **5. Cobblestone** | **6. Tidal Pool** |
| ___ robot | ___ umbrella | ___ painting** |
| ___ pair of pliers | ___ hairbrush | ___ store |
| ___ mobile house | ___ community | ___ town** |
| ___ feast | ___ totem pole | ___ dance |
| ___ garbage | ___ hotel** | ___ war** |

| **7. Sea Star** | **8. Tide** | **9. Sun** |
| ___ spaceship | ___ song | ___ jewel |
| ___ can opener | ___ mop | ___ furnace |
| ___ flower | ___ bowling ball | ___ gift |
| ___ robber | ___ legend** | ___ factory** |
| ___ jewel | ___ gift | ___ lamp |

| **10. Mud** | **11. Clam** | **12. Sea Water** |
| ___ pillow | ___ dance | ___ diamond |
| ___ tunnel | ___ legend | ___ soup** |
| ___ piano | ___ potlatch | ___ theatre |
| ___ city | ___ necklace | ___ dance |
| ___ pot-luck | ___ vacuum | ___ factory |
| ___ dinner | ___ cleaner** | | |

| ___ garden | ___ graveyard** | ___ sunburst |
| ___ flower** | ___ sandcastle | ___ spaceship** |
| ___ mouse-trap | ___ theatre | ___ lawn mower |
| ___ dress | ___ mattress | ___ farmer |
| ___ person | ___ bullets | ___ pin cushion |
Set C: If You Were A...

1. If you were a crab, would you most like to be a:
   - hermit crab
   - edible crab
   - purple shore crab

2. If you were a starfish, would you most like to be a:
   - sunflower star
   - sun star
   - purple star

3. If you were a rock, would you most like to be a:
   - boulder
   - sand grain
   - polished beach pebble

4. If you were a bird, would you most like to be a:
   - bald eagle
   - raven
   - seagull

5. If you were a fish, would you most like to be a:
   - sculpin
   - blenny
   - salmon

6. If you were a type of seashore, would you most like to be a:
   - rocky
   - cobblestone
   - sandy
   - mud flat
   - shore
   - beach

7. If you were the weather, would you most like to be a:
   - sunny day
   - sea lion
   - killer whale

8. If you were a mammal, would you most like to be a:
   - seal
   - sea lion
   - killer whale

9. If you were the wind, would you most like to be a:
   - windy day
   - gentle breeze
   - hurricane

10. If you were the tide, would you most like to be a:
    - low tide
    - high tide
    - ebb tide

11. If you were a boat, would you most like to be a:
    - sail boat
    - ferry boat
    - fishing boat

12. If you were anything you wanted to be at the seashore, what would you most like to be? Why?
I am to the seashore as a . . . . .

1. driver is to passenger is to mechanic is to
a car a car a car

2. story teller is to a story listener is to a story animal is to
a story

3. manager is to hockey puck is uniform is to
a hockey team a hockey team a hockey team

4. leaves are to roots are to bark is to
a tree a tree a tree

5. lock is to bead is to string is to
a necklace a necklace a necklace

6. fruit is to a thorn is to a flower is to a
blackberry bush blackberry bush blackberry bush

7. owner is to a captain is to a deckhand is to a
fishing boat fishing boat fishing boat

8. window is to a door is to a roof is to a
house house house

9. cloth is to a lace is to a stitches is to a
curtain curtain curtain
APPENDIX B

THE SCIENCE CONCEPTS
Community: A group of plants and animals living in the same area and depending on one another for survival.

Conservation: The act of keeping or protecting from loss or injury seashores, and seashore plants and animals.

Desiccation: That combination of sun, wind, and air which dries out or causes plants and animals to lose moisture at low tide.

Ecology: The study of the relationships among plants, animals (including humans), and the place where the plants and animals live.

Food Energy: That combination of raw materials which is used by plants and animals for nourishment. Green plants make food by the process of photosynthesis, with sunlight as the source of energy.

Food Chain: A diagram depicting the food relations among plant, plant eaters, and animal eaters. For example: seaweed ---> sea urchin ---> sea otter ---> seal ---> man.

Food Web: Two or more connected food chains.

Habitat: The place in which a plant or an animal lives: on rocks, under rocks, in crevices, in tidal pools, among seaweeds, in mud, and in sand.

Life Cycle: The growth and development of a plant or an animal, which in turn gives rise to a new generation.

Predator: An animal that eats other animals.

Prey: An animal eaten by another animal.

Protection: To shield or defend from harm or injury; e.g., from predators or from loss of moisture.
Pollution: Anything that decreases the comfort range of the plants and animals which have established themselves in the place under study.

Recycle: The process whereby bacteria (or scavenging animals) break down the remains and wastes of other organisms.

Tidal Cycle: The twice daily rise and fall of the tide: high tide, ebb tide, low tide.

Type of Coastline: The exposed shore that takes the full force of beating waves, the protected shore that receives little wave action, or the transitional shore that is neither completely protected nor completely exposed to the hazards and surf-swept conditions of the open coast.

Type of Seashore: Rocky shore, cobblestone beach, sandy beach, or mudflat.

Zonation: The arrangement of plants and animals in horizontal layers on the shore named according to the length of time they are covered by water and exposed to air: spray zone, high tide zone, middle tide zone, low tide zone.
APPENDIX C

INSTRUCTIONAL METAPHORS
Metaphor questions used to highlight the concepts types of seashores, tidal cycle, and change:

If the seashore were a battleground between the land and the sea, what would be the
- battleline
- sea's weapons
- land's weapons
- generals
- ceasefire
- victors
- losers

WHY?
When would the two armies fight?
When would the scene of be calm

If the seashore were a musical production, what would be the
- instruments
  - violins
  - trumpets
  - piano
  - drums
- conductor
- theatre
- audience

WHY?
When would the music change?
When would the music be loud?
When would the music be soft?

Metaphor questions used to highlight the concepts tidal cycle, habitat, desiccation, and protection:

If a barnacle were a house, what would be its
- roof
- doors
- walls
- basement

WHY?
When would the doors be open?
When would the doors be closed?
Why?

If a cobblestone were a hotel, what would be its
- basement
- rooms
- basement residents
- furnace
- air conditioning
- top floor
- top floor residents

WHY?
Would a resident be allowed to move from the basement to the top floor?
Metaphor questions for highlighting the concepts tidal cycle, predator-prey, and protection:

If a hermit crab were a mobile home, what would be its
- trailer
- trailer hitch
- driver
- passengers
- headlights
- bumper
- gasoline
- door
- exhaust

If a snail were a car, what would be its
- body frame
- doors
- windows
- headlights
- wheels
- bumper
- gasoline
- steering wheel

WHY?
When would the mobile house be parked?
When would the car be parked? If so, how?
When would be mobile house be on the road? Why?
When would the car be on the road? Why?
Would the driver leave the trailer behind? Why?
Could the driver leave the mobile house in for a new home? Why or why not?

WHY?
Would the car change? If so, how?
Could the car be enlarged? If so, where?

Metaphor questions to highlight the concepts life cycle, tidal cycle, recycle, interdependence, and community:

If a crab were a garbage collector, what would be its:
- garbage
- garbage truck
- garbage crusher
- working hours
- fellow garbage collectors
- sanitation department

If a seagull were a janitor, what would be its:
- garbage
- garbage bag
- pick-up sticks
- fellow janitors
- working hours

WHY?

What would happen if all the janitors and garbage collectors went on strike?
Metaphor questions for highlighting the concepts tidal cycle, predator-prey, and protection:

If a barnacle were a fisherman, what would be its
- catch
- boat
- fishing net
- bait

WHY?
What would be the fishing hours?

If a clam were a vacuum cleaner, what would be its
- vacuum (suction)
- air hose
- dirt
- dirt bag
- wheels
- fuel

WHY?
Could the vacuum cleaner get unplugged? Are there different models of vacuum cleaners?

If a sea urchin were a spaceship, what would be its
- spaceship frame
- landing gear
- sensors
- oxygen tanks
- weapons
- electronic hands
- control panel
- exhaust
- enemies

WHY?
What would be the spaceship's mission?
When would the spaceship use its weapons?
When would the spaceship use its landing gear?

If a sculpin (bullhead), were a submarine, what would be its
- rudder
- hatch
- sonar
- weapons
- fuel
- frame
- mission
- enemies
- defence

WHY?
Would the submarine change?
Would the mission change?
Metaphor questions for highlighting the concepts food chain, energy, interdependence, and community:

If a tidal pool were a community, what would be its...
  - houses
  - roads
  - cars
  - factories
  - highrise building
  - underground houses
  - subways
  - grocery stores
  - police department
  - neighborhoods
  - traffic lights
  - police department
  - mayor

WHY?
When is rush hour?

Metaphor questions used to highlight the concepts zonation, interdependence, and community:

If a boulder (or dock piling) were a highrise building, what would be its...
  - first floor
  - second floor
  - third floor
  - fourth floor
  - first-floor residents
  - second-floor residents
  - third-floor residents
  - fourth-floor (penthouse residents)
  - hallways
  - elevator
  - floor decorations
  - manager
  - owner

WHY?
Can a resident move from the first floor to the top floor?

If the food chain were a necklace, what would be its...
  - beads
  - string
  - lock

WHY?
What would happen if the string broke?
APPENDIX D

THE STUDENTS' AWARENESS OF SEASHORE PHENOMENA

AFTER INSTRUCTION
<table>
<thead>
<tr>
<th>Dan</th>
<th>Sharon</th>
<th>Anna</th>
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55. sun
56. tidepools
57. sand
58. mud
59. green sea urchin
60. purple sea urchin
61. red sea urchin
62. herring gull
63. herring
64. sockeye salmon
65. coho salmon
66. pink salmon
67. dog salmon
68. spring salmon
69. rock cod
70. flounder
71. sole
72. black chiton
73. lined chiton
74. periwinkles
75. whelks
76. sandpipers
78. ravens
79. porpoise
80. dolphins
81. baleen
82. blue back coho
83. crane
84. h from
85. red-throated loon
86. grebe
87. pintail
88. acorn barnacle
89. green anemone
90. red-tailed hawk
91. ray egg case

56. rocky beach
57. herring
58. mud shark
59. halibut
60. dog salmon
61. red spring salmon
62. red snapper
63. bass
64. trees above beach
65. sun (p)
66. tide
67. gravel
68. leather star
69. sand worm
70. junk
71. sand
72. black cod
73. red snapper
74. halibut
75. sand (p)
76. gravel
77. leather star
78. sand worm
79. junk
80. sand
81. sand
82. black cod
83. red snapper
84. halibut
85. sand (p)
86. gravel
87. leather star
88. sand worm
89. junk
90. sand
91. sand

59. cobblestones
60. black cod
61. mud shark
62. red snapper
63. halibut
64. dog salmon
65. red spring salmon
66. sand worm
67. leather star
68. sand worm
69. junk
70. sand
71. sand
72. black cod
73. red snapper
74. halibut
75. sand (p)
76. gravel
77. leather star
78. sand worm
79. junk
80. sand
81. sand
82. black cod
83. red snapper
84. halibut
85. sand (p)
86. gravel
87. leather star
88. sand worm
89. junk
90. sand
91. sand
 Jimmy  Luke  Mary
1. clams  eagle  crabs
2. sea anemones  raven  birds
3. sea urchins  crabs  starfish
4. crabs  eels  clams
5. hermit crabs  starfish  sea anemones
6. limpets  bullhead  sea urchins
7. chinese hats  killer whale  snails
8. red shore crab  seal  barnacles
9. rocky crab  mink  water
10. bullheads  sea snake*  shells
11. clingfish  clam  plankton
12. starfish  barnacles  logs
13. eels  mussels  trees
14. chinese (chiton)  oyster  waves
15. sockeye salmon  abalone  wind
16. hump salmon  shark  cobblestones
17. pink salmon  dolphins  rocks
18. steelhead  octopus  mudflat
19. dogfish  sea anemone  seaweed
20. spring salmon  sea urchin  seagull (p)
21. ling cod  tiger fish  sandpipers
22. mud shark  butterfly fish  blood starfish
23. sand worm  hermit crab  sun starfish
24. red snapper  hairy crab  sunflower starfish
25. whisker cod  purple starfish  six-rayed starfish
26. barnacles (p)  butter clam  animal plankton
27. dead snake*  clingfish  plant plankton
28. dock pilings  purple shore crab  sun
29. rocks  salmon  butter clam
30. glass  pacific salmon  periwinkles
31. clam shells  sockeye salmon  red & green anemone
32. kelp  perch  bullheads
33. seaweed  ratfish  clingfish
34. sandy beach  sunflower starfish  purple shore crab
35. rocky beach  leather starfish  hairy crab
36. seagulls  moon Snails  hermit crab
37. seals  shrimp  tide (p)
38. whales  jumping bugs*  logs (p)
39. killer whales  logs (p)  rocks
40. blue whale  rusty nails 
41. porpoise  trading beads*  
42. dolphin  fish bones  
43. ducks  sand  
44. geese  pebbles  
45. crows  mudflat  
46. blue jay  cobblestones  
47. kingfisher  water  
49. plankton (p)  weather  
50. eagle  seagulls  
52. oxygen  
53. sunshine
PUBLICATIONS


