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Cross-Cultural Teaching and Learning: Teaching Environmental Education in Costa Rica

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CROSS-CULTURAL TEACHING AND LEARNING: TEACHING ENVIRONMENTAL EDUCATION IN COSTA RICA

A Thesis Presented

by

CRAIG L. JACKSON

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ABSTRACT

CROSS-CULTURAL TEACHING AND LEARNING: TEACHING ENVIRONMENTAL EDUCATION IN COSTA RICA

June 1997

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Teachers often face large cultural gaps between them and their students. They also often find (especially in science education) that students have not learned what supposedly has been taught them.

To counter this lack of learning, some educators argue students must construct their own learning if that learning is to be meaningful. Furthermore, students must address their own prior alternative conceptions. If they do not, these alternative conceptions may be retained, even in the face of instruction to the contrary.

Freire and others have addressed the gap between teachers and students. They have emphasized the need for educators to make learning meaningful by validating students' prior understanding, relating their teaching to the students' experiences, and empowering their students.

The teacher is left questioning how can she achieve these goals: (1) What should her role be? (2) What dispositions should she adopt? and (3) What critical and creative thinking abilities should she employ?

Citing Richard Paul, Teresa Amabile, Paolo Freire, and Strike and Posner, among others, this thesis addresses these questions by examining literature on critical and creative

thinking, liberatory education, and conceptual change, and relating these to my experiences as a Peace Corps volunteer in Costa Rica. It presents my preparation and development of a program of studies in environmental education as a case study for cross-cultural teaching and learning. I explain how I addressed my three goals: to (1) teach environmental principles to my students (2) share teaching strategies and techniques with other teachers and (3) empower my students to realize they can and should make their own decisions with respect to their environment, but should also approach issues from a multilogical perspective.

I show how the teacher can help her students construct their own learning by relating lessons to the students' experiences and building upon them. I indicate ways in which prior alternative conceptions can be confronted and multilogical perspectives encouraged. Finally, I emphasize the teacher should examine and understand both her students' background(s) and her own, and may, at various times, have to play five different roles: (1) facilitator (2) guide (3) model (4) learner and (5) sharer.

This thesis is dedicated to my mother, Jeanne M. McHugh

ACKNOWLEDGEMENTS

I would like to express my gratitude to *Proyecto Consolidación del Area de Conservación Llanuras de Tortuguero* (PACTo) for their permission to reproduce in two of my lesson plans pages 46-47 and 50-51 from the book *Guía de Campo de las Especies Más Comunes del Area de Conservación de Tortuguero* by José Solano Marín. I would also like to acknowledge Editorial Norman for their permission to reproduce the drawings I had made which were based on the illustrations of the oxygen - carbon dioxide and nitrogen cycles on pages 200-201 of their book, *Biología Integrada: Los Seres Vivos y Su Ambiente*. Finally, I also feel it incumbent upon me to acknowledge the generosity of the Perry Castañeda Library of the University of Texas at Austin and Project Central America of the Minnetonka Public Schools in Minnesota for making their maps available via the World Wide Web for non-commercial use.

In the writing and production of this thesis I would like to acknowledge the generous help of Peg Cronin, who reviewed the manuscript and made many editorial suggestions concerning both style and content, and the many computer consultants at University of Massachusetts Boston without whose help this thesis would never have been brought to fruition. I would also like to gratefully acknowledge the support and advice given me by the members of my committee: Delores Gallo, my advisor, who, prior to my leaving for Costa Rica, had challenged me to write my book Discovering Urban Nature (in some ways a forerunner to this thesis), and since my return has encouraged me in pursuing and completing this thesis; Tim Sieber, whose comment to me before I left that too often environmentalists forget and/or ignore that human beings too are a part of nature remained uppermost in my mind as I lived and taught in Costa Rica; and Carol Smith, who constantly challenged me to clarify my political position as well as my educational philosophy and practice.

The background of my thesis is my role as a Peace Corps volunteer in Costa Rica. Thus, I am indebted as well to many in that country. I would like to acknowledge the support given to me by the United States Peace Corps in Costa Rica, and especially that of Gilberto Ugalde, my supervisor, who gave me both the freedom and encouragement to develop and write my program of studies. I am also indebted to the many teachers and principals of the schools in which I taught, who welcomed me into their classrooms and in many instances worked together with me. But most of all I am indebted to my students there, who enthusiastically participated in most of my lessons and activities as they constructed their own learning, and when they did not (or stared at me blank-eyed), made clear to me those lessons that needed to be changed.

PREFACE

As anybody who writes in English, I was faced with several problems which are rooted in the language. The first one stems from the traditional English usage of male pronouns when referring to human beings in general. This has been justified by saying that the male "generic" pronoun is being used inclusively in these instances. A number of studies have shown, however, that this is not the psychological interpretation made by most readers (both male and female) when reading, and that, in fact, the use of male "generic" pronouns has diminished the status of women in our society. A number of solutions have been followed by various authors -- including both male and female pronouns at the same time (e.g., s/he,his/her, or her and/or him); alternating the use of male and female pronouns; using plural generic pronouns instead (they, their); or using the female "generic" pronoun (she, her) instead of the male ones (he, his, him). Although there are a few times when I have used plural pronouns to avoid confusion, for the most part (excluding, of course, direct quotations) I have chosen the latter solution (i.e., to use the female "generic"). I have not done this because I feel the female generic is any more inclusive; rather it is consciously felt by most to be more exclusive than the male pronoun, since we have been acculturated to ignore the subtle sexism of the male generic pronoun. On the other hand, coming across a female generic pronoun causes the reader to "sit up" as she is reading, and thus, she is constantly confronted with the sexist nature of our language and how she has been conditioned to accept it. While using the female generic pronoun may slow down the reader, I feel it is both justified and important to do so if we hope to eliminate the sexist assumptions of our language.

In a similar way, our language does not easily allow citizens or residents of the United States to be properly named. Instead, we have allotted to ourselves alone the name "Americans," which is not only inaccurate but also offensive to many people who are also

Americans, but may not live in the United States. [The term should refer to anybody who lives in North, Central or South America.] Other languages do in fact have distinct words for residents of the United States (e.g., in Spanish the correct term is *"estadounidense"*), but these names are often not used either. [In much of Latin America they use the term *"norteamericano"* to refer to us, which is in a way an insult to both Mexicans and Canadians.] A Colombian friend suggested to me the term "USAnian" as an alternative, which I have adopted for this thesis. Again, as in my use of the female generic, I use the term to alert the reader to the inadequacy of our language and our own arrogance in assuming linguistically that we are the only Americans.I realize this usage is much more controversial than my use of the female generic, but trust my reader will understand why I do it.

Finally, in terms of language usage, the reader will note that I have interspersed a number of Spanish words within the text. I have used these because I feel they more clearly express the concepts under discussion than their English equivalents. I am aware of difficulties that the use of foreign phrases can present, and thus, as much as is possible, have tried to indicate the meanings of these words when they are first introduced, even if they are not exactly definable.

The reader should also remember that while this thesis is about my experiences in Costa Rica and the development of my environmental education program, it is not solely about the program. Thus, I have chosen to include the program (translated into English, as well as in the original Spanish) solely in appendices. I would also like to state that the program (and its fairly literal translation) have not been changed to reflect my subsequent thinking about my own educational practices or even edited to correct errors originally made in its writing. While I have translated the program of studies which I wrote, I have not translated some of the materials which I used in that program -- several articles and the

English translation to help the reader better understand those lessons. Similarly, I have reproduced the original drawings I made for my program, but have not translated the captions within them.

Finally, within the text of my thesis I have cited and quoted from a number of works written in Spanish. The reader should understand that these translations are my own, and while I believe they are accurate and reflect their authors' intent, they may in fact not be totally faithful to the original. I hope this is not so, but want to apologize in advance if I have misstated anyone's positions through inaccurate translation. Nevertheless, the translations I present clearly represent my understanding of the authors' intent, and reflect how they have influenced my thinking.

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INTRODUCTION

Problems to Which My Thesis Is Directed

Today many teachers find themselves in classrooms where their students' cultural, social, educational, and historical backgrounds are very different from their own. Too often these differences are dismissed as insignificant by teachers as they try to "impart their wisdom" to their students, and knowingly, or unknowingly, at the same time base their teaching and their students' learning upon their own (the teachers') cultural values and experiences. This aspect of teaching, while not often acknowledged, has always existed as educators have transmitted to their students the dominant values of the society. Most educators have also, to a lesser or greater degree, understood their students to be a tabula rasa, a "blank slate," on which to imprint the teacher's knowledge.

This method of teaching has increasingly become more inadequate as the cultural gulfs in society have widened and as educational systems and training and preparation in diverse skills (not only in the United States, but throughout the world) have been extended to more and more people. Some would say that this democratization (broadening of educational opportunities) has led to its downgrading. In contrast to this view, I would argue that the supposed "downgrading" of education throughout the world principally reflects teaching and evaluative practices that are class-based and focused on writing and the regurgitation of what has been "taught."

Note that my criticism of the existing educational system is twofold: it is based on briefly summarize my position in this introduction, before examining it in detail in the body of my thesis.

Critique of the Present Educational System

Alternatives to the banking concept of education. Many educators have decried the above-mentioned educational practices, practices which Paolo Freire (1970) calls the "banking" concept of education, in which the teacher "deposits" knowledge into her students, only to have them "withdraw" it during examinations. Alternative methods of teaching and evaluation, among them those emphasizing critical and creative thinking, have been proposed in an effort to improve educational achievement, and to some degree have been successful.

In support of this criticism and the proposed changes, psychological and social science research in education and learning in general have shown that learning is a complex process, and that what an individual learns is constructed from the totality of her experiences, both formal and informal. This constructivist view of learning also asserts that unless an individual constructs her own knowledge, she often has difficulty retaining that knowledge, and even more so in transferring it when appropriate and/or necessary.

However, the individual often finds herself confronted by new experiences or information that do not fit in with her prior conceptions and/or understanding. This type of discrepancy often creates problems in school. A student's "naive" or prior conceptions (which some authors refer to as "misconceptions") often conflict with the "accepted" knowledge that her teachers and textbooks try to impart. She may or may not realize this and/or try to integrate this new knowledge into what she has already learned. If she does realize this and wants to integrate the new information, she may find she has to unlearn what has previously been learned and restructure that knowledge in the light of the new information. It is also possible that she finds she has to totally reconstruct her knowledge.

Failure on the part of teachers to recognize their students' prior conceptions, adequately address them, and make clear the inadequacy of these prior explanations, may result in students' inability to modify their existing views and reconstruct their own knowledge. This is especially so in science education, where the discrepancy between common-sense theories of natural or scientific phenomena and scientific understanding is often acute. Thus, teachers in general, and especially those in science, must encourage and enable their students not only to construct their learning by accommodating new ideas and information with old conceptions, but also to restructure, or even reconstruct, their learning when their old conceptions are incapable of accommodating new ideas, and they need to develop new conceptions. To do this, teachers need to provide their students with new experiences that challenge them to examine their prior conceptions and formulate new ones.

The political function of education. But although many educators acknowledge the validity of Freire's criticism of "banking education," too often they do not embrace his other criticism of education, i.e., that the main functions of public education systems are to reinforce the society's dominant ideology and to train individuals who can contribute to the society, which holds that dominant ideology. [Private systems may have other goals in addition (e.g., religious education); however, in almost all instances these will not totally replace the other functions.]

One can see how these two functions, training and reinforcement of the society's dominant ideology, are dominant here in the United States, by looking at criticisms that have often been made of our educational system, such as the following example illustrates. In 1991 a report "Every Child a Winner" was released by the Massachusetts Business Alliance for Education. This report was acclaimed by many different community groups and strongly recommended by Harold Raynolds, Jr., the State Commissioner of Education at that time. I here quote from a condensation of that report published by the Massachusetts Department of Education: (1991)

> Massachusetts and the nation are faced with a serious crisis . . . .
> Simply stated the crisis is this:
> The public education system is failing to provide students with the knowledge and skills they need to be productive, informed citizens in coming decades.
> The prospect of an under-educated citizenry, unable to understand or cope with issues arising in the management of the country and the Commonwealth, should alarm everyone.
> The inability of many public school students and graduates to qualify for even entry-level jobs, or to successfully compete with their counterparts from other industrialized countries, is a clear signal that the education system needs dramatic improvement -- soon. (p. 4)

If this statement does not seem unusual, it is no wonder; for it has become ingrained into our society that the purpose of education is to produce productive members of the society (to enable individuals to "get good jobs" and "get ahead"). We seldom, if ever, question this rationale.

But should that be the goal of education? Should the purpose of the public education system be to train students and prepare them to qualify for jobs and compete successfully?

Willard Daggett, a leader in school reform, stated the following when discussing the purpose of public education: (Massachusetts Department of Education 1992, 3)

> Ask what adult roles a high school graduate should know. The answers probably will be life-long learning, citizenship [we must define what it is] basic skills as a worker, being a good member of a family, and good use of leisure time.

Note that in his summation of the needs of adults, only one of the needs relates to work, and that to basic skills; yet this is what we emphasize. We might ask ourselves are we neglecting other needs in preparing students for work?

I would posit, as I believe Freire does, that the purpose of education should not be solely preparation for work, i.e., training in useful skills, but instead it should be preparation for life. What is the difference? Preparation for life means that students need to learn how to think for themselves; use reason, but also weigh other factors in making decisions that affect their lives and those of others; and use and enhance their creative abilities in all facets of their lives. Furthermore, repeating Daggett's words cited above, they also need to prepare themselves for "lifelong learning, citizenship . . . , [to be] a good member of a family, and [to make] good use of leisure time." These are additional to preparation for work ("basic skills as a worker").

Work, however, takes prominence in our system because the dominant ideology of our society is a capitalist one. The purpose of our economic system is to produce and sell goods that are competitive in the world market and at the same time provide a profitable return for investors. School preparation for work, i.e., training, reduces the costs of production for business, making it more competitive, thereby increasing profit margins. [Note: Any other society which has an economic-based ideology might also be used to illustrate this prominence of training for work in education.] We rarely, if ever, question that society in general, and not the businesses or other enterprises, themselves, should pay the costs of this training. The bias, which is not immediately evident, can be illuminated by looking at a contrary example -- we would never expect public education to pay for the training of priests!

What is the result of this emphasis on work? While some students may indeed be trained well, and this training may provide them with many of the benefits that society offers, and in some cases even empower them to make decisions, most students will not be trained well, much less empowered. Why? The answer lies in the nature of training itself, which is also why failure to acknowledge this criticism often results in the failure of instituted reforms to change education significantly. Training sets up a teacher/learner dichotomy, with the teacher's role seen as distinct from that of her students. Their relationship is that she instructs them and they receive her instruction.

Liberatory Education -- An Alternative Concept

However, if we accept that students can only truly learn as they construct their own knowledge, and that what they learn is dependent upon both what they experience in their lives and how they interpret those experiences, then we have to view education and the interaction between teachers and students instead as being one of mutual learning and teaching, as each shares and learns from the other. True education means self-empowerment of all students, and the role of the teacher becomes that of a guide.

Self-empowerment means more than merely constructing one's learning. It also means making decisions that affect one's life. The true teacher enables her students to take control of their lives. Their education may prepare them to lead, at other times to follow. However, they will make these decisions themselves, and even if they choose to follow, they will still feel self-empowered to question the decisions of others, if the need arises. In helping her students to create their own liberatory education, an additional problem is presented to the teacher. She must also help her students to view the world in a multilogical way, in such a way that their decisions will take into account more than their own socio- and egocentric desires.

As a student in the Critical and Creative Thinking Graduate Program at the University of Massachusetts in Boston, I often found myself pondering these problems, especially as they relate to teaching in our multicultural society in urban situations:

1. How does a teacher bridge the cultural gap that often exists between her and her students?

2. How does she help her students empower themselves to construct their own understanding, make decisions in their lives, and take into account the needs/desires of others as well as their own?

3. What should her role as teacher be and how should she perform it?

4. What attitudes and dispositions should she have, and how can she encourage similar attitudes and dispositions in her students, and develop as well their critical and creative thinking skills and abilities?

When the United States Peace Corps invited me to serve as a volunteer in Costa Rica and teach environmental education in 1993, I was given the opportunity to test my educational philosophy and many of my ideas on cross-cultural teaching and learning. At

I had worked. These were to serve as a model, for them and others, of ways to teach environmental education.

This thesis is an analysis of that experience and of the development of my program of studies. It explains the ideas and problems which were addressed, how I prepared myself to teach in that country, how and what I taught, some indication of the successes and failures I experienced, and how I incorporated all of these experiences in developing my program of studies in environmental education -- discarding some lessons, modifying and rewriting others, and writing new ones as well.

Although my thesis deals specifically with my role as a Peace Corps volunteer in Costa Rica, I feel the philosophy I followed, the methods I employed, my successes and my failures can be instructive to any teacher who finds a cultural gulf between her and her students. Additionally, as my program was centered on science education, I hope it will help other teachers to reflect on ways of providing their students with the framework and guidance they need to construct their own scientific understanding, and to realize the importance of basing students' learning primarily upon their own experiences. I also hope it will provide them with ideas on how to integrate multilogical reasoning into science education and ways to implement portfolio assessments as a means of evaluation. Finally, in my evaluation of the program I developed, I try to analyze both successful and unsuccessful ways I helped children confront their ecological alternative conceptions and reconstruct their scientific understanding of the environment.

My Role as a Peace Corps Volunteer

In June 1993, I began training to be a Peace Corps volunteer in environmental education in Costa Rica. After three months of training in Spanish, environmental education, and cultural adaptation, I was sworn in and assigned to the region around Santiago de Puriscal.

Although the canton of Puriscal is much larger than the region in which I worked, I will use the popular method of referring to the city Santiago and the surrounding region where I worked as "Puriscal." This region could best be classified as semi-rural --Santiago had a total population of about 10,000, with another 10,000 located in the rest of the canton. I lived in Desamparaditos (500 inhabitants), several villages in which I worked were as much as twice that size, but most were much smaller.

As an environmental education Peace Corps volunteer, my major job assignment was to work within the educational system to help integrate environmental education into the school curriculum. Over the next $2^1/_2$ years, I developed my ideas in 12 different schools, where I taught grades ranging from 2-6. The lessons I designed began with the grand biodiversity of Costa Rica and went on to examine the concepts of climate, habitat, niche, the roles of living and non-living things in the world, and how ecosystems function. Each lesson built on the concepts which had been developed and explored in the previous lesson. The final lessons dealt with various environmental problems and encouraged the students to not only examine them in the light of the concepts we had constructed in the previous lessons, but also to propose solutions for them. The lessons I taught were the basis of the program I subsequently developed.

Thesis Outline

Below is a synopsis of the chapters of my thesis, what they contain, and also what can be found in the appendices:

Chapter 1 -- There is a brief description of the problems to which my thesis is directed and my role as a Peace Corps volunteer, and I present an outline of my thesis.

Chapter 2 -- I present a summary of recent political, social, economic, and environmental events and/or factors that serve as background for the environmental problems that Costa Rica faces and the solutions that have been proposed.

Chapter 3 -- I present a detailed analysis of how I perceived myself, my role, and my beliefs prior to my service as a Peace Corps volunteer.

Chapter 4 --	I present a brief summary of some of the attitudes and dispositions of critical and creative thinking, as well as some of their skills and abilities, which I adopted and used in my preparation and teaching, and which I encouraged and tried to develop in my students.
Chapter 5 --	I present an examination of current (conceptual change) learning theory and of its application to science education in particular.
Chapter 6 --	I present an analysis of the program of studies I developed, detailing how I tried to integrate critical and creative thinking attitudes and dispositions and skills and abilities into the program. I also discuss how I tried to provide a framework for my students to construct their own scientific understanding of the environment, and how I based my lessons on their own environment and their understanding of it.
Chapter 7 --	I evaluate my program in three different ways. First, I look at the science curriculum guidelines and state how my program attempts to address them. Second, I discuss the portfolio assessment method of evaluation which is incorporated within the program. Third, I evaluate the effectiveness of the program, particularly in light of conceptual change theory, discuss some of its strengths and weaknesses, and indicate parts that I might change and how I might change them, having reflected on the program the past year.
Chapter 8 --	I summarize some of my insights on teaching that my experience in Costa Rica gave me. I review the most important ways to bridge cultural gaps, educational philosophy, some effective teaching techniques, and the role of the teacher.
Appendix 1 -	This contains the full text of the program of studies I developed in English.
Appendix 2 -	This contains the full text of the program of studies I developed in its original Spanish.
Appendix 3 -	This contains the full text of the Costa Rican Science Curriculum Guidelines with respect to the environment for grades 4, 5, & 6 in my English translation.
Appendix 4 -	This contains the full text of the Costa Rican Science Curriculum Guidelines with respect to the environment for grades 4, 5, & 6 in its original Spanish.
Appendix 5 -	This contains charts showing the schools in which I taught each year, the grades taught, and the number of students in each class.
Appendix 6 -	This contains the crossword puzzle (in Spanish) which I designed to review concepts related to the environment.

Figure 1. Map showing location of Costa Rica in Central America
Source: Courtesy of Project Central America

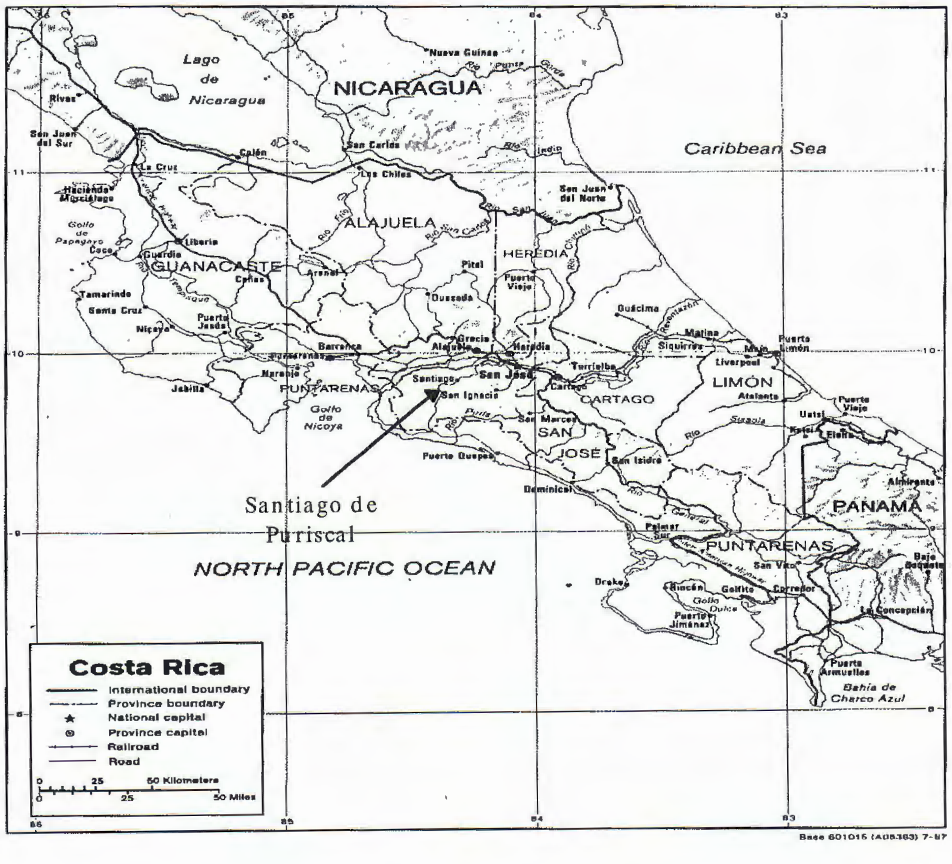


Figure 2. Geophysical map of Costa Rica indicating location of Santiago de Puriscal
Source: Perry-Castañeda Library Map Collection of the University of Texas at Austin.

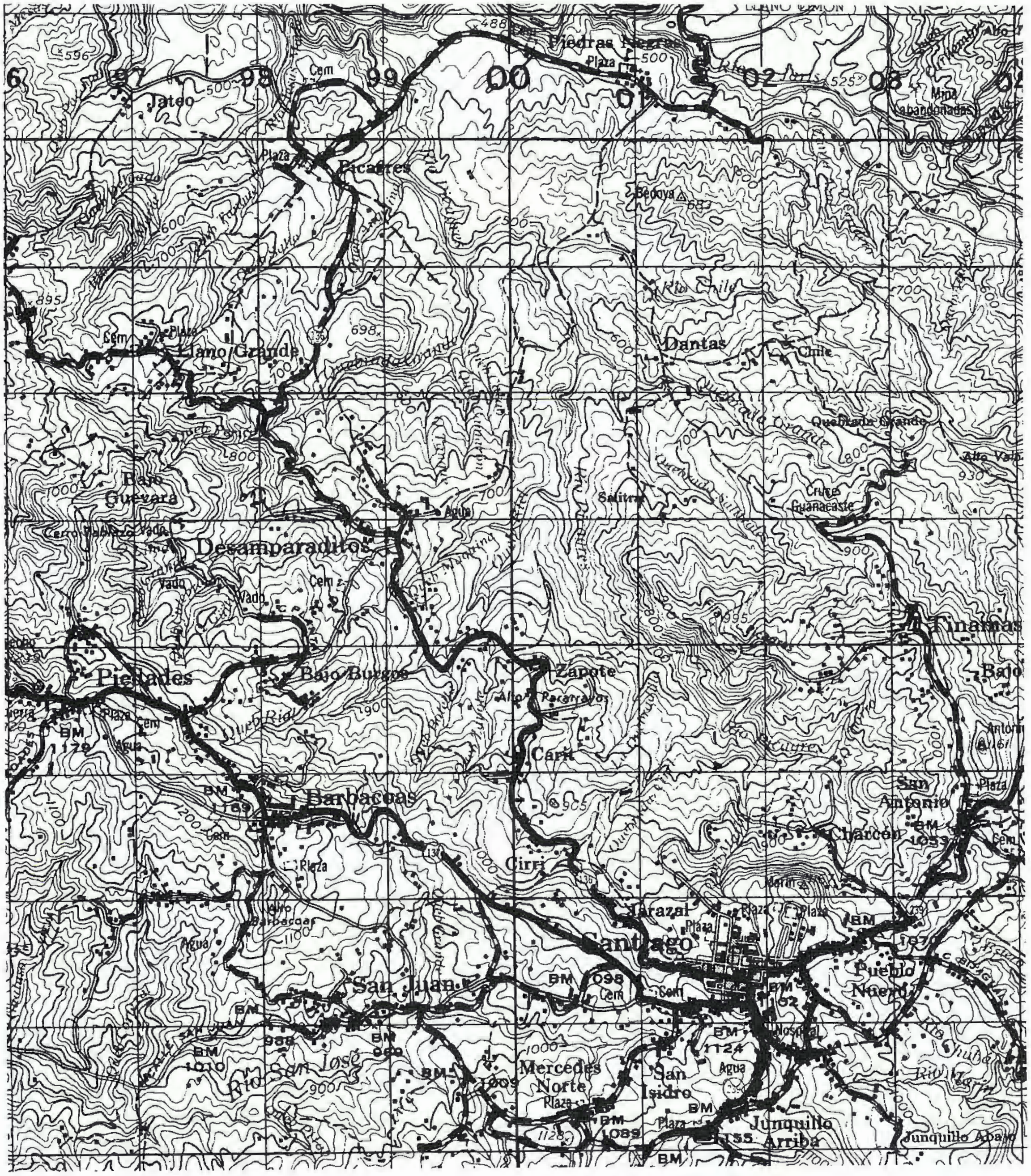


Figure 3. Region around Santiago de Puriscal in which most of my schools were located
Soource: Topographic map of the Rio Grande region of Costa Rica

CHAPTER 2

COSTA RICA/PURISCAL -- RECENT HISTORICAL BACKGROUND

In this thesis I examine my role as a Peace Corps volunteer and the program of studies that I developed during my $2^1/_2$ years in Costa Rica. However, since any good analysis requires a clear understanding of background issues, in this chapter I briefly describe recent political, social, and economic events that have occurred in Costa Rica. Also, as a foreigner, to be an effective teacher I needed to understand the economic and social situation of the country. I summarize how these factors, particularly economic ones, serve as background for the environmental problems that Costa Rica faces and the solutions that have been proposed. I also describe its educational system, since it was within that system that I worked. Finally, I note the particular characteristics of Puriscal in these areas.

Overview - The Nation as a Whole

Political and Social Factors

Costa Rica has a democratic form of government and, since 1948, has had no national army. Because it does not have a large military budget, Costa Rica has been able to devote a higher percentage of its budget to social programs and its educational system than other countries in the region. It has also had a more stable government than most other Latin American nations since 1948, with peaceful elections every four years. This stability and an educated work force has encouraged foreign investment, and Costa Rica today has a relatively large number of small-scale industrial manufacturing facilities primarily in clothing and food processing. In recent years, the population growth in the Central Valley (already the region of the largest cities and the greatest population in the country) has dramatically increased, as people move into more urban areas where these industrial jobs are located.

Nevertheless, Costa Rica is still a predominantly agricultural country. Located about ten degrees north of the equator, with varied terrain, its major products and exports are bananas from the tropical lowlands and coffee, its principal export, from the highlands. Sugar and beef production are also important, although their importance is presently declining.

Economic Factors

Following World War II when the prices of commodities (such as coffee) rose, Costa Rica and other Latin American countries began to invest their excess profits in small-scale industries. This economic policy, called import substitution, was designed to accomplish two ends. First, by beginning to produce their own manufactured goods, these Latin American countries could steadily decrease their dependence on imports from developed countries. Secondly, although the prices of commodities had been high at that time during and immediately following the war, these countries knew how volatile these prices are, and wanted to decrease their total economic reliance upon the sale of these products. State-owned companies were set up in crucial industries, and multinational corporations were invited to build subsidiaries as well. At the same time agro-industrial enterprises, often foreign-owned, were established. (Green 1991)

In Costa Rica, the "Revolution of 1948," a civil war, led to a number of social reforms, the nationalization of the banks, and the elimination of the army. As a result, moneys were invested in poorer parts of the economy -- providing housing, education, energy, health and nutrition programs. (Edelman and Oviedo 1993) To alleviate pressures for land from peasants who had been displaced due to the expansion of the cattle and sugar agro-industries, the Costa Rican government also implemented limited land reform programs.

Industrialization was furthered by membership in the Central American Common Market. High tariffs were lowered within the region, competition was encouraged, and it became beneficial for transnational companies to set up subsidiaries in Costa Rica. The Costa Rican government also financed industrialization projects by borrowing money from international banks.

One of the problems with import substitution, not only for Costa Rica but also for the rest of Latin American, was that it was based on the use of capital-intensive Western technology. Thus, to build factories to provide goods for the domestic market required the importation of heavy machinery. The costs of these imports sometimes outweighed the advantages of import substitution. Additionally, Costa Rica had to finance these imports with its agricultural exports, principally coffee and bananas. When foreign exchange earnings were insufficient, the need to purchase this machinery compelled small countries like Costa Rica to go into debt.

When oil prices began to rise rapidly in the early 1970s, the Costa Rican government took out additional loans to continue to spur the growth of its manufacturing and agro-industrial enterprises. These loans were cheap (3% interest), and not only Costa Rica but many other Latin American nations received these below-inflation interest rates from international banks deluged by petrodollars.

However, since most of these loans had been variable-rate and not fixed-rate loans, a sudden rise in United States interest rates (announced by the Reagan administration), combined with the recession which had been caused by another large increase in oil prices in 1979, provoked the major debt crisis of the early 1980s. The cost of borrowing rose from 3%/year to 10%/year. Instead of paying loans priced below the rate of inflation and lower than their economic growth, Costa Rica and other Latin American countries found themselves facing interest costs far above both. It quickly became clear they could not keep up with their payments, and their debts began to spiral rapidly upward.

Although increases in coffee prices in 1976 and 1977 had helped Costa Rica to offset earlier oil price hikes, coffee prices dropped sharply in 1978, which left Costa Rica especially vulnerable to the oil price increases in 1979 and 1980. (Blachman and Hellman 1986) Thus, in 1980 Costa Rica found itself faced with one of the highest ($2021) per capita debts in the world. (Edelman and Oviedo 1993, 23) Costa Rica was offered two loan options in 1980-1981 by the International Monetary Fund (IMF), but the restrictions were so harsh that the government was compelled by public outcry to break off the negotiations. Unable to pay its debt, Costa Rica declared a unilateral moratorium in July 1981 -- more than a year before Mexico's similar declaration resulted in world-wide economic crisis.

However, the situation deteriorated rapidly. By 1982, Costa Rica's debt had nearly doubled to $4 billion, and the *colón* had been devalued 500%. Inflation had soared to almost 100% and unemployment had doubled. Costa Rica was again forced to negotiate with the IMF and this time to accept even harsher austerity measures. (Edelman and Kenen 1989) The infusion of money brought down inflation, but although some aspects of the austerity program were applied, Costa Rica was "let off easy." To understand why, we have to look outside Costa Rica's borders, toward Nicaragua.

Although it is beyond the scope of my thesis to examine the war in Nicaragua, suffice it to say that the United States' concern with the Sandinistan revolution helped to temporarily relieve the economic crisis in Costa Rica. To prop up the Costa Rican economy and preserve Costa Rica as a "showcase of capitalist third-world development" in Latin America, the United States injected $4 billion into the Costa Rican economy to help it meet its debt obligations. In addition, funds were set aside to privatize existing public institutions and to offer incentives and subsidies to private investment to stimulate non-traditional export production, as neoliberal policies were imposed by the United States. (Edelman and Kenen 1989)

When the war in Nicaragua ended, the United States ended its largesse, and Costa Rica was left facing its huge debts, with its ability to pay severely restricted by the granting of tax-free concessions to many new industrial and agro-industrial enterprises. Again it was forced to seek relief from the IMF, and Costa Rica negotiated a series of new loans (*Programas de Ajuste Economico*), PAE I, II, and III, each of which required structural adjustments in the economy and political structure. Each forced greater and greater restrictions upon the Costa Rican government.

When I arrived in Costa Rica, controversy over the terms of PAE III was high. Opposition to the most drastic conditions of this loan agreement was probably one of the factors that led to the election of the opposition candidate, José Maria Figueres, as president in 1994. Nevertheless, two years later the new president was forced to accept virtually all of these conditions.

These economic factors are indicative of neoliberalism, and have shaped not only policies relating to the environment, but also basic economic policies and conditions in the country, a topic to which I shall return. But first, I would like to discuss some environmental factors which will help to put things in perspective.

Environmental Problems

As a tropical country Costa Rica was well-forested in the past, with many species of valuable tropical hardwoods. Over-exploitation of these hardwoods has left little forest remaining outside of its national parks. What little remains is being cut down rapidly, and Costa Rica has one of the highest deforestation rates in the world. Although lumber is still being cut down for wood products in some regions, the destruction of forests to create banana plantations is still, as it has been in the past, a major component of this deforestation. The movement toward increased cattle production in the 1960s, to take advantage of world demand for beef from multinational corporations (such as MacDonald's), further added to deforestation rates in regions that were formerly forested hillsides.

The effect of this deforestation is not only felt in the decline of wood production. Deforestation has also led to very high levels of erosion in what is, to a large degree, a very hilly and often mountainous country. Being a tropical country, Costa Rica is subjected to frequent and very intense rainfall, which rapidly washes away unprotected topsoil. This loss of topsoil has greatly increased the costs of agricultural production.

In banana plantations, located in flat country, erosion is not as great a problem. Rather the effects of monoculture over vast areas lead to not only the loss of nutrients in the soil, and resultant high use of fertilizers and/or abandonment of denuded land, but also the high use of pesticides. These effects not only increase the costs of production, but also increase the health risks to both workers and consumers.

Deforestation, with its accompanying problems of increased erosion and increased agricultural costs, and the increased health problems caused by heavy use of pesticides are two of the major environmental problems faced by Costa Rica today. To these should be added the problem of trash, which has exploded with increased development. To combat these and other environmental problems, the government has been helped by a strong environmental movement within the country.

The Growth of Environmental Awareness in Costa Rica

In the mid 19th century, a number of traveler naturalists "discovered" Costa Rica, which led to numerous field expeditions and the establishment of the *Museo Nacional* by the end of the century. Later, during the first half of the 20th century, numerous major scientific studies of tropical ecology were written by a brilliant Costa Rican, Clodomiro Picado Twight. In 1942 the *Instituto Interamericano de Ciencias Agricolas*, the present-day *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE), was established by the Organization of American States, and in the late 1950s the *Universidad de Costa Rica* began to emphasize basic science and research in its biology department. These are only a few of the highlights of the history of the study of the natural sciences in Costa Rica. However, they clearly show a historical awareness and appreciation of the importance of the country's biological diversity. (Gómez and Savage 1983)

It was only, however, as the diverse biological riches of the country were seen as threatened that a move was made to conserve them through land protection. In 1945 the first national park was declared setting aside a forested area south of Cartago. Further agitation by private individuals and scientists led to national park status for the immediate surrounding area of every volcanic crater in 1955 and the establishment of the National Park System in 1969. (Bermudez Acuña and Mena Araya 1993) As of August 1993, almost 25% of Costa Rica's total land area was under some form of protected status, owned by the government. (Michael Smith 1995) These protected areas preserve many of the incredibly high number of species that exist in Costa Rica. Additionally, numerous private organizations have also set aside land to be protected, comprising possibly another 10% of the total land area of Costa Rica.

Laws have also been passed which not only set aside land, but also regulate its use in certain instances. Chief among these was a recently passed law which prohibited the cutting of trees within so many feet of any fresh water -- be it spring, stream, river, or lake. Other laws require government permission before any trees in an area can be cut. There are also laws which prohibit the hunting of certain species, or the taking of their eggs. On the whole, the laws of Costa Rica are a model for the preservation of the natural environment.

While the forestry laws above were directed principally toward preserving the purity of water sources, Costa Rica also saw the need to slow down the tremendous erosion which takes place during the rainy season. This erosion not only reduces agricultural production, but frequently results in landslides, which threaten the destruction of houses and roads, and sometimes take people's lives. To stem this erosion, the Costa Rican government has passed laws which give incentives to landowners who reforest their lands, and programs have been established to provide them with young seedlings for planting.

Realizing the importance of education in addition to laws to change attitudes and behaviors with respect to the environment, the Ministry of Education (MEP) began a program of environmental education in 1983. Peace Corps volunteers in environmental education began by participating in the design of workshops for teachers in 1988, and in 1990 began working directly with teachers and students in the rural public schools of all seven provinces of the country. (Ugalde 1994)

Economic Pressures and the Growth of Tourism

Although the efforts of private individuals, scientists, and groups concerned with the environment should not be discounted in assessing the establishment of a national park system and model environmental legislation, I believe there was an equally if not more compelling reason -- an economic one. As Costa Rica's debt continued to increase (as noted above), it found that its agricultural exports could not sustain its economy, much less bring in sufficient foreign capital to pay off its debts. Not only were its traditional exports subject to increased competition from other countries and to the vagaries of the world market, so too were the non-traditional exports they had been encouraged to pursue. For example, farmers who had switched to cocoa production (after World Bank urging) were left with huge debts and no market for their cocoa after a sharp nose-dive in prices. (Barry 1991, 35) At the same time, with the production of basic foodstuffs curtailed in favor of agricultural exports, Costa Rica found itself having to import greater and greater amounts of grain, particularly rice, which necessitated additional foreign exchange.

As foreigners began coming to Costa Rica to see and study its natural environment, Costa Ricans saw that tourism could generate the income it needed -- providing dollars for its economy. Given its relative political stability, Costa Rica became a tropical vacation "paradise," as tourists flocked not only to its beaches, but also to its natural areas. By setting aside huge tracts of land as national parks, Costa Rica was able to attract greater and greater numbers of tourists each year. In 1987 tourism was the third largest source of foreign currency after coffee and bananas -- 277,861 tourists came with total revenues of $136.3 million. By 1993 tourism had by far become the largest source of foreign currency with revenues of $577.4 million and a total of 689,872 tourists. (Brennan 1994, 4)

Policies of Neoliberalism

The political, social, and economic policies that are now being pursued by Costa Rica's government may be jointly classified as neoliberalism. I have already referred to some of the changes that took place in Costa Rica's economy after the end of the war in Nicaragua. These changes were in general forced upon it by the international banking community in return for needed loans. They are similar to the prescriptions given to other developing countries throughout the world, which are to a large degree forced upon these countries by the imperatives of the present global economic system. In Costa Rica, as elsewhere, they are designed to not only "improve" the economy, but also make significant social changes as well. The changes prescribed for Costa Rica fall into the following four different categories, which I will discuss in turn:

1. Reductions in government and privatization
2. Changes in agriculture
3. Industrial policy
4. Tourism development

Reductions in government and privatization. One of the chief, if not the chief, tenet of neoliberalism is the superiority of the private sector to the public one. According to this tenet, supposedly "inefficient and political" government agencies can and should be replaced by supposedly "efficient and non-political" private ones. Not only should the agencies be replaced, but government policies themselves should not be formulated by political interests, but by "non-political" ones -- skilled technocrats.

Over the years, numerous cutbacks in government employment and spending have been demanded in return for loans from the IMF, as well as the privatization of many government agencies. Most recently, privatization inroads have been made into the national banking system and electric power company, *Instituto Costarricense de Electricidad* (ICE). These institutions have until recently been some of the most sacrosanct of government agencies (being very popular legacies of the Civil War), but it appears they too may eventually become totally privatized.

Changes in agriculture. With each new loan, new changes have been demanded in the country's agricultural policies. "In accord with the economics of comparative advantage, . . . [members of the international banking community] have all insisted that there be an increased effort to promote exports that are competitively priced in the world market." (Barry 1991, 32) Farm credits and loans are extended to non-traditional agricultural (and often agro-industrial) sectors, but not given to producers of basic foods. This has led to an increase in the production of non-traditional crops -- vegetables of various kinds and ornamental flowers, and the concomitant decrease in agricultural production for domestic consumption, with greater and greater percentages of staple grains, such as rice and corn, being imported each year.

Industrial policy. Similarly, policies have been implemented to encourage the development of electronics and textile production for export. Tax-free industrial zones and export subsidies were established, and transnational companies set up many subsidiaries, especially in the fields of food processing, beverages, and tobacco. In addition, special

United States laws enable companies to manufacture goods in Costa Rica, and then import them into the United States duty-free.

Tourism. Finally, as we have seen, tourism has greatly expanded. This expansion has been aided by legislation to provide tax incentives for tourism-related activities. These have been directed primarily toward large-scale developments, with many luxury hotels and resorts being built. Although there appeared to be a glut of hotel space in 1993, the Costa Rican Tourism Institute still predicted that by the year 1998 over thirty thousand new rooms would be needed. (Brennan 1994, 3) Thus, it is likely these subsidies will be continued. Furthermore, tourism also demands the expansion of infrastructure -- the construction of new and better roads and airports.

Effects of Neoliberalism

Social changes in Costa Rica in the last fifteen years have been dramatic. Income distribution has become further skewed; larger producers, both agricultural and industrial, receive generous subsidies, while smaller producers have higher-priced credit. The use of pesticides has grown dramatically as monocultures and the production of non-native, and thus, less disease-resistant crops, have come to dominate agriculture. Costs in tourist areas have risen rapidly, and while some individuals no doubt have benefited, the economic gains for most people from jobs in the tourist industry have not been sufficient to keep up with the rising costs. Instead, residents find themselves in economic competition with wealthier tourists and the businesses which cater to them.

As economic conditions in the countryside have become more difficult, large numbers of people have moved into the Central Valley (which now holds three-fourths of the total Costa Rican population), and social tensions have increased. Landless *campesinos* have formed squatter settlements on the outskirts of cities, and battles with police have taken place over their right to stay there. As income has become more skewed and poverty has increased, crime has risen -- particularly in the cities, but also in some of the less rural towns. With government cutbacks, the network of social services (such as health care) have become unavailable or more difficult to obtain for those less well-off. Also, government employees either lose their jobs and/or benefits, as resources are shifted to the private sector.

Recently, the educational system has become the arena of conflict as teachers try not only to maintain their pensions, but seek to restore cutbacks in public education. At the same time private education is being expanded. Thus, the educational system is now taking on the same two-tier characteristic that the health care system has already assumed. This struggle is but one example of the increasing polarization and class stratification which is taking place in Costa Rica today, as resources are shifted away from the public sector.

Consumerism has taken hold as more and more appliances, household goods, and miscellaneous items are sold and purchased. With this increase in purchases have come corresponding increases in waste produced, and both water and air pollution. Today Costa Rica faces a severe crisis as it seeks to rid itself of the increasing amount of waste produced in the country, particularly in the Central Valley. Communities chosen as proposed sites for sanitary landfills engage in pitched battles with the police, and even rural communities find their landfills overflowing, and sometimes closed down for health reasons.

Sustainable Development (*Desarollo Sostenible*)

As the conditions of the poor in developing countries have worsened even as the economies of those countries have grown under neoliberalism, a different philosophy of development has arisen -- *desarollo sostenible* (sustainable development). Growing numbers of people have questioned the attitude that development should be pursued at all costs, and even that economic development should be a country's main priority. They have seen that this push toward development can not only deplete the natural resources of a country, but also create worse conditions for many of its people.

However, unlike many environmentalists of the developed world, those who espouse this new view do not propose to stop development because it impacts upon the "natural" world. Rather their solution is to slow it down, and to try when possible to utilize natural resources in such a way that they are not depleted. It should be noted that this philosophy of sustainable development regards human beings as part of the natural environment; hence the protection and preservation of human social and cultural environments is equally important to that of the rest of nature. This different emphasis can be noted in my translations of statements made by Costa Rican environmentalists, Alexander Bonilla and V. Sanchez; James Gustave Speth of the United Nations; and the World Commission on the Environment and Development.

> I can no longer understand our continuing to talk in favor of the environment without addressing ourselves to the essential necessities of the population . . .
> . . . we can not lose sight that the human being is the principal natural resource to protect. (Bonilla 1994b, 2-3)

A different concept of conservation has arisen as well -- one much more concerned about conserving natural resources for use in the future, than solely preserving exotic animals and ecosystems for tourism.

> Conservation of nature is not simply the romantic notion that the countryside or exotic animals should be preserved for our recreation. The objective of conservation is to save from degradation those resources which regulate the functions of the natural world. (Sanchez 1983, 133)

With respect to eco-tourism, the economic benefit of conservation promoted by neoliberalism, Bonilla further states:

> Our countries should not preserve biodiversity, thinking only to satisfy the eco-tourism needs of industrialized countries; our forests should not just be a visual delight for only a few. No, we should protect our biodiversity and preserve it because it represents a vital element in the development of our people. (1994b, 3)

Implicit, and sometimes explicit in this philosophy, is the necessity for a redistribution of resources in order to raise the living standards of the poor in developing countries. There is also an explicit criticism of the attitudes and policies of developed nations. Although many of these developed countries squandered their own natural resources in their development (not to mention exploiting those of poorer countries), they now demand of developing nations that they conserve their own natural resources. This somewhat hypocritical stance is made worse by the developed nations' refusal (on the whole) to offer developing countries other means (sufficient resources) to achieve development.

Many ecologists now understand that unless alternative means of sufficiency and/or the possibility to utilize the natural resources of the country in sustainable ways are offered to the poor in developing nations, eventually they will be forced by their necessity to over-utilize and ultimately destroy these resources. In Costa Rica this has become evident by the numerous struggles over the encroachment of farmers, hunters, and miners into various national parks.

> It is not enough to declare that tropical forests and their biodiversity should be preserved; we must be able to offer alternatives to the peasant, to ranchers, to lumbermen, to industries so that the forest can be maintained and even more enriched. (Bonilla 1994a, 17)

Taking as his focus human development as opposed to economic development, James Gustave Speth, administrator of the United Nations Development Project, defines *desarollo humano sostenible* (sustainable human development):

> [It] is a development that not only brings about economic growth, but which also distributes equally its benefits; that regenerates the environment instead of destroying it, that encourages the autonomy of people, instead of marginalizing them. It is a development which grants priority to the poor, which enlarges their options and opportunities and which provides for their participation in decisions which affect their lives. It is a development that favors human beings, favors nature, favors the creation of employment, and favors women. (Speth, cited in Caamaño 1995, 15)

Taking the above into account, we can now analyze the following definition of *desarollo sostenible* offered by the World Commission on the Environment and Development: "A new path of progress which satisfies the needs and hopes of present generations, without compromising the capacity of future generations to satisfy their own needs." (cited in Caamaño 1995, 17)

Thus, we can see that *desarollo sostenible* has three essential elements:

1. Sufficient improvement in the quality of life of human beings, justly distributed to all levels of society, with special emphasis given to improving the situation of the poorest
2. Active participation of all sectors in decision-making processes that directly affect them
3. Preservation of ecological equilibrium, so that future generations can benefit as well.

This concept of *desarollo sostenible* was a current idea in Costa Rica during the time I spent there, and indeed Costa Rica had been one of its prime proponents, especially in the United Nations. In my teaching, my conversations, and in the program I developed, as an environmental educator I felt it was important that I emphasize all three of the above points, and not just the need for ecological equilibrium.

I have described in depth the situation in Costa Rica, because as a Peace Corps volunteer I was cognizant that my work could not be undertaken within a vacuum. As a "foreign expert" it was incumbent upon me to understand the economic and social situation around me. But since a country is to some degree a sum of its parts, I would now like to briefly describe the region in which I worked -- Puriscal.

Puriscal

Although approximately $^1/_2$ of its workforce works in the Central Valley or in other non-agricultural occupations, Puriscal is a mostly agricultural region. Located in hilly country, the main product is coffee, with cattle, sugar and tobacco of much less importance, although the amount of land devoted to cattle production is by far the greatest. This region was, for over fifty years, the "breadbasket" of the Central Valley. Today, however, many of its soils are relatively poor in nutrients, and its importance as a food-producing region has diminished greatly.

Erosion is a major problem, due primarily to the large amount of pastureland and other agricultural pursuits in what were at one time forested hillsides. The region has a tropical dry climate, which means that it has two distinct seasons -- a rainy one (often with intense showers), from about April to the end of November, and a dry one (without any significant rain for days, and sometimes for weeks) during the rest of the year. The effects of this climate on the denuded hills can be severe, as soils are first baked and then rapidly washed away. It is not unusual for several tons of topsoil to be washed away in hours!

The situation in Puriscal, though similar to many semi-rural cities in Costa Rica, has been compounded by one additional factor, which worsened its economy quite severely. For approximately three months, from April to June 1990, the region was beset by earthquakes (almost 12,000 tremors, several up to 5.0 on the Richter Scale). After relative calm, in December of that year, a much larger earthquake struck -- possibly as high as 7.0! [Although it was only measured at 5.9, I was told that the tape in the seismograph was being changed when the earthquake began.] The quake was centered in Carít, about 4 kilometers north of Santiago, and located within the Picagres River Valley. Structural damage to houses, schools, and churches was great, and it appears that minor slippages of land were, and possibly still are, a result of seismic activities in the area.

Due to the high level of deforestation, the impoverishment of the soil, and the massive effects of the earthquakes of 1990, different government ministries, principally the *Ministerio de Recursos, Energía, y Minas* (MIRENEM) and the *Ministerio de Educación Publica* (MEP) began a joint project centered on the Picagres River watershed to rebuild, reforest, and improve agricultural practices, and thereby help the economy of the region to recover. Part of the project consisted of demonstration projects and the formation of community groups to adopt "new and better practices" of land management. Another important part of this program was environmental education in the elementary schools, to give the future workers of the region the consciousness and knowledge to follow and/or adopt sound environmental practices. It was within and in conjunction with this program that I began my work as a volunteer.

Educational System -- Costa Rica/Puriscal

Administrative Aspects

Before discussing my intervention within the classrooms of Puriscal and the development of my program of studies, I will offer a brief description of the educational system in Costa Rica in general, and in Puriscal specifically. First, public education is free for all children through high school, and there are some scholarships for students in the public universities. In larger communities, where there are sufficient numbers of students, preschool and kindergarten are also offered. Elementary school (*escuela*) consists of grades 1-6, and a student is required to pass a regional district exam at the end of 6th grade to graduate. High school (*colegio*) is either 5 or 6 years depending on whether the student is in an academic or technical high school, respectively. At the end of high school, a student has to pass a nation-wide competency exam to graduate.

The educational system is broken down administratively by regions, and then subdivided by districts. Elementary schools are generally located in all communities, unless extremely small. I believe a community had to have a total of 25 eligible children. In Puriscal, the region in which I taught, the majority of my schools were located in District 4, which contained about 20 schools. Of these, the largest had almost 200 students while the smallest had close to 25 students. The grammar school of the city Santiago de Puriscal, which was significantly larger, was not in this district. In general, a student might have up to a 2-3 mile walk to and from school, although in some instances the distance could be even greater.

Costa Rica takes great pride in its educational system as one of the finest in Latin America, and boasts a very high literacy rate of 93%. However, as in many countries (the United States included), the literacy rate of Costa Rica may not truly indicate competence in a language. Being able "to read and write" (to decipher and use written language) does not always indicate the ability to comprehend and analyze more than the most basic type of writing, nor to effectively communicate in writing one's own thoughts.

Other than having district and nation-wide competency exams to graduate from *escuela* and *colegio*, respectively, and being funded nationally not locally, the general educational system of Costa Rica seems similar to our own system of universal public education. However, a closer look reveals that there are significant differences between our two systems, some of which I will describe below.

In Puriscal, classes are half-day, with some grades in the morning, others in the afternoon. In schools with fewer than three elementary teachers some grades were combined, and some of my schools only had one regular teacher. Classes switch each day -- if children come in the morning one day, they will generally have class in the afternoon the next. In some schools they also switched each week, while others maintained the same schedule. Taking into account recess time and lunch, there could conceivably be as little as three hours of class time a day. Teacher meetings were once a month, during class time, and there were a large number of religious holidays. The end result was that Costa Rica not only had one of the shortest school years in the world (about 180 days), but with half-days, teacher meetings, and other special occurrences there was a very limited amount of class time even in those days. Teachers also generally teach different classes and often grades, both morning and afternoon, thus increasing the administrative work required of them. All full-time teachers teach at least two classes a day.

Costs of Education

To the best of my knowledge, attendance in *escuela* was not required, needless to say attendance in *colegio*. More importantly, there are considerable costs for children to attend school -- uniforms, notebooks, pencils, pens, rulers, etc., not to mention transportation to and from school. Children in school are also less able to help in the fields when labor is needed to achieve economic survival. The end result is that many children do not even finish *escuela*, much less *colegio*.

In Puriscal, children in *escuela* were provided lunch and/or snack depending on whether their class was scheduled either for the morning or afternoon, although I did note that in some instances -- where children were very poor -- they were able to come for lunch, even if the rest of their class was scheduled at a different time. There also seemed to be leeway in the necessity of school uniforms for those who appeared poorer (or sometimes, if one had not been washed). Children in *escuela* could also ride the public bus free, although its infrequency and/or schedule meant that children generally walked to school. In outlying communities without bus service they always walked to school, unless some other means of transportation was available. Students in *colegio* had to pay the costs of their food and bus transportation. For larger communities, such as Desamparaditos (where I lived), a special bus was scheduled to provide return transportation for the students who attended high school at night (*colegio nocturno*).

A parent once told me that for her two children to attend *colegio* it cost her at least 1000 *colones* (about $5/day or $100/month).

. Her family (two adults, two teenagers, and three younger children) were farmers, and she once estimated their monthly income during the local harvest season as 80,000 *colones* (about $400). During part of the year, to extend their income the husband traveled to other parts of the country, where he could use his tractor (few persons owned these) to haul sugar cane, and other agricultural products. Nevertheless, it should be understood that during at least part of the year there was no income. This example shows that for many families the cost of education (possibly as much as 25% of total income in this family's case) is a considerable expense.

It is therefore not surprising that a number of students do not finish (graduate) from *escuela*, much less from *colegio*. Whereas 1st, 2nd, and 3rd grade might have many students, the numbers could be seen to drop in upper grades. Particularly noticeable would be the relatively higher proportion of boys in the upper grades. Presumably, the girls were taken out of school to help care for younger children, cook, and take care of the house. More importantly, since they would, in most instances, become housewives, further education was not seen as necessary. In Puriscal, this effect was not nearly as strong as I have observed in less-developed countries (indeed, one 6th grade class I taught consisted almost entirely of girls); nevertheless, it was still evident, particularly in more rural schools. Even if they did not drop out of school, girls, as they got older, were still given many household and childcare responsibilities.

Given the above factors, it is surprising that so many children do attend school. It is clear that not only do parents value the importance of an education, but so do children. In general, it was my belief that, even in upper elementary grades, children liked school and wanted to be in the classroom, despite having to walk long distances to get there. This desire on the part of the children was certainly one of their positive attitudinal parameters that helped me in my role as teacher there.

Teaching Methods

Although there were exceptions, in general, the teaching style employed was rote learning. Either the teacher would write on the blackboard and the students would copy what was written in their notebooks, or the students would copy sentences and sometimes paragraphs out of a text book. In some instances, there would be discussion beforehand or afterward. As the number of text books (soft cover) was generally limited, children would often be in groups, with one child reading from the text while the others copied what was said. In general, students would copy verbatim anything written on the board or in books, being especially conscious that it appear neat. They would liberally use "wite-out," and write, rewrite, and sometimes rewrite again. Grading appears to have been based on two things: first, a review of the child's notebook, with special emphasis placed on neatness, and second, short answer tests, which generally asked for recall of facts. Sometimes classwork and/or participation was also graded.

Although there were differences depending on the school, generally there were very few resources. Books were few, and the school "libraries" consisted of not only few but generally very old books. Only one school had what we in the United States would call a library; in addition to being totally disorganized, most of the books in it were for high school students and/or adults since it was the former community library. In most schools, the new books were kept locked up in the teachers' office, and thus, were generally not available. With the exception of posters provided by the government and environmental agencies, there were few extra materials. There were few subject texts (generally "watered down" paperback versions) for each grade. Thus, these had to be shared and were never, to my knowledge, taken home for studying. Most schools did not even have paper for children to use, and teachers often had to buy chalk and other school items with their own funds.

<u>Attitudinal Parameters</u>

What positive attitudinal parameters did the students/teachers display? The children's desire to be in school was mirrored by the teachers' general desire to teach, most of which seemed genuine and not related solely to economics. Students also displayed *respeto* (respect) toward their teachers (including me). Indeed, this *respeto* was given me as a professional by all members of the community -- students, teachers, parents, and non-parents. Linked to this was the general positive attitude of "Ticos" (Costa Ricans) toward the United States, and by extension toward USAnians (persons from the United States), and the desire of many of my students to learn English from me.

The children in my classes were also able to work well in groups. With very few exceptions (in one case, a boy whose parents insisted he work alone) all participated in group discussions and activities. Their ability to cooperate and work together in groups may be shown by my inability to recall ever having a child come up to me and say "_________ is not doing his/her share," although at times it appeared to me that this indeed was the case.

Some attitudes, which I perceived as negative, stemmed from the aforementioned positive ones. One was that my students' desire to do well in school was primarily based on their desire to please me and others, exhibiting a primarily external locus of motivation, which studies have shown to be less effective than intrinsic sources of motivation. Their *respeto* for teachers led to a style of learning that instead of questioning, accepted teacher instruction as authority, without comment. This in turn led to styles of rote memorization and direct copying of whatever was written, instead of active class participation and thoughtful note-taking, or the summing-up of their own thoughts on the subject. Finally, it led to what often seemed to me excessive overemphasis on neatness and constant use of "wite-out," which slowed class.

In looking back at these learning styles and behaviors, I realize that they were adaptive, for given the system of evaluation these methods held the best possibility of success. They were culturally-based as well, even as my negative reaction to them was based on my own cultural/educational biases. Sueiro Ross writes that whereas in the United States "children are expected to be self-sufficient, independent, competitive, and questioning; the Hispanic Culture stresses instead compliance, dependency, cooperation, and consideration of others." (1974, 120)

Upon reflection, I have come to realize that not only were the attitudes I perceived "culturally correct" for my students, but my perception of them came from my different cultural viewpoint. My statement above concerning the lack of "active class participation and thoughtful note-taking" is based upon my perception of their actions as individuals in the class --- the absence of "the summing-up of their own thoughts on the subject." On the other hand, I have already stated they participated actively in group activities -- in keeping with the Hispanic value of allocentrism or group behavior (Cortez 1981; Marín and VanOss Marín 1991). Nevertheless, it is instructive that I did not give the same importance to their group work in the above statement decrying their "lack of active participation."

Additional Factors

Two other factors which affected my teaching bear comment. The first is that the response of teachers in my classroom varied widely -- some saw it as a break for them, despite my plea they remain in the class; some stayed in class, but instead of participating used the time to catch up on other work; some stayed in class and helped with explanations; and a few actively participated in my class. I felt the latter classes were my most successful, and also feel that those teachers will be able to receive the greatest benefit from the program of studies I wrote.

The second factor is that much as there was a change toward the concept of *desarollo sostenible*, in the last year of my service there was a major change in the national curriculum guidelines (See Appendix 2). These moved away from the emphasis on rote memory of factual information toward more conceptual work and critical thinking. Insofar as my program had dealt with some of these same overarching themes, teachers with whom I had previously worked were receptive to my incorporating them in their classes. On the other hand, since the curriculum guidelines were more comprehensive, some teachers felt overwhelmed, and thus gave me less classroom time.

The Importance of the Foregoing Analysis

I stated at the beginning of this chapter that, as a foreign teacher, to be effective it was important to understand the background of my students and their country. However, this type of analysis is also useful, and indeed necessary, for any teacher who wants her students to be active participants in their learning. Teachers should have a good understanding of the background(s) of their students to effectively relate their lessons to the students' experiences. The difference in my background situation and that of my students in Costa Rica may have been more extreme in some ways than that which faces most teachers, but I present this analysis as a model of the type of understanding of their students for which teachers should strive. I hope that it will serve as a guide to the many teachers who today increasingly find themselves facing cultural gulfs in the classroom, as I noted in my introductory chapter.

One reason I have examined in such detail the effects of political and economic structures on Costa Rica over the years, and the more recent demands placed upon it by neoliberal policies, is because they clearly affected the political, economic, and social lives of the people with whom I interacted. But, as I have noted above, they also affected the environmental conditions of the country and decisions that had been and were being made concerning the environment. Indeed, I felt those factors and their effects were as important to consider in designing my school program of environmental education as the educational parameters I have discussed. Finally, I have examined these factors in such detail to give an indication of what I perceived as the major sources of the problems of the country -- problems which I attempted to address when I was there. I have tried to express as clearly as possible my views on neoliberalism to help the reader understand my perspective and to understand somewhat the partial dilemma I faced as a Peace Corps volunteer. That dilemma stemmed from my political and educational beliefs, which I will examine in detail in the next chapter.

CHAPTER 3

MYSELF, MY ROLE, AND MY BELIEFS

Teaching is an interactive process. Therefore, I must not only examine the effects of my students' and other teachers' attitudes, their cultural values, and so forth, but also my "hidden curriculum" (Freire) -- my prior experiences, cultural values, politics, and philosophy of teaching and learning. This is true in any situation but especially crucial when one teaches in a foreign nation or when the teacher's cultural background is different from her students.

Foreign Experts and Cultural Differences

The role of foreign "experts" as they interact with host country nationals can be a problematic one. The likelihood of problems is proportional to not only the extent of cultural differences they encounter and their ability to communicate and interact through language, but also through their self-perceptions. Having been recruited as "experts," they are expected to be expert. However, if they are overconfident in their abilities, they may be perceived as intellectually arrogant. Host country nationals will increase their cultural/social distance from them, and the experts' ability to perceive and/or design relevant solutions will be decreased. It is more likely foreign "experts" will find themselves overwhelmed and insecure in a new cultural milieu. If so, they will have too little confidence, will withdraw from cultural/social interactions, and their effectiveness will be similarly reduced. (Freire 1973)

My "Expert" Status

Although teachers and members of my community saw me as an expert in both teaching and environmental education (especially as I was older than other volunteers and most teachers), I in no way felt myself so, and generally tried to discourage this thinking. After all, although qualified to teach elementary school, I had done very little grade school teaching. The majority of my teaching experience had been as the English teacher in a bi-lingual preschool.

Likewise, my experience in environmental education had been almost entirely in informal settings. I had helped to organize a community environmental group and led numerous field trips, but these were either related almost exclusively to birds or related to environments very different than the one in which I now found myself.

I emphasized that they, the teachers (and even the students), were much more knowledgeable of the environmental problems of Puriscal. I saw my participation in their classrooms as being one of sharing general ideas and techniques, which could be applied to environmental education, and stimulating dialogue and critical reflection on environmental issues.

I have already noted the *respeto* accorded me by teachers. Peace Corps volunteers in general have been welcomed in Costa Rica. Additionally, I had the benefit of not being perceived/seen as an instrument of higher administrative authorities (the Ministry of Public Education [MEP]), who were dissatisfied with teacher performance. Rather, I had been introduced to the staff of the schools by members of MIRENEM (the Ministry of Natural Resources), through the personal request of my immediate supervisor in Peace Corps, who had formerly lived in Puriscal and was well known. This personal recommendation was invaluable to me, and I always endeavored to justify it in my relations with teachers and staff. In general, therefore, even if teachers did not actively participate, I was given much support by teachers and/or principals, and also given a great deal of latitude in my classes.

Unlike many foreign "experts," as a Peace Corps volunteer I lived in and was seen as a member of one of the communities in which I taught. [The majority of Peace Corps volunteers purposely live in the communities in which they work.] I did not live in Santiago, where I would have been one of many *gringos*, but in Desamparaditos, a semi-rural community of somewhat over five hundred residents, where I was *maestro* (teacher). I participated in community and/or religious festivities, went to church on occasion, practiced and played soccer and attended matches, and shot pool at times. My preschool experience helped me to have a playful relationship with young children, and I often engaged older ones in singing songs and played with toddlers and babies. I was also basically "adopted" by one family with two young children.

Cultural Differences

Nevertheless, there were cultural differences between me and the people with whom I worked. I was in some ways prepared for them. I had taught in a predominantly Hispanic preschool, lived in Latin America previously for brief periods of time, and had taken a course in Hispanic culture and another one on cross-cultural perspectives before leaving for Costa Rica. In addition, I benefitted from the considerable time the Peace Corps devotes in training to address problems which may result from cultural differences. Probably better preparation had been trial-and-error learning I gained from some culturally "insensitive" interactions I had had with various persons, the most recent of which occurred with my host family mother during the final weeks of training. [Although one may say or do something with the best of intentions from your own cultural viewpoint, your action or what you said may be construed negatively from another cultural viewpoint.] Thus, I was extremely wary of saying things the "wrong" way!

Where these cultural differences most manifested themselves was in the classroom, something I am only fully realizing as I write this. Although, in general, school time was more "exact," there were times when I still became frustrated by my students' inability to be responsive to my sense of time. I have already mentioned my frustration with what seemed to me their excessive "obsession" with neatness, and I often found myself frustrated by their *respeto* and its concomitant "non-participation," while at the same time I indeed wanted their *respeto*. I'm sure there were times my students felt they were receiving mixed-signals, not knowing for example when I wanted them to write things in their notebooks and when just to listen and participate in discussions. These mixed-signals were intensified by the variations in teaching style of the teachers in the different classes which I taught.

Communication Problems - Language

But by far the greatest difficulty I faced was one of communication. Although my Spanish undoubtedly improved, I never considered myself fluent. While in informal communication this could be overcome, in the classroom it was a much more serious impediment. There were times when this became frustrating for both my students and myself, often exacerbated by local usage (names) unfamiliar to me and my poor pronunciation. If the teacher was in the classroom, she could help; however, I often found myself in situations where although I wanted students to actively participate in discussions and/or ask questions, they could not understand me or I them!

Knowing how bad was my mastery of Spanish and my pronunciation (I am almost a purely visual learner and cannot hear many vocal distinctions), I was generally not defensive in these situations -- unless in a humorous way. Indeed, humor was one of the principal strategies I employed in my classes, not only for language difficulties, but also to engage students in active participation.

While, on the one hand, my language inabilities were a disadvantage, they were also an advantage in that they helped to diminish some of my "expert" status. It was also easier to involve teachers in my classes (particularly in my first year), as communication "bridges," and thus, share teaching ideas and techniques with them.

Political Philosophy

The last aspects of my "hidden curriculum" that I want to discuss are my political and educational philosophies and how they affected my teaching. As a 60s radical, I am by nature somewhat skeptical when too much praise is lavished on anything. Costa Rica had seemed too idyllic and its environmental policies too enlightened. Indeed, prior to leaving for Costa Rica, for one of my final papers at the University of Massachusetts, I had pursued as my theme whether the creation of Costa Rica's large park system served as a funnel directing peasant labor away from farming toward other (more attractive for the ruling class) labor choices -- *maquilas* (low-wage industries), banana plantations, and tourism. I had also questioned a policy of natural preservation that wants to preserve all of nature, but defines people as being outside of nature, and therefore does not consider their needs to be part of the equation.

Although I knew, as a Peace Corps volunteer in environmental education, it would be difficult to fully put forth my political perceptions, these perceptions were clearly part of my understanding, and I did at times raise them. It is interesting to me that Costa Rica, during my time as a volunteer, became a strong proponent of *desarollo sostenible*, an acknowledgment that human economic, social, and cultural development should be considered at the same time as "natural" preservation. Perhaps the contradiction of having one-fourth of its total land area devoted to conservation while many of its inhabitants live in squatter settlements, and the general well-being of many has worsened, led Costa Rica to similar conclusions I had drawn.

Educational Philosophy

Finally, I would like to discuss pedagogy, my philosophy of education and how it affected my performance in Costa Rica. As an educator I felt strongly that my pedagogical values should be those values I was least willing to compromise. I had been influenced by my reading of Freire and his notions of liberatory education, especially as it intersected with much of my political philosophy.

I have already mentioned in my introduction his criticism directed toward "banking" education and his emphasis on the need for education to be based on the students' experience. Another educational technique he advocated was the use of dialogue. He emphasized that a major role of the teacher is to engage her students in dialogue, have them discuss and exchange ideas with her and each other, and jointly address problems. For him, this was not only a good technique, but a way in which the teacher could affirm the validity of her students' experience, and thus, empower them to think and act on their own.

What then was my educational philosophy as I left for Costa Rica? In writing a paper for my course, Cross-Cultural Perspectives, before I left, I summarized it and would like to refer to that paper now. I had examined my own educational background, not limited to school, and found these five factors which were instrumental in making my education meaningful:

1. Caring adults
2. A moral value system
3. Excitement of learning
4. Creative opportunities
5. Relationship to the present

Using the broader conception that Freire and others have of education, I analyzed these factors to clarify my own educational philosophy. This then was my philosophy and the importance I gave to each of these factors (which I will discuss in turn), as I approached my role as an educator in Costa Rica.

To begin with, I knew I could not as an educator recreate for my students the conditions of my youth, <u>nor should I</u>! The situation and context of my students would be very different and so would be their needs! What I could, and should strive for, would be to provide for them the five essential ingredients listed above. My main problem would be how best to do this within a culture in which I am a foreigner.

First of all, it was important to remember as Giroux states that "schools represent only one important site where education takes place, where men and women both produce and are the product of specific social and pedagogical relations." (Giroux 1985, xiii) If I were to truly engage in liberatory education, it could not only be done within the school system. My role as an educator must be part of all my interactions with others.

One meaning of the verb "educate" is "to stimulate or develop the mental or moral growth of," (American Heritage Dictionary 1985) and it is that meaning which I intend. Furthermore, an educator is "a person constantly readjusting his knowledge who calls forth knowledge from his students." (Freire 1985, 55) She does not only instruct, nor does she see that as her primary role. Rather, she helps her students synthesize new knowledge with their old, while she in turn learns from them.

Caring Adults

Educators must care about those they educate. If a teacher does not care for a child, she cannot educate that child. She will only be able to instruct her. For education above all means sharing, both talking and listening, and that kind of exchange is not possible without caring. Unable to establish a bond with the child the teacher may well lose her. Education (genuine two-way interchange and growth) will be replaced by didactic one-way instruction, and what the child learns will have little or no meaning for her.

Moral Value System

Educators face a dilemma when the issue of moral values arises. On the one hand, they want to inculcate good moral values in their students. On the other hand, they want to respect the values of their students and know they cannot, and should not, try to impose their own value system(s) upon others. This dilemma is even stronger for the educator who is teaching those of a different cultural background(s), where the differences between values may be greater.

What should I as an educator do? To begin, I should help others to appreciate their own cultural and moral values, and to understand how they relate to their "deeper beliefs about the very nature of what it means to be human, to dream . . . ." (Giroux 1985, xiii) Unless my students first understand and appreciate their own cultural values and how they are grounded within their own culture, they will find it difficult to examine those values and compare them with other value systems. And this is what I must also do -- I must be able to provide them with the support to examine these values, and, if it becomes necessary, to change them.

Helping my students to understand their cultural values does not mean I need to remain morally neutral, nor negate my own values. Instead, I must be clear about my own values and be as consistent as possible in living up to them. At the same time, I should also share my own moral uncertainties and indicate to them when and how I make and weigh value judgments. I too should examine my values and, if it becomes necessary, be willing to change them. In this way, by modeling my own thinking processes and internal struggles, I will help them to better examine their own values and moral uncertainties.

Excitement of Learning

As an educator I have to excite my students as much as possible, i.e., whet their appetite for learning. This is not always easy to do, however, for every topic will not be of interest to everyone. Students will like and hate different things, and more importantly, will have different types of abilities and learning styles. To a degree I can use a "promise of things to come" as justification for learning, but I must be honest in how I present this, for I too am "painfully aware that schooling is not necessarily opening the door of opportunity." (Trueba 1989, 112)

I also cannot say that "education is the key to success." Not only do I not believe it myself, but it is clear to my students that there are other "easier" ways to success (defined in terms of recognition and money), e.g., selling drugs and excelling in sports. Nor can I assume they will "learn for the sake of learning." They might for subjects and topics they enjoy, but there is not much chance they will for others. Can I then argue utilitarian value? Again, to a degree it may be useful, but I need to emphasize that the basis of their education should not be for them to become simply "good workers."

Instead, I must illuminate the relevance of a critical pedagogy for my students. (Aronowitz and Giroux 1985) The basis of their education should be to "develop knowledge and skills that provide [them] with the tools they will need to become leaders" [emphasis mine]. (Aronowitz and Giroux 1985, 32) I must emphasize their right and responsibility as human beings to transform their society for the betterment of all. This can only be achieved by making students the "subjects" not the "objects" of their own education. "The educator's role is to propose problems . . . in order to help the learners arrive at a more and more critical view of their reality." (Freire 1985, 55) Through problem-posing and dialogue I can make "knowledge meaningful, critical, and ultimately emancipatory." (Aronowitz and Giroux 1985, 37)

Creative Opportunities

What does this mean in practice? Here we see the importance of creativity. As Freire says, "To study is not to consume ideas, but to create and re-create them." (1985, 4) When the child or student uses what she knows or has learned to create something new, she has totally appropriated that knowledge. She has given it new meaning -- meaning that can combine with desire, language, and/or values to empower her in her life. Further study may lead to the further re-creation of meaning as understanding is advanced.

Of crucial importance for this process to occur, however, is for the student to have the freedom to create. Thus, not only must I the educator help to create dialogue through problem-posing, I must also provide the student with many opportunities for creative presentation and engagement. The student who is allowed to explore her interests, presented problems relative to them, asked to report on those interests, and allowed to collaborate with her peers in her studies will be more likely to appropriate for herself and be able to utilize her new knowledge and understanding than the student who is given an assignment with "set" problems, worksheets to be filled out, or drill practice.

Relevance to the Present and Student Experiences

There is, however, one other requirement for education to be meaningful and that is that it be relevant to the present, i.e., it allows students to collectively address issues in their lives, and to "develop a deep and abiding faith in the struggle to overcome injustices and to change themselves." Education must make possible "new forms of culture, alternative social practices, new modes of communication, and a practical [and hopeful] vision for the future." (Aronowitz and Giroux 1985, 36-37) The experiences, values, and problems of both the students and their respective communities must be integrated into the curriculum. Unless education addresses the reality of all students, and provides them with the tools to both understand it and to change it if necessary, it will remain what it is today -- a selective "weeding-out" process designed to perpetuate the existing society.

The basis of my educational philosophy was then, and still is, that a teacher can only teach and a student can only learn something if it has some relationship to prior experience and/or knowledge. The role of the teacher, therefore, is to affirm the students' present understanding and help them to develop the means to investigate further. She should guide them to make a critical appraisal of their learning -- creating a framework for their conceptualizations, and encourage them based upon this learning to draw their own conclusions, from which they will launch new investigations. As the teacher does this, she in turn learns from the students' experiences, which also enables her to better facilitate their learning.

Fundamental to my ability to teach in Puriscal, was the involvement of my students in their own learning. My lessons were principally based on discussions of their own experiences and/or investigations. However, as a teacher, my role was to help them expand that understanding -- to help them construct a framework to encompass not only their present knowledge, but also new knowledge.

As I taught in the schools in Puriscal, I tried to incorporate this philosophy into my classes and lessons. In addition to emphasizing the importance of my students' experiences in our discussions, I emphasized that they themselves should and do have the right <u>and</u> the responsibility to make their own decisions in their lives. I tried to empower them by having them realize through our lessons that their knowledge of local conditions was often superior to that of so-called "experts," and that they had the capacity to address and solve problems that confronted them. I encouraged them to look at problems from a multilogical perspective (giving equal attention to all viewpoints), and to realize that most problems do not have easy answers. Although I was sometimes at odds with official environmental policy, I emphasized that in the future they would have to make decisions regarding land usage, disposal of waste, the cutting of trees, the use of pesticides, and other environmental matters, and that sometimes the decisions they would make would not be what environmentalists might desire.

These are some of the ways in which I tried to incorporate my political and educational philosophy in my classes, ways that I will describe in greater detail in my chapter on the implementation of my program. But as Giroux pointed out, schools are only one arena of education. Thus, I often raised many of these issues of environmental "relativism" in conversations with parents of the children and other adults outside of school, as well.

I also expressed my political views. The clearest example of this was my "unofficial" (but well-known by teachers, parents, and often children) support of the teachers' strike during my last year in Costa Rica. I saw the strike as an attempt to change some of the neoliberal policies that the government was pursuing, to preserve some of the socialist aspects of the government, and to restore Costa Rican sovereignty (which was being eroded by the demands of international banks). However, while I supported the strike and discussed and argued its merits with many friends, I always stated clearly these were my views, and that it was their country, not mine, and they had to make their own decisions whether to support it or not. Likewise, although I attended strike meetings regularly, I never tried to influence decisions the teachers were making.

CHAPTER 4
CRITICAL AND CREATIVE THINKING

Introduction

In response to criticism of our educational system some philosophers, educators, and psychologists have emphasized the development of critical and creative thinking. In brief, they have advocated the importance of the thinking process, and not just the content which is learned. Although they agree that the content of education (i.e., background knowledge) is essential for students to learn, they also insist it is not enough to learn only facts; students must also learn how to interpret and expand upon these "facts." If their learning is to be meaningful, students need to think critically and creatively .

The recent emphasis on critical and creative thinking in education began in reaction to two perceptions by educators. Students did not seem to be learning much of what was being taught, and they also did not seem to be able to transfer that learning when appropriate and/or necessary. Furthermore, even when students were considered knowledgeable, there was increasing evidence (Gardner 1991) that they were unable to apply what they had learned. There is also a philosophical base for this change in emphasis, however. As problems in our world have been increasingly seen to be multilogical ("can be analyzed and approached from more than one, often from conflicting, points of view or frames of reference" [Paul 1992, 660]), many have realized that the development of thinking skills and dispositions is indispensable to making justifiable decisions in all phases of life.

Prior to my Peace Corps service, I was a graduate student in the Critical and Creative Thinking Program at the University of Massachusetts Boston. I was therefore cognizant of many of the ideas of this movement and, to the extent to which I had incorporated them into my philosophy of education, based my program of studies upon them. In this chapter I will briefly review some of the tenets of the movement and suggested teaching strategies, which I tried to incorporate in my teaching. I will save for future chapters more specific ideas on conceptual change learning and science education, and how I implemented these ideas into my program of studies.

Defining Terms

Before analyzing some of the important tenets of the critical and creative thinking movement, I feel it would be useful to look at some of the definitions that have been offered. These will help to clarify and categorize different strategies that the movement offers, and ultimately to analyze the program of studies I implemented. I will define each aspect separately, as has traditionally been done, although I should state at the outset that the division between creative and critical thinking is not clear-cut.

Critical Thinking

Robert Ennis, one of the first proponents of the critical thinking movement, emphasized its importance in our lives and gave this definition: "Critical thinking is reasonable reflective thinking that is focused on deciding what to believe or do." (1987, 10) Although *reasonable* could be construed as "common sense," in other formulations of his definition he has used the word, *rational.* Therefore, I feel his use of the term implies that reason, i.e., logical thought, is an essential component of critical thinking. Similarly, the term *reflective* indicates a metacognitive component -- thinking about one's thinking. However, to me his use of the term signifies more than that, for a reflection is something perceived; thus, to reflect on something is to examine its perception. This implies that the thinker needs to move outside of her own frame of reference to perceive her own thinking.

The critical thinker is also *focused on deciding*. Her thinking is directed and purposeful. Her goal is to *decide what to believe or do*. The critical thinker is not passive, but active. It is her thinking that is used to make this decision, not somebody else's. She does not merely think to give others new ideas, but to decide for herself her own behavior.

Although Richard Paul would agree with Ennis' definition, he also insists that there are two types of critical thinking (both included in Ennis' formulation) -- weak sense and strong sense. Weak sense critical thinking is directed "toward serving the interests of a particular individual or group," but strong sense critical thinking "take[s] into account the interests of diverse persons or groups." (Paul, 1992, 48) He further states it is only the strong sense critical thinker who will always make the "right" decision. I agree with Paul that there is a difference between these two types of thinking, and that "interests of diverse persons or groups" must be taken into account, if we want to try to make the right decision. However, I also feel that true "strong sense" critical thinking is an ideal, to be striven for, but impossible to achieve. Thus, it is impossible (in my view) to state (as Paul does) that someone can always make the right decision.

Creative Thinking

Although there is close agreement in defining critical thinking, there is a much wider range of views as to what constitutes creative thinking, or creativity. Although the creative genius has always been admired, the term "creativity" (at least in the vernacular) has generally only been thought to apply primarily to artistic endeavors, not more academic ones. In almost all cases, the term was used to denote a special talent which an individual had in some particular artistic field. The creativity of individual artists was based upon the creativeness of their art (artistic product), which was judged by that field's arbiters during a particular historical time. The judgment was subjective and might change over time. Later, the idea of special talent creativity was extended to other fields as well. More recently, however, a different conception of creativity has been put forth that views and defines creativity as a more general trait of individuals, even if those individuals may or may not have what would be seen as "special talent creativity."

Product definitions. Nevertheless, even though our connotative usage of the term "creativity" has changed over time, most would still agree that the creativity of an individual can only be inferred by something produced, whether partial or finished. Creativity is inferred if a product is both original and appropriate. This definition based upon the creative product does not fully work, however, for it is possible, as Teresa Amabile (1983b) says, for someone to produce an original and appropriate product using totally algorithmic steps -- a product which most would not attribute to the creativity of the individual. Amabile thus adds that "the path to solution" must be a heuristic one. "A product or response will be judged as creative to the extent that a) it is both a novel and appropriate, useful, correct, or valuable response to the task at hand and b) the task is heuristic rather than algorithmic." (360) Still, we can see that even this definition, and any other definition of creativity inferred from a product, rests upon the opinion(s) of the above arbiters, since the creativeness of a product is a subjective and historical judgment.

Process definitions. Other writers (such as Rogers 1970) have defined creativity by looking at it as a process. He states, "The creative process is the emergence in action of a novel relational product, growing out of the uniqueness of the individual on the one hand, and the materials, events, people, or circumstances of his life on the other." (p. 139) While this definition gives more importance to the uniqueness of the individual and her life circumstances, it still is dependent on who arbitrates what is a "novel relational product."

Psychological views. To avoid this problem, others have again looked at creativity as it relates to the person. This is, of course, not new, as traditionally (see above) creativity was thought to be a special trait of few individuals. The modern psychological view, however, is more inclusive.

> Creativity is . . . a peculiar intersection between three psychological attributes: intelligence, cognitive style, and personality/motivation. Taken together, these three facets of the mind help us understand what lies behind the creative individual. (Sternberg 1988, 126)

There is another way to define creativity, however, one that emphasizes creativity as an affective characteristic of individuals. Feldhusen and Treffinger state that "Creativity can be viewed as a process of change in thinking and action." (1980, 31) What causes this process of change to take place? Grace Stanistreet, a pioneer in the introduction of creative arts into the regular school curriculum on all levels, says it "begin[s] with urgency to satisfy a need or desire." (1987, 9) Others such as Rogers, Maslow, and Moustakas have linked the creative impulse (urgency) to an individual's self-actualization. (Davis 1992) As Moustakas says, "It is this experience of expressing and actualizing one's individual identity in an integrated form in communication with one's self, with nature, and with other persons that I call creative." (1967, 26)

It is my opinion that this type of creativity is what we are seeking, when as the world becomes objectivized around us, we search for ways to maintain our individuality, our personal being -- what we define as being human. But, as Moustakas also says, this individuality cannot be sought in isolation; it must also be in communication with other individuals and with nature (of which we are all a part). Thus, for me, the following definition is more useful and more liberatory than one based upon product(s) or abilities.

> Creativity is a lifestyle, a way of living, a way of growing, and a way of perceiving the world. Living creatively is developing your talents, learning to use your abilities, and striving to become what you are capable of becoming. Being creative is exploring new ideas, new places, and new activities. Being creative is developing a sensitivity to problems of others and problems of humankind. (Davis 1992, 7)

Characteristics of Critical and Creative Thinking

Skills and Abilities

Critical thinkers have seen a need to better clarify the types of thinking which should be taught. Ennis (1987), one of the first to do this, defined twelve different broad abilities involved in critical thinking, and then subdivided these. He saw these abilities as covering four basic areas of critical thinking ability:

1. Clarity - The clarification of problems involves the abilities to focus, analyze arguments, ask questions, define terms, and identify assumptions.

2. Basis - The basis for one's decisions involves the abilities to judge credibility and observe.

3. Inference - The abilities to infer not only include the logical abilities to deduce and induce, but also the ability to make non-biased value judgments after careful consideration of all relevant information.

4. Interaction - Within this category are both the ability to decide and how to interact with others in making decisions.

In the field of creativity as well, attempts were made to identify certain cognitive abilities that creative persons exhibited. Among these were the abilities to define problems, visualize and/or imagine, think analogically and metaphorically, predict outcomes and/or consequences, analyze, synthesize, evaluate, think logically, regress, and concentrate. (Davis 1992, 88) These have been broadly classified as creativity-relevant skills.

Comparing these with the aforementioned critical thinking skills, one can see a great deal of overlap. Many authors have noted this and have referred to both almost interchangeably. For example, in accord with Paul (1987) and Swartz (1987), Perkins (1987) states explicitly that critical and creative thinking are complementary: "Critical and creative thinking are not entirely separate; good critical thinking is creative in its insights, whereas good creative thinking invariably involves critical appraisal and improvement of the product in progress." (p. 66)

Dispositions

The explicit incorporation of dispositions and attitudes, as well as skills, is one of the things that distinguishes the critical and creative thinking movement from other educational reform movements. When one considers the similarities of the attitudes or dispositions necessary for each, the complementarity and overlap of critical and creative thinking is even more apparent.

One of the earliest advocates of critical thinking, Ennis (1987) felt that in addition to skills and abilities, there was a need to include dispositions to think critically. Thus, he added to the list of abilities mentioned above fourteen different dispositions. Richard Paul, another proponent of critical thinking, reduces Ennis' fourteen dispositions to nine "affective strategies," which he regards as interdependent. (Paul 1992, 394) Like Ennis' dispositions, many of these can be related to the necessity for the critical thinker to be open-minded (development of insight into egocentricity or sociocentricity, fair-mindedness, intellectual humility and suspension of judgment, and intellectual courage and integrity). Others (independent thinking, intellectual curiosity and perseverance, and confidence in the use of reason) all relate to the importance of reason in arriving at decisions. However, both Ennis and Paul also include one other -- empathy -- sensitivity to and understanding of the feelings that underlie the thoughts of others.

Likewise, in the field of creativity certain personality traits and dispositions were seen as important. Among these were independence, adventurousness, curiosity, perceptiveness, tolerance for ambiguity, open-mindedness, fluency, flexibility, and originality. (Davis 1992, 8) Again, the similarities in dispositions between the two types of thinking are evident.

While all of these dispositions are no doubt important, other writers, in seeking to explain creativity, have emphasized a different factor -- motivation -- to which, in a sense, almost all of these are related. In their view (and mine), creativity is dependent on motivation and thus, cannot so much be taught as be encouraged. How then might it be encouraged? Rogers says "Perhaps the most fundamental condition of creativity is that the source of evaluative judgment is internal." (1970, 144)

Amabile (1983a) too notes the importance of intrinsic motivation. In her componential framework of creativity she asserts that a creative performance is dependent on the following combination:

[Creativity = Domain-relevant skills + Creativity-relevant skills + Task motivation]

She emphasizes that whereas domain-relevant skills will determine the appropriateness and/or correctness of a creative product and creativity-relevant skills its novelty, task motivation will determine the level and type of engagement made by its creator. In simpler terms, whereas domain-relevant skills and creativity-relevant skills will determine what an individual <u>can</u> do, task motivation is the determining factor in what she <u>will</u> do. (p. 77, 86)

Having developed her theory, she then designed experiments to test the positive and/or detrimental effects of various factors on task motivation. She found the following conditions enhanced creativity: (Amabile 1983a, 194-96)

1. Free choice in task engagement (how to do the task)
2. Intrinsic orientation toward the task
3. Cognitively and perceptually stimulating environments
4. For children at least, playful and fantasy-oriented activities prior to task engagement
5. Interpersonal detachment between individuals and authority figures

Alternatively, these social factors were seen to undermine creativity:

1. Constrained choice (how to do a task)
2. Reward tied to task fulfillment
3. External evaluation
4. Peer pressure
5. Surveillance

In summing up her conclusions Amabile stated:

> Conditions that are most conducive to creativity include conditions free of salient extrinsic constraints on performance, conditions that encourage self-direction, and conditions where intrinsic reasons for engaging in activities are stressed over extrinsic reasons. Creative performance is different from ordinary performance in that it can be undermined by the offer of reward, the expectation of evaluation, and other social factors that have traditionally been seen as facilitating performance. (1983a, 208)

Dispositional Theory of Thinking-- Combining Dispositions and Skills

In the last few years (during the time I was in Costa Rica), dispositions have been seen as more and more important, and rather than continue to try to maintain separate categories of critical and creative thinking abilities and dispositions, some theorists have conflated them into a dispositional theory of thinking. (Perkins, Jay, and Tishman 1993) They have done this not only to avoid repetition, but because they feel dispositions in reality have three different facets:

1. Motivation or inclination (which has always been recognized)
2. An ability component (not only does one have the inclination, one has the capability)
3. A sensitivity component (a need to be alert to situations in which certain dispositions and/or skills are needed)

They have further examined the literature on critical and creative thinking, and through their analysis have advanced seven broad thinking dispositions, which they feel are necessary and sufficient to characterize good thinking. These dispositions are the following: (Perkins, Jay, and Tishman 1993, 6)

1. To be broad and adventurous
2. Toward sustained curiosity
3. To clarify and seek understanding
4. To be planful and strategic
5. To be intellectually careful
6. To seek and evaluate reasons
7. To be metacognitive

Applying Dispositional Theory

These dispositions, and their concomitant inclinations, sensitivities, and abilities, are what teachers should encourage in their students to help them inculcate and practice critical and creative thinking and make their learning meaningful. Incorporating these dispositions into their thinking will enable students to learn how to make intelligent decisions in a multilogical world, transfer their knowledge when necessary, and overcome their egocentric and sociocentric tendencies. Since these dispositions and types of thinking overlap, I will at times refer to them separately, and at times interchangeably, as I address these problems.

Dealing with a Multilogical World

Good thinking requires open-mindedness (Ennis 1987, Paul 1992) or broadness. (Perkins, Jay, and Tishman 1993) Not only is the world too complex to allow for simplistic solutions, but this complexity means that there are many different points of view, all of which originate within their own frames of reference. In order for us to make intelligent decisions, we must be able to consider equally all different viewpoints. While, as I have previously argued, this ideal is impossible, we should strive to be able to think "dialogically," i.e., to think within more than one perspective, or frame of reference. (Paul 1992, 644)

Why is this so important? Paul states that most problems in the world are not "monological." They cannot be "settled within one frame of reference with a definite set of logical moves." He says instead they are multilogical --"more than one kind of incompatible [emphasis mine] logic can be advanced for their settlement." (1987, 128) It is not enough to only consider different viewpoints, we also must "seek and evaluate reasons." (Perkins, Jay, and Tishman 1993, 8) In Paul's terminology, not only must we think within logically incompatible frames of reference, we must weigh "facts" in a world where almost all "facts" are in reality "reasoned judgments." (1987, 140-141)

> A critical thinker . . . is someone who is able to think well and fairmindedly not just about her own beliefs and viewpoints, but about beliefs and viewpoints that are diametrically opposed to her own. And not just to think about them, but to explore and appreciate their adequacy, their cohesion, their very reasonableness vis-à-vis her own. (Nosich 1992, v)

The educational experience of most students in school, however, is almost the complete opposite. Not only are few problems presented in school multilogical, but seldom are students encouraged to engage in dialogical thinking. Students are told what to think, rather than how to think. (Paul 1987; 1992, 36)

> The rule rather than the exception today is that students are in countless ways encouraged to believe that there are more or less authoritative answers readily available for most of the important questions and decisions we face, or at least, authoritative frames of reference through which such answers can be pursued. (Paul 1987, 131)

If we indeed want our students to become stronger critical thinkers, we must provide them with the opportunity to reason dialogically by presenting them with multilogical issues.

The Problem of Intuitive Understandings

But we face another, perhaps even greater problem in our educational system, and that is simply that "children are quite reluctant to change conceptions even in the face of instruction which seek [sic] such change." (Duschl and Gitomer 1991, 842) Gardner says this is because children come to school with *intuitive understandings,* which are often in conflict with what is taught in school. These may manifest themselves as *misconceptions* in science, *rigidly applied algorithms* in mathematics, or *stereotypes* and *simplifications* in the humanities and the arts. (1991) In the next chapter I will examine in depth the cognitive nature of this problem, especially as it relates to alternative conceptions in science. Here, however, I would like to address Paul's ideas on the social basis of certain intuitive understandings (Gardner's stereotypes and simplifications) and how they lead to prejudice and narrow thinking.

Paul states that, much as children come to school with scientific misconceptions, they also bring social "misconceptions" (stereotypes and simplifications) that are equally ingrained. Examples of these stereotypes include false conceptions about other races, and economic systems (e.g., socialism), or even other political parties. An example of a simplification could be the belief that the United States government always acts to defend the rights of the poor -- both here and abroad.

These ideas are not only ingrained, they are also very powerful, in that they are often the common "truths" of a society -- "truths" which are often not challenged directly in school. Thus, even when the child is taught different ideas in school, the new ideas often do not replace these old ones in the life of the child outside of school.

> Children do not *transfer* the knowledge they learn in school to new settings because they already have activated ideas and beliefs in place to use in those settings . . . . As long as school learning is simply superimposed on top of the child's own activated ignorance, that ignorance will continue to rule in the life-world of the child and his or her scholastic learning will remain largely inert. (Paul 1987, 134)

Paul (1992) calls these ideas and beliefs that children already possess prior to what they "learn" in school, the individuals' "egocentric and sociocentric habits of thought." While Paul agrees there are other types of intuitive understandings, he emphasizes those that are social and are social in their origin. He says that children come to accept the teachings of authority because they receive rewards, tangible and/or intangible, for doing so.

> Children come to be persuaded . . . that their goodness depends on believing what those who are in authority over them believe. When love and affection are contingent on specific beliefs, then those beliefs become an integral part of the child's identity. (Paul 1992, 172)

Our social prejudices and biases and our individual ones are subtly inculcated into our thinking, often without our conscious knowledge that they exist within us. "Social life effortlessly and skillfully fosters collective illusions while personal life fosters individual ones." (Paul 1992, xii) All of these combine to form what Paul (1992) calls our "primary egocentric and sociocentric nature" -- "an integrated cognitive and affective system" which consists of "a complex mixture of beliefs, values, drives, and assumptions" and "generates a total frame of reference through which we can come to perceive, think, and judge." (Paul 1987, 142)

It is our "primary egocentric and sociocentric nature" that makes it difficult for anyone to think critically in Paul's strong sense. Thus, as I previously stated, my opinion is that although one can get outside of their frame of reference at times, at other times I feel it may be impossible. To do so, one has to deny the "rightness" of her own frame of reference, a rightness she has been conditioned to accept without examination, and this is not always possible.

Overcoming Egocentric and Sociocentric Tendencies

It is clear that for anyone to reason dialogically, they must try to overcome their egocentric and sociocentric tendencies, or at least become fully aware of them. Unless they do so, it will be impossible for them to truly consider other viewpoints. What are the thinking dispositions that students should adopt to understand and overcome these tendencies? In somewhat different language than is used by Perkins, Jay, and Tishman (1993), Swartz (1987) cites a number of them.

First of all, a student needs to have a questioning attitude. She also needs to consider and evaluate all arguments. She must understand the importance of points of view and frames of reference, and she must be able to adopt others' as her own, so she can think through their reasoning in her evaluation of their arguments. In short, she must not only question, but also be open-minded and flexible.

In her thinking a student should take a holistic view of situations -- analyzing them in broad, not narrow terms. In addition to looking at the present situation, she should look at past influences and effects and try to predict future outcomes. She should take responsibility for her own learning, seeking the information she needs to make her reasoned judgments. But she has an even greater responsibility, which is to take responsibility for her reasoned judgments -- acknowledge, defend, and act upon them -- but also be willing to change them if they become inconsistent or are successfully challenged.

In approaching issues she will of necessity use her critical thinking skills -- logical reasoning, precise use of language, evaluation and interpretation of value judgments, analysis of different viewpoints, and her ability to make reasoned judgments. However, Swartz also cites the importance of using what are normally categorized as creative thinking skills -- fluency and originality of thought, and elaboration of one's thinking. As have other thinkers, he emphasizes the interconnectedness of creative and critical thinking skills and attitudes or dispositions.

> Good critical and creative thinking take place in a context of questioning and open inquiry that requires a certain spirit of thought manifested in certain attitudes and dispositions like being open minded and considering points of view other than one's own. (Swartz 1987, 121)

Encouraging Good Thinking in the Classroom

Environment or Classroom Climate

Gardner (1991), Paul (1987, 1992), and Swartz (1987) have all made suggestions on the integration of critical thinking into the classroom. [Gardner uses the term "education for understanding."] Above all, the environment should welcome questioning attitudes. Students should be encouraged to participate and given the opportunity to "think through" their ideas verbally. Criticism of ideas should be principled and directed to the idea presented, not the presenter of the idea. Positive as well as negative criticism should be encouraged. It should be accepted that sometimes discussions will be open-ended; at other times students will be asked to evaluate issues. Participation not "correctness" should be stressed, and ample opportunity for small group activities and discussions should be given, with sufficient time also given to the special dynamics of group process.

In the field of creativity, we have already seen that Amabile (1983a) has shown that the most important social factors which contribute to creativity are the degree of task motivation, specifically the degree to which the creator's motivation is intrinsic rather than extrinsic, and the absence or presence of external constraints. It seems therefore that the best way to enhance creativity is to create a climate that is conducive to increasing task motivation. What should this climate be like?

In many ways a climate conducive to creative thinking is similar to one conducive for critical thinking. It should be non-judgmental (or at least judgment should be deferred, as it is in brainstorming). Gallo says it is important that the classroom climate be "psychologically safe, non-authoritarian, stimulating, responsive" and that it should provide both opportunities and requests for free expression of thoughts and feelings. Such a climate will "reduce anxiety and concomitant habitual response." (1973, 93-94)

It should both permit speculation (Gordon 1961) and may, and should at times, be playful to allow one's imagination to function. "Not all play is creative, but . . . all creativity contains play. Play in the creative process means the activity of floating and considering associations *apparently* irrelevant to the product." (1961, 110)

The climate should be flexible, providing freedom, but not permissiveness. Gallo points out that "overly ambiguous environments" (with little or no direction) may produce frustration and anxiety in students and thus reduce creative responses. (1973, 97) At the same time it should be challenging, with challenges both worthy and appropriate. Challenge differs from competition in that it "asks of the individual only *his best*," whereas "competition may ask of the individual what he is incapable of giving at this stage of his development." (Stanistreet 1987, 9)

Although the physical aspect of the classroom may not be important, what is important is that the classroom be "open" insofar as there exists an "atmosphere for developing critical inquiry, curiosity, exploration, and self-directed learning, without grading or authoritative teaching." (Amabile 1983a, 162: summarizing the research findings by Ramey and Piper 1974; Sullivan 1974)

The Teacher's Role

Modeling behavior. Through modeling and through the rules she establishes, the teacher can help her students create the type of environment referred to above, one conducive to critical and creative thinking. "It is the teacher's responsibility to be accepting of the student's response, to provide encouragement and reinforcement for all ideas, and to reduce or eliminate the criticism of the other class members." (Feldhusen and Treffinger 1980, 71)

As she models these qualities for her students she will also instill in them a creative attitude -- one that affirms the uniqueness of each individual and her importance -- as it seeks to find creative solutions. "The crucial element in fostering creative thinking is attitude; to nurture creativity one must foster a positive attitude toward the creative enterprise and toward the individual as a source of competence, worth, and that enterprise." (Gallo 1973, 119)

Facilitation. The teacher's role should primarily be that of a facilitator. She should encourage divergent thinking and creative responses through techniques such as brainstorming and by using questions to examine and expand her students' thinking. At the same time, she should encourage them to do likewise. Most of her questions should be open-ended and ask students to explain their reasoning and not just respond in a "yes/no" fashion, unless those "yes/no" questions serve as a prelude to examine underlying biases, both perceived and unperceived.

She should be able to direct her students to information sources and help them to use good reasoning skills. But in order to do so, she herself must possess sufficient background knowledge of the subject. She also should have developed and must utilize her own critical and creative thinking skills.

General guidelines. Both group and individual investigations and activities should be included in the curriculum, and students should be given responsibility for their own learning. In addition, teaching should invite "students to explicate, understand, and critique their own deepest prejudices, biases, and misconceptions, thereby allowing students to discover and contrast their own egocentric and sociocentric tendencies." (Paul 1987, 140)

The teacher should be concerned as much with the process whereby her students learn, as with the information they learn. She should give clear, unambiguous directions whenever possible for the tasks she presents her students, but not dictate or direct their path of inquiry more than is necessary. The tasks she gives her students should be challenging but not impossible to perform, investigate, or report on, nor should she ever ask of them something she would not do herself. Finally, as much as possible, her students' assignments should be connected to their daily experience.

Many authors have put forth guidelines for creative teaching and the encouragement of critical and creative thinking in students. Although the following were specifically proposed to improve creativity, most can easily be seen to apply to both types of thinking. I would therefore like to summarize and emphasize some of these general guidelines, which I tried to implement in my work.

According to Stanistreet (1987), a teacher should (1) be creative herself (or demonstrate her creativity) (2) establish a rapport with her students (3) expose her students to new experiences, but also take advantage of using the "here and now" as a learning opportunity and (4) challenge her students, while at the same time setting reasonable boundaries and limits on <u>what</u> to do, not <u>how</u> to do it. Gallo (1973) adds that the teacher should (5) be enthusiastic, excited, and take part in learning activities with her students (6) show by her behavior the importance of her students' learning experiences (7) promote confidence and (8) expect and request, but not demand, participation by her students. Finally, James Smith (1966) says the teacher should (9) emphasize the importance of process as much, if not more, than product (10) create motivational tensions (11) withdraw at times to let her students "face the unknown themselves" and (12) promote "success-oriented" learning, without making the success too easy or automatic.

<u>Specific recommendations</u>. Others have made much more specific recommendations. Paul (1992) recommends that teachers give children explicit practice in

various aspects of critical thinking -- logical reasoning, dialogical discussion, Socratic questioning, group decision-making, and determination of bias (including their own). He also says that teachers should design multilogical "assignments that compel students to think their own way through the logic of the content, using their own experiences, their own assumptions, [and] their own ideas." (Paul 1992, 302) While Swartz (1987) agrees these should be taught, he recommends this be done through a "conceptual-infusion" approach, whereby within the curriculum, teachers develop their own lessons, which are specifically designed to enhance the development of good thinking skills.

The teacher must also provide opportunities for her students to directly confront discrepancies between their own intuitive understandings or egocentric and sociocentric habits of thought and those of disciplinary experts. They must be able to discover for themselves when to suspend or replace their habits of thought.

> Education for understanding can come about only if students somehow become able to integrate the prescholastic with the scholastic and disciplinary ways of knowing and, when such integration does not prove possible, to suspend or replace the prescholastic way of knowing in favor of the scholastic forms of knowing. (Gardner 1991, 149)

Teachers must also learn the importance of these habits of thought, however, for there are times "when a prescholastic form of knowing may harbor a different or even a deeper form of understanding than the discipline-related form of knowing learned in school." (Gardner 1991, 149) For example, a teacher who has "assimilated sophisticated understandings . . . [may be less] able to see into the mind of the child and recognize its tendencies toward misconceptions and stereotyped thinking." (Gardner 1991, 179)

Freire (1973), in his essay "Extension or Communication," also discusses this problem, which often occurs in development projects when "experts" are trying to teach peasants. [Freire uses the term "expert" to indicate those who have been educated to think <u>differently</u> than peasants. He does not use it to mean their understanding and/or knowledge is necessarily better. It may or may not be, depending on the situation.] He states two negative possibilities which can occur when "experts" are teaching peasants. One is that an "expert" may have difficulty understanding the world view of a peasant and thus, may not be able to teach him/her. Another possibility is, in assuming the expert world view is the only correct one, the "expert" will be unable to recognize the validity of the peasant's world view, which may be better adapted to the actual conditions. As both an "expert" and a teacher in Costa Rica, I knew it was important to understand the different world views and concepts of those I taught.

The Importance of Dialogue

The teacher should also encourage and facilitate dialogue in her class. However, when she encourages dialogue as a facilitator, she must not abdicate her role as teacher. She should guide the discussion, contribute to it from her greater knowledge, encourage her students to put forth their opinions, and not negate, but also put forth her own. (Freire and Macedo 1995)

Often teachers will find that the issues that are most important to students are per se not in the curriculum. Teachers must be willing to address these issues as well, for "training in critical thinking should involve highly controversial issues of considerable, personal, social, or intellectual importance that are not seriously addressed in the regular curriculum." (Scrivens 1985, 12)

Much as it is important in the development of critical thinking for a teacher to engage her students in controversial issues, the teacher should also encourage the discussion and exploration of issues from specifically moral perspectives, and not shy away from these issues. I raised this issue of moral values in my last chapter, but would now like to expand upon what I said.

The teacher should not impose her moral views on her students, but neither should she deny them. Instead, she should express her views to her students, listen to theirs with respect, and acquaint them with other views. She and her students should feel free to challenge any with which they disagree. In this way, all will be better able to explore the ethical dimensions of issues, and her students will be better able to form their own moral views.

Not to put forth and defend her moral view would lead her students to feel morality is not important. Conversely, to impose it or to conceal other views would deny her moral position. As Freire says:

> To challenge educands with regard to their certitudes is a duty of the progressive educator. What kind of educator would I be if I did not feel moved by a powerful impulse to seek, without lying, convincing arguments in defense of the dreams for which I struggle, in defense of the "why" of the hope with which I act as an educator?
>
> What is not permissible to be doing is conceal truths, deny information, impose principles, eviscerate the educands of their freedom, or punish them, no matter by what method, if for various reasons they fail to accept my discourse -- reject my utopia. (1995, 83)

If a teacher is consistent in her behavior with respect to her moral views, she will set an example for her students. They will understand it is not enough to espouse a view, one must live it. If in her behavior she constantly shows her highest goal is that her actions affirm the life of the individual as part of Nature, they will be more likely to act in a similar manner.

Evaluation of Thinking Skills

Any attempt to integrate critical and creative thinking into education must also address the problem of evaluation. Paul says that genuine understanding or knowledge will be demonstrated by "the students' ability to explain in their own words, with examples, the meaning and significance of the knowledge, why it is so, and to *spontaneously* recall and use it when relevant." (Paul 1992, 43) For an individual to have genuine knowledge, she must not only understand something and be able to explain it, she must also be able to apply it. Thus, for Paul, an individual's inability to transfer knowledge implies it was not learned.

Although this ability to transfer knowledge may be determined by formal tests, there are other means of evaluation. By evaluating the abilities of her students to think when doing homework, addressing problems, during discussions, and in other classroom activities, a teacher can determine whether her teaching has been effective in creating understanding, what concepts need further investigation and/or clarification, and whether her students are transferring their learning.

Even in more formal situations, teachers can put greater emphasis on the process over the product. (James Smith 1966; Stanistreet 1987) This could be done for individual assignments or might be used as part of a portfolio assessment, in which the teacher evaluates the progress of her students, both as they work on individual projects and as they progress through the year. (Feldhusen and Treffinger 1980; Duschl and Gitomer 1991)

However, teachers should be especially careful when they evaluate creative efforts by their students since external evaluation often seems to constrain creative performance. (Amabile 1983a) One way to minimize this effect is by having the children do their own self-evaluations. (Feldhusen and Treffinger 1980) Teachers can also seek to reduce the potential negative effect of external evaluation by making the project interesting, i.e., increasing the intrinsic enjoyment of doing it. (Amabile 1983a)

While a teacher should be concerned with the degree of originality and elaboration when evaluating her students' creative work, most important, in my opinion, is that she use different criteria, and evaluate her students according to their abilities. Rather than grade creative efforts as she does other student products, she should only comment and evaluate based on these criteria: (Stanistreet 1987, 101)

1. Did the student "satisfy the obligation" of the assignment?
2. Was the student's work authentic (a true expression of her feelings)?
3. Was it worthy of the student given her capabilities?

The Importance of Taking One's Lessons to Heart

I have outlined in this chapter many of the ideas and the philosophy behind the present day emphasis on critical and creative thinking, ideas with which I was in agreement when I left for Costa Rica. While I did not have these sources with me when I developed and wrote my program of studies, inasmuch as I had, in Freire's words, "appropriated" these ideas, they were a major influence on my teaching.

Of these ideas certainly among the most important for me as a teacher were the crucial role that intrinsic motivation plays in student performance; the importance to cultivate not only skills of observation and reasoning, but also the dispositions to do so; ways to create a good classroom climate; and the importance of providing children with the means to transfer their learning. But of all these ideas, the most salient one for me was the need to engage in multilogical reasoning and to try to step outside of one's normal frame of reference. I knew that not only as a teacher would I want to encourage my students to examine issues from different perspectives, but, more importantly, I should be willing and strive to do so myself.

While I had read and thought about the problems of experts, I now realize that I had not fully internalized the thought that, as a foreigner, my ideas might be too narrow or mal-adaptive, and that I too needed to recognize the sociocentricity of my beliefs and would have to adopt a Costa Rican viewpoint at times and re-analyze my ideas in that light. After all, I was not only educated but politically conscious! Incidents like the following helped to challenge my egocentricism and realize the truth behind Paul's statements:

During my training period I had been surprised that my "family" had plastic artificial flowers in the house. I thought to myself they looked pretty "tacky" and could not understand why with all the beautiful flowers Costa Rica possesses (Birds-of-paradise can be found on roadsides!) my "family" had artificial ones on the table. I assumed it was due to the "fascination with all things Western (even the worst parts of our plasticized culture)" that Ticos were purported to have. For Mothers' Day, we the volunteers on that street bought real flowers for each one of the mothers of our "families" (each of us [I know I was] thinking it would be a pleasure to have some real flowers in the house for a change!). And, in accord with my desire, my "mother" did put the flowers inside the house on the kitchen table. And I also know that in our house this also delighted the literally hundreds of flies attracted by the flowers who joined us at the kitchen table when we ate!

CHAPTER 5

CURRENT LEARNING THEORY AND TEACHING SCIENCE

Introduction

I did not address intuitive understandings or alternative conceptions in science in the previous chapter, but have instead reserved them for this separate chapter for two reasons. First, as I stated, I feel the reasons for these "misconceptions" are much more cognitively related. Explaining their origins and how they are best reconciled with "expert" knowledge has led to a relatively new theory in the psychology of learning -- "conceptual-change theory," a "constructivist" theory of learning.

The second reason I have reserved these for this separate chapter is that when I left for Costa Rica, I was not cognizant of this theory. Nevertheless, the basis of my educational philosophy was then, and still is, (as I have previously mentioned) "that a teacher can only teach and a student can only learn something if it has some relationship to prior experience and/or knowledge." This was, in essence, a constructivist theory of learning.

Upon my return I had the opportunity to study and examine this theory and its relationship to teaching children science, issues which I will address in this chapter. I also had the opportunity to examine from hindsight my own teaching and this program, and to understand better its strengths and weaknesses, which I will discuss in the chapter preceding the final one.

Constructive Learning

My philosophical belief (stated above) when I left for Costa Rica is similar to that of most current educational psychologists who view a learner's prior knowledge as the primary determinant of future learning. Implicit in this view of Ausubel (1968) and others, is the further understanding that meaningful learning requires that the learner reconstruct her knowledge. In Schuell's words, today "learning is generally considered to be an active, constructive process, rather than a passive, reproductive process." (1985, 126) But from where does one obtain the materials with which to construct one's knowledge?

West and Pines (1985) state that children have two qualitatively different sources of knowledge -- the "intuitive" or "naive" knowledge they acquire from their interaction with their environment and formal knowledge that they receive in formal instruction. Children's intuitive knowledge constitutes their reality and beliefs acquired over time, is influenced by their language and culture, and is informed by all their sensory experiences (including television) and informal instruction from their parents and others. On the other hand, formal instruction is goal-directed, and is informed through the children's parents, teachers, school, books, and by other experts. Children integrate these two sources to construct their own understanding.

West and Pines state that this construction may occur in one of four ways:

1. Children may not receive formal instruction in a particular field. Thus, their understanding will be solely a result of their intuitive knowledge.
2. Children may receive formal instruction in a particular subject, but not have any (or very little) intuitive understanding of it. In that case, their understanding will be shaped almost wholly by their formal instruction.
3. The two types of knowledge may be congruent. In this case the two sources of knowledge will reinforce each other and extend their understanding of concepts.
4. In the final situation, the intuitive knowledge of children and their formal instruction may come into conflict.

As a child's formal instruction progresses the child will at first integrate and differentiate the various parts of school knowledge, as she constructs her own understanding of that knowledge in a process West and Pines call "conceptual development." As her understanding of this knowledge increases she will at times see that it is congruent with her intuitive knowledge, and her conceptual development will be reinforced. On the other hand, if her new formal understanding is seen to be in conflict with her intuitive knowledge, she has different options. If the differences are not great, she may find that she can resolve them and slightly reformulate her conceptual understanding, a process they call "conceptual resolution." In Strike and Posner's (1985) terminology, both conceptual development and conceptual resolution would be classified as "assimilation."

But the child may find she cannot resolve the differences. She may ignore the conflict (often as a result of not perceiving it in the first place), or dismiss its significance. Alternatively, she may recognize the need to resolve the conflict by either "restructuring" her understanding to interpret her intuitive concept(s) differently in order to accommodate her new conceptions, or she may find herself completely abandoning her intuitive concept(s) and adopting the formal one, a process I would call "reconstruction" of her understanding. I use the different terms "restructure" and "reconstruct" to differentiate learning in which part of the intuitive concept(s) can be retained, and that in which the intuitive concept(s) has to be totally abandoned, respectively. In either instance, the old concept(s) has to accommodate the new one(s).

Since this process of "conceptual change" or "accommodation" (Strike and Posner 1985) necessitates the abandonment of long-held beliefs, it is often a difficult one and may not be made. Strike and Posner give four necessary conditions for conceptual change or accommodation to occur: (1985, 216)

1. There must be sufficient "dissatisfaction" with one's present conception(s).
2. The new conception(s) must be intelligible or "minimally understood."
3. The new conception(s) "must appear initially plausible."
4. The new conception(s) "should suggest fruitful research," i.e., be useful.

Accommodation may often be gradual for children. It has been described as a "competition between conceptions." (Strike and Posner 1985, 221) As these conceptions compete in her mind, the child, in most situations, only gradually gives up her prior belief(s) or "alternative conception(s)" to embrace an incompatible one(s).

Formerly, the process of accommodation was thought to be relatively straightforward and the learning of advanced concepts (in children, especially) part of a maturation process. As a result, most teachers seldom felt it necessary to first convince children to abandon a prior conception(s). Instead, they merely "taught" their students the advanced concept(s) and expected the children would learn from them. (Freyberg and Osborne 1985) However, "there is now overwhelming evidence that many learners cling to their prior conceptions tenaciously in face of conflicting evidence and attempted persuasion." (Head and Sutton 1985, 96)

Children's Science

Theoretical Considerations

Both the tenacity of prior conceptions and their inhibitory effect is particularly evident in science education where children's prior intuitive knowledge is a much greater obstacle than in most subjects.

> In general, studies of text comprehension indicate the facilitative effect of schemata or a person's world knowledge. However, studies of science learning . . . indicate that world knowledge may be logically antagonistic to science content and may persist after science instruction. (Champagne, Gunstone, and Klopfer 1985, 66)

This naive or intuitive knowledge related to science has been called "children's science" by Osborne and Freyberg. They state that it is characterized by the following: (1985,12)

1. It is developed informally by children as they interact with the world and develop meanings for words related to science and views of the world which relate to scientific ideas.

2. Ideas of children's science are often strongly held and are often significantly different than the views of scientists.

3. These intuitive ideas are both sensible and coherent from the children's point of view and may remain uninfluenced or can be influenced in unanticipated ways by science teaching.

Why is children's science so different than scientists' science? Schollum and Osborne (1985) cite four reasons:

1. Young children are limited in their ability to reason abstractly.
2. Children do not demand that scientific theories be comprehensive, testable (capable of being disproved), or consistent.
3. Children's thinking is necessarily limited by their level of maturity, use of language, experiences, and knowledge of others' ideas and experiences.
4. Children are unlikely to interact with persons with a scientific perspective outside of school.

To these four reasons I would add a more general fifth one, namely that scientific theories are often counter-intuitive.

Unfortunately, to understand science education (especially in the elementary school), it is not sufficient to consider only children's science and scientists' science. One also has to at least consider what Gilbert, Watts, and Osborne (1985) call "curricular science," "teacher science," and "student science." In their view, as shown in Figure 4 on the next page, only a portion of scientists' science (S_{sc}) is chosen to be curricular science (S_{cr}) when the curriculum is planned. The prior scientific understanding of the teacher and her transformation of curricular science (S_{cr}) into lesson plans constitute teacher science (S_t). Through her teaching and the classroom activities, in which students engage themselves, their children's science (S_{ch}) is transformed into student science (S_{st}). Ideally, student science (S_{st}) will be at least equivalent to curricular science (S_{cr}), if not even closer to scientist's science (S_{sc}).

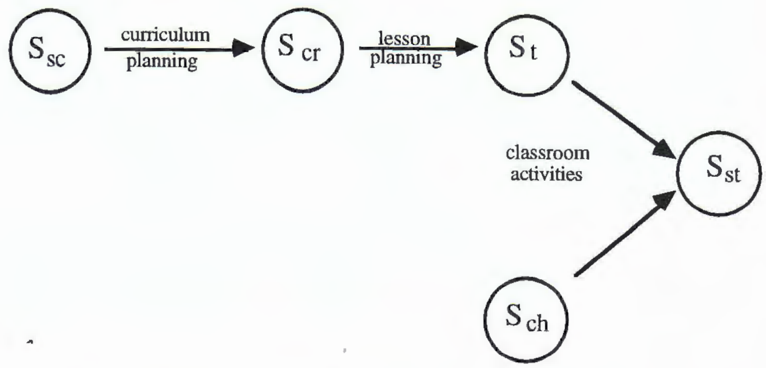


Figure 4. Transformations of scientific knowledge
Source: Taken from Gilbert, Watts, and Osborne 1985, 12).

Naive Biology and Ecological Misconceptions

While most research into children's science has looked at their conceptual views related to physics, there has been some related to naive theories of biology and particularly to ecological alternative conceptions that children have. Hatano and Iganaki (1994) state that one aspect of young children's naive biology is that they use modified personification to infer information about living things. They also imply that children have generally changed these views by the age of ten. However, it's possible that some aspects of these views persist as has been shown for other aspects of children's science.

This tendency to personify all living things would partially account for the great difficulty that teaching photosynthesis presents to teachers. (Smith and Anderson 1984; Roth 1984; and my own observations, referred to in a later chapter) Children continue to personify plants, at least in part, and thus, interpret the plants' intake of minerals and water by their root systems as similar to the children's own intake of food. This interpretation is, of course, in conflict with the scientific explanation that plants produce their own food through photosynthesis. [Plants use sunlight and chlorophyll to chemically convert water and carbon dioxide to produce their own food, glucose, and the byproduct, oxygen.] Even

Lawson (1988), who attempts to dismiss the need for extensive "conceptual change teaching" in the biological sciences (based upon a very small interview sample), notes that his interviews indicated that children had a naive theory of photosynthesis.

The belief that plants consume their food through their roots is not the only biological alternative conception that teachers confront. Although there have been relatively few studies of alternative conceptions in the field of ecology, some major ones in that field have been identified through research. Munson (1994) identifies some of the other topics in which alternative conceptions are found and briefly discusses them:

Food chains and food webs (p. 31):

1. The most basic misconception is that food/energy relationships are interpreted as simple food chains, instead of as complex webs.

2. Other misconceptions are that organisms that are higher in a food web:
   (a) eat everything that is lower in the web
   (b) have larger populations

3. Another misconception is that the top of a food chain has the most energy because energy accumulates up the chain.

In contrast, the scientific conception of food chains/webs is:

1. Food/energy relationships must be viewed as a complex web linking all organisms within an ecosystem.

2. Organisms higher in a food web
   (a) feed on some of the organisms which are lower in the web
   (b) have smaller populations than organisms lower in the food web

3. Available energy decreases as one progresses up a food web.

Ecological adaptation and evolution (p. 32)

Misconceptions are found in understanding how hereditary traits develop, what is their nature, and how they are passed on. They include the following beliefs:

1. Traits are either developed by individual organisms in response to their needs or because they are a part of a grand plan.

2. Traits are properties of populations, not individuals.

3. Traits are "passed on by bigger, stronger organisms that replace the smaller weaker ones," rather than being determined by natural selection.

In contrast, the scientific conception of hereditary traits and how they are passed on to other generations is:

1. Traits occur randomly through genetic mutations.

2. Traits are properties of individuals and may vary within a population.

3. Some random traits are passed on through "natural selection." [These traits allow the individual to be more reproductively successful, i.e., the individuals pass on more of their traits (and these traits in particular) to future populations. Over time, the new trait becomes dominant.]

Carrying capacity (p. 32):

Misconceptions are:

1. "Populations exist in states of either constant growth or decline depending on their position in a food chain."

2. Some ecosystems are seen as being limitless resources, allowing for limitless growth.

In contrast, the scientific conception of carrying capacity is:

1. Populations are in a "state of dynamic equilibrium, i.e., population numbers may fluctuate but only "around an average population size."

Ecosystems (p. 33):

Misconceptions are:

1. Varying a population in an ecosystem will only affect those organisms which are directly connected through a food chain.

2. Some populations are not important; therefore, varying them will not affect an ecosystem.

3. Varying the population of an organism affects the populations of all other organisms in the ecosystem to the same degree

In contrast, the scientific conception of an ecosystem is:

1. Varying the population of any organism affects the entire ecosystem.

2. Varying the population of an organism within an ecosystem affects other populations to varying degrees.

Niche (p. 33):

Misconceptions are:

1. "The needs and roles of species in an ecosystem are general and typical of similar species," not unique to that species.
2. "Species coexist in an ecosystem because of their compatible needs and behaviors," rather than interacting in "dynamic ways."

In contrast, the scientific conception of niche is:

1. Each species has a unique role in an ecosystem, both in terms of its needs and its effects.

2. While species may each have unique roles, they may interact in dynamic ways.

These five topics are, of course, some of the key concepts that students must understand if they are to have an understanding of ecology. We can see that, as is readily apparent from looking at the above list, many of these alternative conceptions are tied to children's conceptions of food chains. Since at least some of these studies, if not most of them, were done with students who are in high school or older, it can also be seen that "children's science" does not only consist of ideas held by younger children, but may also include those of older children and even adults.

In accordance with conceptual change theory, Munson (1994) emphasizes that if we want to teach these ecological concepts to children and/or hope to have them learn them in high school, we will need to examine the preconceptions (alternative conceptions) that they already have and convince them that these are inadequate ideas. Thus, if we hope to eliminate these alternative conceptions in older children and even adults, it would seem prudent to at least lay the groundwork for conceptual change in elementary school, the years in which most of these alternative conceptions are formed.

This, indeed, is the argument that Gallegos, Jerezano, and Flores (1994) make in discussing their research on elementary students' understanding of food chains. They looked at the students' preconceptions about food chains and webs, which had been found in high school, and decided that since predator-prey relations were the principal determinant of student constructions of food chains, they needed to determine what caused these

They designed a study to identify what were children's operative preconceptions. The results of their study pointed to two basic alternative conceptions: (p. 268)

1. Animals are carnivorous if they are big and ferocious.
2. Animals are herbivorous if they are passive, or, frequently, smaller than the carnivorous animals.

They concluded that it is from these perceptions and their knowledge of animal feeding habits, that children select higher level predators and construct their food chains. The basic predator-prey relation is the only link used, and there is a non-existent producer concept. [In the study directionality of the food chain was often incorrect, indicating a lack of understanding of the role of plants as producers which comprise the first level of the chain. In addition, the introduction of a vulture into a schema caused confusion because children were only basing their food chain on predator-prey relations, and not taking into account the role of decomposers.]

If, as we have previously stated, preconceptions are often developed and based upon one's experiences, we can easily see how and why these conceptions developed. Human beings watched carnivorous animals devouring others, and learned which ones (the largest and most ferocious) to fear as threats to themselves. On the other hand, many herbivorous animals they saw were often passive and attacked and eaten by larger animals. Today, even if most children do not have direct experience with large carnivorous animals, they often see these on television or in books. Similarly, they see these animals attacking smaller herbivorous ones.

As a result of this study Gallegos, Jerezano, and Flores conclude:

> Food chains must be taught not as a simple set of isolated organisms, but as an interactive population embedded in an ecological context. The plant must be seen as the transformer of solar energy into a chemical that is stored in the compound links the plant produces. In this manner the flow of energy through food chain members would be understood, as would the role of the plant as producer and beginner of the food chain. It is important to describe the different trophic levels of consumers, which are their relations in the communities, and to confront this point of view with the children's perceptions of size and ferocity. It must be pointed out that organisms live

> in communities made of many populations in which many food chains and food webs exist. (1994, 268)

In my chapter on evaluation I will analyze several of my lessons in light of conceptual change theory. I will return to these findings by Gallegos, Jerezano, and Flores and other findings as I look in depth at the successes and/or failures of some of my lessons.

Critical and Creative Thinking in Science Education

In teaching science, as opposed to teaching subjects such as social studies that can be more readily seen to be multilogical, one is faced with a different problem in trying to encourage students to use critical and creative thinking skills. After all, much of science does not appear to be multilogical (at least on an elementary level). It is difficult to have children adopt opposing viewpoints. Nor can one expect elementary students to come up with overly creative insights (with respect to "accepted" scientific understanding). One way of addressing this problem is by changing scientific education from "one that embraces scientists' 'ways of knowing' as the dominant objective toward one that favors 'positioning the learner for the next step'." (Duschl and Gitomer 1991, 840) Gardner puts it this way:

> Education is an opportunity for individuals to invent knowledge on their own to a significant extent, to transform what has been encountered in the past, and perhaps eventually to contribute new ideas and concepts to the collective wisdom. (Gardner 1991, 120)

Whereas there is only a remote possibility that students will actually develop new scientifically-accepted ideas, they can learn what has already been learned, as if it were new, if the method of instruction permits them to construct their own knowledge. This, indeed, is where creativity can be found in the science classroom, for as students incorporate what they have learned from different types of investigations with what they already know, they will truly be creating their own knowledge. We can also see that with guidance from their teachers this method of inquiry will best enable them to confront their own prior alternative conceptions.

One can also view science not as an abstract form of knowledge, but as the intersection of conflicting ideas as to how our world functions. By approaching environmental education from an ecological viewpoint, that is indeed what I attempted to do, for ecology is the study of organisms (including human beings) and how they interact with their environment. Since there are many choices and conflicts present and different viewpoints emphasize different aspects of science and different interpretations of "objective" data, the possibility of multilogical reasoning is made more salient.[1]

CHAPTER 6

DEVELOPMENT AND IMPLEMENTATION OF MY PROGRAM

My Goals as a Peace Corps Volunteer

What were my specific goals as a Peace Corps volunteer in environmental education as they related to my work in the school system? I started with three basic ones, and later added a fourth. My three original goals were: (1) to teach environmental principles to students; (2) to share teaching ideas, strategies and techniques with teachers; and (3) to help empower my students to make their own decisions with regard to the environment, and to a lesser degree to help empower the teachers with whom I worked to decide what and how they teach. I would like to examine these three goals, before explaining the fourth, which is, in some sense, an extension of all three.

I knew, as a foreigner, I could not hope to understand all of the environmental factors of that area -- the tremendous number of types of organisms, the relationships between them, the roles each played in their respective ecosystems, nor their relative importance. Nor could I hope to fully understand the complexities and consequences of different types of land use -- economic, environmental, social, or political.

What I could do, and indeed what I did try to do, was to share my understanding of ecological principles with my students. I also encouraged them to adapt these principles to the specific conditions of their towns. My goal was that in so doing and by means of their own observations, investigations, and examinations, they would use these principles to help construct their own understanding of their environments, the problems faced by them, and the effects, good and bad, of possible solutions to these problems.

Likewise, with teachers my goal was to share ideas, principally with respect to teaching strategies and techniques, as I assumed they had an ecological understanding equivalent, or nearly so, to my own. I hoped, both through example and discussion, we could develop better ways to communicate ideas and encourage critical and creative thinking in the students. My goal was, in so doing, they might in the future move away from a style of teaching based primarily on rote memorization to one that embraces questioning and discussion and examines issues in a multilogical way.

My third goal was not originally stated by me, although it clearly was in the back of my mind. It was the empowerment of my students, and to a lesser degree, the teachers of the area. However, as I developed my program and conducted classes, I emphasized this goal more and more, both verbally and within the context of my lesson plans. As the issue of sustainable development came more and more to the fore in political discussion within the country, so too did this goal increase in its expressed importance. It could also be said that this goal of empowerment led me to my fourth goal.

This goal was to partially redesign and write up my program of studies to leave with the teachers with whom I had worked. The program as redesigned is intended primarily for sixth grade. It is designed to provide teachers with a conceptual schema to incorporate and review the major ecological principles which students of sixth grade need to understand (and which are tested in a district-wide exam) to graduate from *escuela*. Secondly, and perhaps more importantly, it is designed to teach and/or encourage in sixth grade students some of the process and thinking skills which will be required of them in *colegio*, and later in the future as citizens.

As stated above, the program in Appendices 1 and 2 is a redesign of the program I carried out in Puriscal, which I wrote before leaving Costa Rica. It contains some unchanged lessons, some modified ones, and some that I did not use myself, but wrote after I had finished teaching. Therefore, in discussing my program I will at times refer to activities I did and the responses of my students; at other times I will refer to the actions teachers might take and possible expected responses from their students. I will try to differentiate these activities within this chapter, and I trust therefore my change in focus and often in tense will be understood. Finally, I will refer to the lessons by name and number. The full written content of each lesson may be found in English in Appendix 1, or in its original Spanish in Appendix 2.

First Teaching Experiences

When I arrived in Puriscal, although I was nominally under the supervision of the regional education department, my job was actually to help coordinate (with MIRENEM, the Ministry of Natural Resources, Energy, and Mines), the elementary school environmental education program of the Picagres River Watershed Project. I quickly discovered my partner, Roger Delgado of MIRENEM, although knowledgeable, was not a teacher, and thus, I took over the teaching role.

With Roger, I started teaching late in the school year in five schools. My first classes were spent trying to introduce some ecological concepts, using information they had previously "learned," and trying to connect these concepts. With older students (5th and 6th grades) I used the web of life game (See lesson 14) to introduce the concepts of ecosystems and food chains. In this game the students represent different parts of an ecosystem to physically demonstrate by means of a string the web of interconnections that exist within that ecosystem. I also attempted to demonstrate what occurs during photosynthesis by having the children enact the recombination of water and carbon dioxide to form glucose and oxygen (See Lesson 4). I discussed with children the importance of photosynthesis as the basis of almost all food chains on earth. In my discussions, I used a questioning technique -- asking the students questions about their understanding of their local environment to establish the concepts I was teaching. For example, in our discussion of photosynthesis I began by asking students what were some major uses of plants. After soliciting the answer "food," I then asked them what were the necessities of plants to introduce the components that would be used in photosynthesis.

I designed a crossword puzzle and first taught the lessons which I have since revised into "Farm for Sale" and "A Community Seeking Employment" (See Appendix 6 and lesson plans 19 and 20). In Farm for Sale (19) students are formed into groups, and then each group makes decisions on how to utilize a given piece of degraded pastureland they have just purchased in both an economically-productive and ecologically-sensitive way. Similarly, in my lesson, A Community Seeking Employment (20), students again are formed into groups, but this time the problem which is presented to them is to increase employment in a specified imaginary community. In prior discussion the class has proposed several solutions. The task of each group is to examine one of these proposed solutions; state how they might implement it; analyze problems (environmental and/or social) it might cause; and suggest ways to ameliorate those problems.

I also began to introduce seemingly facile questions to examine critically the students' generally non-critical and often biased responses. For example, in some classes I would begin a discussion with the question "Is it okay to cut trees in a forest?" The purpose of this question is not to merely state forests should be preserved, but to examine the students' non-critical responses, and delve into the reasoning behind them and why that sort of non-critical reasoning is inadequate in addressing the problems of society. [In Costa Rica today, the educational system has emphasized the importance of conserving forests to such a degree that most students will automatically say "No" to this question]. I asked students to identify and evaluate the reasons for their response to this question, and then challenged it by pointing out opposing views and/or its inadequacy in addressing human needs. In this way, I led the students to understand that this "pro conservationist" response is a naive one and no more an example of critical thinking than the former urge on

Since during my initial visit to Puriscal Roger had taken me to other schools in the area and introduced me, I decided to follow up on these prior introductions. I went to a number of these schools, reintroduced myself to the teachers and principals and offered my services. I began first informal, and then formal classes, as I became better acquainted with the teachers. By the end of the school year (December) I was teaching in eleven different schools each week (and sometimes more than one class in a school). I had become familiar with the students and teachers and had gained both the enthusiasm of the students and the trust of many teachers and principals in a number of different schools. When school ended, I was looking forward to beginning in these schools the next year.

Strategy -- Build an Ecological Framework

As I approached the next year, I knew if I were to teach one class per week -- to take on that responsibility -- I could not just teach disconnected lessons from a source such as Ambiente en Acción (a book of lessons in environmental education written by previous Peace Corps volunteers and staff). Instead I needed to teach environmental principles in a connected way -- to help the students construct a conceptual framework within which they could construct their own knowledge. The broad framework I chose was ecology.

The problem I faced was how to transform the general principals of biology and environmental education in the school curriculum into a program of studies which encouraged the students through active investigation and participation to better understand and improve their own environment. I had seen that students in Costa Rica had a general concept of the biological importance of Costa Rica. However, I sensed that this consciousness, as is much of school learning, was divorced from their daily experience. What I needed to do was to relate this broad environmental consciousness to their knowledge and understanding of the place in which they lived. Using their local

1. Students can investigate their own environment more easily, which allows for active participation.

2. The ability to learn is enhanced through active participation.

3. It is easier to understand ecological principles if they are connected to students' previous knowledge.

4. The students' understanding of their local environment was greater than mine. Thus, they would be more likely to construct meaning together with me rather than just accept what I said, since the students would more easily accept my role as facilitator (and not as "expert").

My Role as I Perceived It

In teaching and designing my lessons and program of studies I had two basic objectives: First, I needed to involve my students in their own learning. Second, I needed to show respect for and acknowledge their experience and popular knowledge as having validity, and use them as the basis for their further learning. I could not assume my "expert" knowledge was superior to theirs.

By themselves these two objectives were not sufficient, however, for in designing my lessons my goal was not only to engage the students in active learning, but also to help them to realize they could and should make decisions about their own future, specifically with respect to their environment. To do this, I not only needed to validate their cultural experience and knowledge and their ability to conduct further investigations, I also had to present to them different perspectives on the use/abuse of nature, and help them to understand the basis for these conflicting ideas on how to utilize natural resources. As Freire says:

> The education of human beings should never be restricted to a true intellectual training that limits itself to merely exposing students to . . . a pedagogy of conflict — as if all existed on an equal basis — without creating conditions that will enable students to understand the nature of the ideologies that created the conflicts in the first place. (Freire and Macedo 1995, 389)

For example, although I only specifically devoted one lesson (Lesson 20) to *desarollo sostenible*, the idea was contained within many of the questions and discussions I had with my students. As we examined the environment, we looked at it not in isolation, but in relation to them. We examined various actions as they impacted on people, as well as on the rest of the natural world. In doing so, my goal and "ethical duty" (in Freire's words) was to challenge my students "to critically engage with their world so they can act upon it and on it." (Freire and Macedo, 1995, 391)

However, my program of studies was not only designed for the children who attended the schools; I also designed it for the teachers with whom I worked, as well as for others who might find it useful. Thus, it's important to look at my role vis à vis other teachers as well. Again, I tried not to impose my ideas on them, but rather to create conditions (i.e., a program of studies) within which they could engage issues critically and creatively. Although my lessons often give very detailed steps as to how to present ideas, in my introduction I point out these ideas are mine and they should feel free to adopt and/or modify any as they choose. I have also suggested in many lessons additional ideas which they might pursue and/or from which to make other lessons.

In writing this program of studies my purpose was not to create a defined curriculum, but to suggest a method of approach (an ecological one) for teaching environmental education, and ideas which they could develop using their own critical and creative thinking abilities. Since a great amount of dialogue is involved in every lesson, teachers can to a large degree make the program their own, if they approach it critically.

Teaching

The nature of teaching is two-fold. There is the role/planning/ performance of the teacher and the role/reaction/performance of the student(s). Indeed, the two parts of teaching are reciprocal -- each either reinforces or weakens the quality of the other. Of necessity therefore, the principles of creativity and critical thought should be applied and used in both. As a teacher it was incumbent upon me to not only employ these principles in my own investigation, planning, and conduct of a lesson, but also to create (i.e., to make possible) the conditions for my students to engage in critical and creative thought themselves.

Preparation and Investigations

Every teacher must engage in two kinds of preparation: (1) her own examination and appropriation of the material to be taught and (2) preparation of lesson plans to help her students learn that material. Normally, the teacher's learning process extends over a long period of time as she continually adds to her knowledge and modifies her understanding. In my case, as for any foreign "expert," this learning process was different -- I was taught in a very short amount of time a great deal of country-specific knowledge, which I then had to incorporate within my broader conceptual knowledge of the environment. In my prior preparation and study (see chapter 1), I had made a broad socio-historical analysis of Costa Rica, and examined its political and economic background and its effect on environmental policies. I now tried to further incorporate within that broad analysis my own observations and understanding of local issues, i.e., how those policies affected daily life in Puriscal and vice versa.

What were the specific dispositions and/or methods and techniques of critical and creative thinking which I utilized in my own learning and for planning and implementing my lessons? Whereas my prior investigations had been mostly conducted through reading critically, now I needed to use many other critical and creative thinking skills: listening and communicating through dialogue, assuming others' viewpoints, analyzing, synthesizing, and evaluating. Likewise my dispositions were also indicative of critical and creative thinking: open-mindedness, empathy, a questioning attitude, and the willingness to confront my own learned attitudes and habits. I needed to recognize that my understanding of issues had been formed by my own socio-cultural conditions. However, if I was to help my students develop a deeper understanding of those same issues, we would have to

I knew if I was to teach children better ways to utilize natural resources, I needed to have a much better understanding of the environment in which they lived. I talked with and questioned technical experts about various erosion control techniques and the relative advantages of different types of trees in reforestation programs. I visited demonstration projects to see how these techniques were implemented and actively participated in both planting trees and clearing weeds and brush around already-planted trees to obtain a first-hand knowledge of the extent of manual labor necessary for successful reforestation programs.

I also spoke with "non-experts." I discussed with farmers their crop rotations and the relative benefits of planting coffee, tobacco, and sugar cane, both in terms of land use and economic costs, as well as economic benefits, the market for the products, and the stability or lack thereof of prices. I visited and spoke with workers in *trapiches* (small sugar processing facilities similar in purpose to the sugar shacks of New England) to understand why they needed to burn rubber tires in addition to the sugar cane husks. I also spoke with managers of new, more efficient *trapiches* to learn how their efficiency obviated the need to use rubber tires to maintain the heat necessary to process the sugar. I spoke with fruit growers and others about their use of pesticides both to kill insects that damaged fruits, and also to control the damages to the trees wrought by leaf-cutting ants. Finally, I also discussed with various teachers the different characteristics (economic and social) of the communities in which they taught, communities which I might be in only once per week, so I could adapt my lessons better to their specific conditions. Again, I could not, and did not, assume (as a foreign "expert") that my understanding was better, but neither did I assume that the Costa Rican expert was the only source I should and could learn from.

I also observed the environment (systematically and non-systematically). I kept a journal of my nature observations when I asked my students to do the same, and continued this journal for the entire time I was in Costa Rica. I observed the symbiotic relationship of ants and acacia trees and noted (with pain) how effectively the biting ants protected their host trees. I noted how quickly (within days) leaf-cutting ants stripped the ornamental trees outside of my house and experimented with recommended environmentally benign repellents, as well as some of my own design. In doing so, I became aware of their inadequacies, and understood why the people of my village continued to use strong pesticides against these ants. These, of course, were only a few of the observations which I made, but they show how my curiosity served to further prepare me for my job. I investigated new questions that arose in my mind -- through further observations, or when these were insufficient, through books or further questioning of others.

Design of Lessons

As I developed my understanding of environmental issues in Puriscal, I was faced with the challenge of how to develop lesson plans that would help my students further their own understanding of these issues. The lessons had to be creative to some degree if they were to engage the students in active inquiry. Equally, they had to be designed to challenge my students to think critically. Although most of the lesson plans in my program of studies were my own creation, some were adaptations of others' ideas, e.g., the lessons on senses (B), the tree (5A), ecosystems (14), soil conservation (16), and pesticides (17).

Even when a lesson may have been designed in a lecture-format manner to accommodate the lack of textual resources (e.g., the Geology of Costa Rica [10A]), I include a way for the students to learn through active participation and challenge them to think critically. I suggest a way in which the students may simulate with their hands the effects of subduction and orogeny (the building up of mountains due to pressure generated when one plate moves under another one), or the way in which pressures on faults in the Earth can produce tremors, or in more extreme cases, earthquakes. During the teacher's presentation of the lecture portion of the lesson she depicts in a drawing on the blackboard the gradual and more abrupt changes that formed Costa Rica. Starting with the first formations of islands between two large land masses, she shows how these first became an archipelago, and then an isthmus connecting North and South America. She then shows how this isthmus was both enlarged and radically changed by the emergence of the central volcanic mountain ranges, before erosion created the coastal plains and Costa Rica basically assumed its present form.

Having visually depicted these changes and having reconstructed the geologic history of Costa Rica, the teacher can now engage the students in critical thinking. She leads a discussion that seeks to answer how this formation affected and explains the present biological diversity of Costa Rica. This question calls upon the students to critically examine how geological processes contribute to the creation of different types of environments. It also enables the teacher to introduce factors that contribute to speciation, and further information concerning the biodiversity of Costa Rica. For example, she can tell them that in Costa Rica species from both the Northern and Southern Hemisphere are present. She can also explain that Atlantic and Pacific life forms (both on land and sea) are different, and how these life forms have separated into different species due to the geographic isolation caused by the creation of the land bridge and the rise of the central mountain ranges.

<u>Ecological framework</u>. The lessons were designed within the broad framework of ecology. Each lesson is directly related to the last. I began the program of studies with a look at the biodiversity of Costa Rica, before breaking it down into its general components -- climate, habitat, living, and non-living things. I then reconstructed the Costa Rican natural world (*La naturaleza*) using these components -- first breaking them down further into microclimates, microhabitats, niche, animals, plants, water, oxygen, carbon dioxide, nitrogen, rocks, and soil, and then showing their interrelationships and how they combine

to form ecosystems. Finally, I designed additional lessons to examine ways in which human beings can and do affect their environment, both positively and negatively.

One of the tenets of ecology is that it is equally, if not more important, to learn about and understand the relationships between organisms as it is to learn about the organisms themselves. By taking as the focus of my lessons the relationships between organisms, I avoided the problem of teaching isolated facts, and thus made it cognitively easier for my students to incorporate their new learning. Topics were introduced by beginning with their ecological role, rather than simply their structure and/or characteristics as entities or units in science.

For example, the lessons on microhabitat (3) and habitat (4) were used to introduce "animals," but the basis of these lessons was not the animals themselves but an examination of animals' necessities, how they fulfill them, and how they affect other organisms. In Microclimates and Microhabitats (3) the children record where around their school (and, for their homework, around their house) different animals can be found, i.e., the different microhabitats of organisms. In the next lesson, Habitat, Niche, and the Necessities of Living Things (4), the information gathered by the children is used to conceptualize a species' "habitat" (the sum-total of a species' microhabitats, in which they can obtain and fulfill all their necessities). Individual animals are then discussed, their necessities examined, how these are fulfilled, and what are the effects on the rest of the environment of their actions. Through examination of these effects, a critical understanding of the importance of each animal within its environment is obtained, and the children derive a conceptual understanding of ecological niche (the specific role an organism plays in a particular ecosystem [its environment]) before it is defined.

In other lessons the ecological relationships were made more explicit. The lesson on rocks (10) discusses not only their formation, but also how they break down to form different types of soil, while the lesson on soil (11), especially the homework, involves the children in examining and investigating the relative quality of different types of soil in the cultivation of crops. The lesson on food chains and webs (6) is based upon an examination of the ways in which organisms satisfy their nutritional needs, often at the expense of others, and of how, through satisfying their nutritional needs, energy is transferred from one organism to the next. Again, different types of relationships between organisms within populations and communities are the basis of the respective lessons on ecology (12 & 13).

Background knowledge. In each lesson the specific environmental conditions of Puriscal[2] served as our reference point for discussion, investigation, analysis, and further investigation of the interrelationships that exist in *La naturaleza*. In constantly relating my lessons to their environment, I made extensive use of my students' background knowledge. This was not only for practical reasons (there were few books or other reference materials), but also for conceptual ones. It was easier to construct and/or restructure or reconstruct their conceptual understanding if it was based on their background knowledge. When I did not use it as the basis for a lesson (e.g., the lessons, *Tortuga Verde* [D] and Observation [A]), it was to try to create a "neutral" approach to a subject.

In most lessons the students' background knowledge is analyzed as a prelude to either new observations being made and/or concepts being introduced and formed. These are then synthesized -- integrating new understanding with existing knowledge. For example, the concept of species and the importance of biodiversity are derived from the students' initial understanding. Similarly, the conceptual schema of ecological relationships derives from the categorization of those relationships with which students are familiar. I also attempted to derive the concept of photosynthesis by first beginning with the students' basic understanding of the necessity of plants for water, although this was less successful for reasons I will discuss in the next chapter.

More rarely the students' background knowledge is analyzed solely to establish a common or basic understanding before going further in the lesson. Examples of this can be seen in both the lessons on water and air, which begin with a discussion of their uses to establish in everybody's mind the multiple ways in which we are dependent on each.

However, at times the students are called upon to evaluate their prior understandings, as occurs in the discussions following each group's proposed solution as to how best to utilize the land in the lesson, Farm for Sale (19). Sometimes, this evaluation brings into question existing ways of thinking and reveals how and why they are in error. The students are then led to a new and more advanced conceptual understanding. By so doing, i.e., having the students discover errors in their prior understanding, it is more likely that the new understanding will take precedence. This type of questioning and reconceptualization is especially evident in Lesson 4 (Habitat, Niche, and the Necessities of Living Things). In this lesson students' antipathies toward "destructive" organisms, such as snakes and leaf-cutting ants, are challenged by looking at their importance ecologically. Students are led to a more critical understanding of the role of these organisms, both positive and negative, and encouraged to explore similar issues from various perspectives.

Active and Local

In creating my program I knew it was important to encourage student participation. Most lessons and/or homework were designed to engage the students in active investigation of their environment. In most investigations, choice is given to the students as to whether or not to perform these in groups, and the make-up of each group (although I did limit the number in each group). An added plus of using the students' own environment for investigations and activities is that, if students engage themselves in their work, success is virtually guaranteed. As a teacher, I tried never to ask students to do something they could not do. [For example, to require them to make a report on the fauna and flora of Europe would require resources to which they did not, and in all likelihood could not, have access.] I believe this orientation toward success of my classes was one of the ways in which my students were not only kept interested, but also challenged to undertake further investigations.

Creating enthusiasm -- games and role-takings. It was important that I create a motivating atmosphere conducive to active learning and to critical and creative thinking. In this I was fortunate to be teaching in a relatively rural area, for I was often able to use the natural environment outside each school as a stimulus and as the site of many of our investigations.

In addition to maintaining interest and enthusiasm with many investigations outside the class, on occasion I used games to introduce concepts and/or had the children assume the roles of different entities. These games and role-takings are incorporated in several of the lessons in my program. In Plants (5), the children play the roles of the different carbon, oxygen, and hydrogen atoms, and physically act out what happens as carbon dioxide and water are combined to form glucose and oxygen. In The Tree (5A), the children act out the roles of the different parts of a tree, to emphasize both their functions and their interdependency. In Food Chains/Webs (6) some children initially represent the different parts of a food chain. By adding other children that might also receive sustenance from elements of this food chain, it quickly becomes visually apparent that food chains are in reality much more complex, more like webs.

This visual representation of the complexity of interrelationships in nature is made even more clear in the game used in Ecosystems (14). Each child represents one or more parts of an ecosystem, and a ball of string is tossed successively from child to child, as the child states the ecological relationship which exists between them. The ball of string is unraveled and a physical connection (the string) is established between each one and some

As the process continues, it soon becomes apparent that there exists a whole network of relationships within an ecosystem, and that these relationships may be of various, not just nutritional, types. Children can also observe that there are relations not only between living things, but also between them and non-living parts of the environment. Breathing and photosynthesis are the more obvious examples, but the game also shows the importance of other non-living things (e.g., protection given by rocks). Additionally, the teacher can use this game to indicate the relative importance of different parts of the ecosystem. It often becomes quickly apparent that human beings are generally less important in terms of the needs of other organisms. This observation and others can, of course, be explored further by the teacher if she wishes.

In my program of studies I also suggest role plays, puppet shows, and plays (some of which I myself had used) that can be used in conjunction with different lessons (e.g., Ecological Equilibrium [15], Pesticides [17], and Trash and Garbage [18]). The use of puppets and plays can be especially effective if older students prepare these to perform for younger ones or the whole school. By their non-threatening way of raising serious issues, they avoid defensiveness (e.g., the students' immediate denial that they litter). They also are very effective as a spur to an individual activity (e.g., a clean-up around the town) or a more prolonged campaign. Finally, they, and even more so role plays, as in Ecological Equilibrium (15), allow the students to express what may in fact be their opinions, but which they would never under ordinary circumstances express for fear of censure.

But role plays have a much more important function. They give students the "permission," as well as the <u>obligation</u>, to look at issues from different viewpoints and to argue their respective merits. By so doing, the students often come to the realization that each side may have valid viewpoints and a multilogical perspective is encouraged. Issues are no longer seen as "black and white," and the need to make reasoned judgments becomes apparent.

Another method I devised to arouse the interest of my students I call "open competition."[3] Although competition is generally not conducive to critical and creative thinking, I have found that if it is not tied to a tangible reward, and if the competition is seen as a game and not a "test," it can help to increase participation and interest. An "open competition" is similar to brainstorming in that the students are encouraged to make educated guesses, with a number of answers being initially accepted for each item. Where it differs, however, is that there is a correct (generally numeric) answer, and thus the competition does not seek divergent thinking on the part of the students. These answers are either withheld by the teacher until the end of the competition, or given after a number of different responses have been heard for each item, depending on the subject. The method allows for participation by all students and the excitement generated by the open guesses encourages all students to participate, especially since no score is kept.

My use of "open competition" does more, however, than just increase student participation and enthusiasm. By recording on the blackboard the students' numerical guesses and comparing them with the actual answers, the teacher can help them (as I did) to visually understand the degree of their prior alternative conceptions, and thus, lay the framework for reconceptualization of their ideas. In The Biodiversity of Costa Rica (1) the students are asked to guess the number of species of a type of living thing (e.g., mammals) that can be found in Costa Rica, after having first been given the total number of species of that type that exist in the world. In so doing, the students are led both to see the large number of species that exist in Costa Rica (they generally underestimate), and to appreciate the high proportion found in Costa Rica in comparison with the rest of the world. This new information is then used to construct the concept of biodiversity, and to determine that the biodiversity of Costa Rica is very high.

Similarly, in Lesson 18 (Trash and Garbage) by first having to guess the amount of time necessary for the total decomposition of various types of garbage and/or trash, the students are led to understand that trash lasts for a much longer time than they had previously thought. [In most of my classes, students' estimates, especially for inorganic trash, were much lower than actually occurs.] The seriousness of trash as a problem, not only for the present, but even more so in the future is thus made evident, as is the necessity of reducing its production. The comparison of figures also helps to establish clearly the ecological difference between garbage (organic material) and trash (generally non-organic material). This provides a basis for the following discussion on the relative benefits of different types of solutions, the 4 R's: refusal, reduction, reuse, and recycling.

On occasion, to further interest and participation, I also used group competitions. However, when I did I never gave tangible rewards, and even when giving praise to a group winner of a competition, I always announced second winners, third winners, and so on, to also give praise to others. Again, I found this was a successful strategy, especially if the competition was clearly seen as a game. Such a competition is used in my lesson on the senses, in which blindfolded students are asked to differentiate and/or match branches of different types of trees. Through this activity they understand the importance of also using non-visual senses in making observations about the world.

Since the tone of a class is often set at the beginning of the school year, I initially used an open competition in my first class to introduce the concept of biodiversity. Although it is still Lesson 1 in my curriculum, I have since decided it is more important to begin with the teaching of observation skills (A), which I now recommend be taught first.

Creating an Environment for Critical and Creative Thinking

Without discounting their importance, it was necessary to encourage more than active and enthusiastic participation. I needed to create an environment that was conducive to risk-taking and to critical and creative thinking. How did I do this? In general I was enthusiastic in class and participated in investigations inside and outside the class (e.g., sometimes, during recess while the children were playing, I would examine insects in various plants and share my observations with children who came over to watch). I even on occasion acted out scenarios. I tried to establish an environment accepting of mistakes by admitting errors I had made (not only in language usage) and joking together with my students about my poor pronunciation and my inability to sometimes understand what they were saying. I modeled my acceptance of effort over perfection by my crude drawings of animals, plants, and other things on the blackboard, and I often used word games -- sometimes to gain students' attention or introduce topics, other times to review concepts previously learned. Finally, I attempted to maintain an atmosphere conducive to the expression of humor to encourage more creative responses.

In my second year, I tried to introduce (more formally than I had the first year) my expectations of them, not only in terms of behavior, i.e., my rules, but also in terms of performance. I wanted to make "public" (Gitomer and Duschl 1995) the criteria which I valued. Thus, in my initial class, I discussed with them the question "How do we learn?" I represented some of the different ways in which one learns by using the first letter of the Spanish verbs to spell out the English words, HOP, SHOP, and LOP:

HOP --- *Hacer, Observar, Pensar* (Do, Observe, Think)

SHOP - *Sentir, Hacer, Observar, Pensar* (Sense, Do, Observe, Think)

LOP --- *Leer, Observar, Pensar* (Read, Observe, Think)

Through this initial discussion I emphasized that observation and thinking were the keys to learning. I tried to clearly emphasize that what I expected and wanted from them was their participation (*Hacer*), and that I wanted them to use their senses (*Sentir*), but most of all what I wanted was for them to observe (*Observar*) and think about (*Pensar*) their observations. I noted how sometimes we do something first, observe what occurs, and then, by thinking about it, learn from the experience (and that this is often the way babies learn). At other times, I said, we sense something, do something as a result of that

I pointed out this latter method of learning was often followed by scientists, sometimes repeatedly, as each new observation led scientists to think up new experiments.

I included LOP in my discussion to emphasize that sometimes we cannot learn directly, but can learn by reading. Nevertheless, even in such an indirect method of learning, we need to relate what we are reading to our own experience and prior understanding, and then think about it, if we hope to learn. I also included reading, but not other verbs (e.g., talking, and listening), because I wanted to emphasize the importance of reading to the children of that semi-rural society, where for most families reading is only practiced minimally, even in school.

Skills/Abilities/Dispositions

What were the specific dispositions, methods, and skills which I tried to develop and teach to my students and which I try to encourage and teach through my program of studies? To a large degree, they are the same ones that I myself had employed in my own preparation. The skills I want to instill are the abilities to observe critically, to listen and communicate through dialogue, to assume others' viewpoints, to analyze and evaluate critically, and to synthesize new ideas. Similarly, I want students to adopt certain dispositions: open-mindedness, empathy, a questioning attitude, and the willingness to confront their own learned attitudes and habits.

Just as I, as a teacher, had needed to understand that my attitudes and opinions had been formed by my own socio-cultural conditions, I also feel it is important that students understand the basis of their attitudes and opinions. With this understanding of their own biases they will then be better able to make reasoned judgments. Since skills and dispositions are often intertwined (e.g., open-mindedness and empathy are closely related to assumption of another's viewpoint and ultimately to the ability to make reasoned judgments), my lessons often combine them as well.

There are two ways in which critical and creative thinking skills can be taught to students and corresponding dispositions encouraged. First, by designing lessons which are specifically focused on one or, at the most, two different skills or dispositions, a classroom teacher can emphasize the importance of the skill(s) and then in subsequent lessons incorporate the skill(s) and/or disposition(s) into any subject matter. Second, in what Swartz (1987) calls a conceptual-fusion approach, the teacher designs the lesson to teach a particular subject concept, but incorporates the skill(s) and/or disposition(s) which she wants the students to learn or display. Given that my time in each class was limited to once per week, I generally followed the second approach, although in a few cases I did emphasize the skill and also designed lessons (A-D), which clearly emphasize the skill learned over the content. (See below). Since I had observed the relative lack of ability the students had in basic skills (observing, reading, doing interviews, and independent thinking), I both designed specific lessons to teach and practice these skills and tried to incorporate them as much as possible within my lessons.

I emphasized some of these skills and dispositions much more than others, as can readily be seen from the following discussion. For each skill or disposition I will briefly note the particular way it was presented in my lesson(s). Insofar as many of these skills and dispositions overlap, some of the examples cited below may of necessity also overlap to some degree.

<u>Observation</u>. One of the primary goals of my program of studies is to inculcate in students good habits of observation -- not only to observe well, but also to observe "objectively," i.e., to observe independently of their prior knowledge and/or conceptions. When I designed the program I knew that, in fact, this was impossible --observations can never be totally "objective" or completely independent of our conceptions. Nevertheless, before introducing the importance of directing our observations according to our purposes, in my program I wanted to try to begin with a more "objective" approach to clarify the

difference between observations and suppositions. I also emphasize that in her discussion of observation the teacher should stress that careful observation and recording of those observations is not only the basis of science, but should be one of the bases for decisions the students make in their lives, particularly as they relate to environmental issues.

I introduce the importance and technique of observation and recording one's observations accurately in the first lesson, and it is a central activity in many subsequent lessons. However, as I will briefly describe below, the purpose and manner in which the observation skills are employed change as the lessons progress. The students progress from simple observations of animal behavior, to incorporating new concepts into their observations, to using observation as a means of classification, and finally to interpreting and classifying the relationships that they can observe within an entire ecosystem. They also begin to understand the importance of observation in scientific experimentation. Since in all of these observations (even the simplest), they employ their background knowledge to describe what they observe, it is clear that observation can never be totally objective.

In the first lesson, Observation (A), I emphasize "what" we can observe and distinguish observation from supposition. The importance of recording observations is stressed and the homework assignment requires that students begin daily observations of an animal or group of animals (e.g., a wasp nest) and record their observations over a period of weeks. The teacher should review the daily observations on a regular basis to suggest ways to improve them (e.g., other things to note), and to assure that they are distinguishing their observations from suppositions. The emphasis of these observations is on noting the behaviors of organisms and the settings (place, time of day, and weather conditions) in which they occur.

In Lesson B (Senses), the importance of making non-visual observations (using our other senses) is emphasized by means of a group competition in tactile awareness. Students are reminded that these non-visual observations can also provide us with information, and that sometimes this information can only be gotten through our other senses. The students are further encouraged to use their other senses in their daily animal observations and to include them in their records.

Having conducted observations of a single animal or group of animals for several weeks, in the class activity and homework for Lesson 3 (Microclimates and Microhabitats), the children are then asked to broaden the scope of their observations. Instead of observing one animal, they observe various locations noting all the creatures found within each location. These observations are then used to help understand the meaning of the concept "habitat." In the following lesson, Lesson 4 (Habitat, Niche, and the Necessities of Living Things), concepts learned are applied to the students' observations in the homework assignment. They are now asked to interpret observations of an animal(s) according to their new understanding of animal necessities and their role in nature.

In both of the lessons, Rocks (10) and Soil (11), the students' observations are used to develop a basis for a classification schema. In Rocks (10) they are asked to classify rocks they have collected according to observable characteristics, such as color and texture; whereas in Soil (11) they are first asked to classify different samples of soil according to color, compactness, and moistness, and then to classify them according to their composition. Again, in the lessons on ecology (12 & 13) and on ecosystems (14), the students' observations are used to classify, only this time what is being classified are different types of relationships that exist within ecosystems, rather than their components.

Finally, in Lesson 16 (Soil Conservation) the students are asked to observe an experiment in which different methods of controlling erosion are tested and draw conclusions from it. The teacher should emphasize that this use of observation in the conduct and interpretation of scientific experiments is one of the chief uses of observation in science today.

Reading critically and interviewing to obtain information. I also wanted to help develop in students other methods of inquiry -- reading and interviewing. To improve their ability to read critically, I designed the lessons, *Guajipal* (C) and *Tortuga Verde* (D), to give them practice. In each lesson, the students are given an article about each type of animal, with a set of questions pertaining to the article. [*Guajipal* (C) describes, discusses, and compares caimans and crocodiles; whereas, *Tortuga Verde* (D) describes and discusses Green Turtles and their nesting habits in Tortuguero National Park.] Although some of the questions are relatively straightforward and merely require careful reading, others require that students use other skills related to critical thinking: analysis, interpretation, inference and the application of background knowledge. The lessons are designed so that the questions in *Guajipal* (C) begin the process of critical thinking on the part of the students. In *Tortuga Verde* (D), the questions are more difficult. There are also questions that require the students to use sound mathematical (i.e., logical) reasoning and to identify and interpret the author's bias.

Whereas in the above two lessons the information source is a description of animals of which the students have little practical knowledge, in Pesticides (17) the information sources that serve as the basis of the lesson are more practical. They are the etiquettes (labels on which is written safety and usage information) that are required by law to be pasted on every pesticide that is sold. Ideally, if the teacher obtains the sample etiquettes from a local store, these will also be etiquettes of pesticides used in the area. Likewise, the lesson is more practical -- to instruct students on where to find various types of information on etiquettes. This information could mean life or death in a case of poisoning or prevent lesser harm from occurring through improper use of the pesticide. In this case, the emphasis is necessarily on finding information and being able to interpret it, and much less on analysis, inference, or criticism.

Although it was important to improve students' reading skills and especially so that they learn how to read and interpret pesticide etiquettes, I knew their access to books and other written materials was limited. For this reason and because I also wanted them to realize the importance of "peasant understanding" with respect to local conditions and problems, I often encouraged them to conduct interviews with members of their community. These were assigned as homework for a number of different lessons.

In the lesson on biodiversity (1), the students are encouraged to interview members of the community to obtain general information. On other occasions these interviews are generally conducted to solicit specific information related to the interviewee's work, as is the case in the lessons on nitrogen (9), soil (11), soil conservation (16), and pesticides (17), in which the students are instructed to interview farmers to learn about specific farming practices and soil conditions. Sometimes this background knowledge is used as the basis of the next lesson; other times it is sought to enable the students to extend what they have learned in a particular lesson.

<u>Questioning attitudes, reasoned judgments, and investigations</u>. Another intent I had was to inculcate a questioning attitude, an important disposition for critical and creative thinking. In general I did this by modeling and by asking students to explain events and/or their observations, and to question accepted solutions and/or opinions. Although I probably used the words *"¿Por qué?"* (Why?) in every lesson, the lessons which most clearly demonstrate the questioning of accepted opinions are *Tortuga Verde* (D) and Ecological equilibrium (15). In *Tortuga Verde* (D), I questioned whether or not, given the tremendous number of eggs produced by Green Turtles, it was still necessary that the harvesting of their eggs be prohibited by law. Similarly, in the introduction to Ecological Equilibrium (15), I questioned whether or not there is in fact a balance of nature (ecological equilibrium).

As I have previously stated, some of my lesson plans specifically present issues as multilogical and call upon the students to assume others' viewpoints, to empathize with others' positions, and/or to make reasoned judgments. In both Farm for Sale (19) and A Community Seeking Employment (20), students are asked to justify and challenge proposals. That many issues are multilogical and necessitate that we make reasoned judgments is more obvious in *Tortuga Verde* (D) in which students are called upon to vote "for" or "against" a law which would eliminate the prohibition imposed against the harvesting of turtle eggs on Tortuguero Beach. The students are asked not only to weigh the effects on turtle populations, but also whether the law discriminates against residents of this area by denying them this means of a livelihood, which is not prohibited in other areas. In this way, they are led to empathize with those who have an "anti-environment" position and engage in multilogical reasoning. Similarly, arguments pro and con are presented by and to students during the mock trial of human beings, who have been accused with the destruction of nature, in the lesson, Ecological Equilibrium (15). Certain students, the judges, are then asked to make a reasoned judgment, after which the whole class discusses the "rightness" of the judgment.

<u>Application of learned concepts to different contexts</u>. I also hoped to develop in my students the abilities to investigate independently, and apply to other contexts what has been learned. In Biodiversity (1), I asked the students to investigate and explain the benefits to Costa Rica of biodiversity in a particular field or area. In Water (7), Air [CO_2-O_2] (8), and Trash and Garbage (18), they are asked to investigate, apply what they have learned, and respond to questions that respectively address themselves to: (1) global warming, (2) the proposed exchange of pollution credits by developed countries and their industries in return for planting trees in tropical undeveloped countries, and (3) the effects on Costa Rica of inaction in addressing its growing trash problem.

Divergent thinking. In Lesson 1, Biodiversity in Costa Rica, the children are asked, "What is the importance for Costa Rica of its high biodiversity?" This question encourages them to expand their understanding of biodiversity from one that views it solely as a total of different and interesting species to one that relates it to the quality of life of human beings in many different areas. The children's answers then serve as the basis for their homework assignment, enabling them to investigate these benefits further.

Similarly, in The Climate of Costa Rica (2) the first question asks the students "Why does Costa Rica have such a high biodiversity?" Again, the students are encouraged to think divergently. This time, however, only one answer is pursued, i.e., its climate. Nevertheless, the teacher acknowledges that the other answers are important, and may pursue them in future lessons.

Divergent thinking is also encouraged in two lessons I have previously discussed -- Farm for Sale (19) and A Community Seeking Employment (20). In these cases the students are asked to propose various solutions or plans to the problem presented, and the teacher should emphasize that there is no right answer. The students are then encouraged to pursue how these plans might be implemented and give their presentation to the class.

Perception and interpretation of bias. I have previously noted that the children are instructed to interpret the author's bias in *Tortuga Verde* (D). A more detailed examination of bias, and how important it is that the reader understand it, is given in Pesticides (17). In this lesson, the children come to realize that the information sheets for pesticides (advertisements distributed by the manufacturer which extol the product for a particular use), although generally much more readable and user-friendly than etiquettes, have as their main and almost sole purpose the selling of the product, and thus often omit information about the safety of the products. They learn that it is critically important that the etiquettes

Other critical and creative thinking skills. The skills and dispositions discussed above were the most important ones which I tried to incorporate within my lessons. I would now like to briefly state some other critical and creative thinking skills I emphasized in Chapter IV (the uses of dialogue and logical reasoning, and the ability to synthesize information to produce a unique communication), and give some examples in which I employed each of them.

Although in most lessons the teacher engages the children in discussion, the importance of dialogue is most evident in two lessons, Ecological Equilibrium (15) and A Community Seeking Employment (20). In both of these lessons students are asked to present positions clearly and argue for them, and later make decisions based upon a careful analysis of these arguments. The students are therefore required not only to argue their "own" viewpoint, but also to listen carefully as opposing viewpoints are argued.

I have already mentioned that logical reasoning is required by at least one of the questions in *Tortuga Verde* (D). In Ecological Equilibrium (15) this skill is further emphasized as the students are required to analyze the logic of arguments presented by both the plaintiffs and the defendants during a mock trial.

Finally, in both Trash and Garbage (18) and A Community Seeking Employment (20) the children are asked to synthesize what they have learned and produce a unique communication. In Trash and Garbage (18) this can take the form of either an essay or a story about the consequences of non-action on the problem of trash in the world. In A Community Seeking Employment (20) the product called for is a detailed plan for addressing the problem of employment in a particular area, which also cites its benefits and drawbacks, and how those drawbacks might be ameliorated.

Specific Lessons

I would now like to discuss in greater depth several of my lessons and how I taught them. My main purpose in discussing the first three lessons is to show how I tried to introduce important critical and creative thinking skills into these lessons and encourage dispositions essential to critical and creative thinking, while at the same time covering topics in the curriculum. I have also chosen these lessons because the skills and/or dispositions developed in each exemplify some of the important ideas of learning which I hold. Following that I would then like to examine one lesson, which I designed after I had finished teaching and was rewriting my program of studies. Although this lesson does not specifically address a part of the curriculum, of all my lessons it best introduces competing moral perspectives, which is a crucial element of critical thinking.

Microclimates, microhabitats, habitats, and niche. The first lesson (actually group of two lessons) which I want to analyze are Lesson 3 (Microclimates and Microhabitats) and Lesson 4 (Habitat, Niche, and the Necessities of Living Things). These two lessons together are a good example which shows how lessons can be designed such that students can construct their own knowledge and therein understand new concepts. My primary objective in designing these lessons was to provide a means for my students to understand two very basic but somewhat confusing ecological concepts -- the "habitat" and "niche" of living organisms. As mentioned earlier, my working definitions are:

habitat -- The habitat of an organism consists of the sum-total of all the places (microhabitats) which provide that organism with all the conditions that enable it to live.

niche -- The niche of an organism is the unique role it plays within its ecosystem and/or environment.

Through the lessons I devised I also sought to fulfill another objective -- to introduce my students to the way in which scientists observe animals and record their behavior, and in so doing learn about their role in nature.

To introduce the concept of microhabitat I approached it obliquely, i.e., I used the concept of climate, which we had already studied, and then broke that concept down into its constituent parts (microclimates). I then invited the students to brainstorm and name all the different places around the school where they could find different microclimates (e.g., under a rock, under the shade of a tree, in a sunny spot of grass, in the air, or beneath a leaf). After listing these on the blackboard, I said these were microhabitats and defined a microhabitat as "a place where one encounters a microclimate."

The students were then instructed to look outside around the school, find ten different animals, and write down in which type of microhabitat they were found. In this way I introduced living organisms into the lesson. Little background knowledge was needed to find animals, so success was virtually guaranteed (I helped if necessary). At the same time having the students record their observations, allowed me to introduce the basis of much of the scientific knowledge about the natural world -- careful observation and recording of those observations -- which the students would carry out throughout these two lessons.

By reviewing the children's observations and writing them on the blackboard, I helped to create a visual conceptual framework of the varied microhabitats found around the school and the different types of animals which could be found in each. The chart I created might have looked in part something like that reproduced below in Table 1:

Table 1. -- Animals found in various microhabitats (partial)

under a rock	sunny grass	beneath a leaf	shade of a tree
black ants	grasshopper	leaf-cutting ants	spider
worm	leaf-cutting ants	grasshopper	brown ants
centipede	spider	cricket	black ants
millipede	butterfly	butterfly	leaf-cutting ants
spider			sparrow

This framework would eventually lead to the conceptualization of the full meaning of the term "habitat" in the next lesson. Additionally, with this framework I modeled what

I expected of the children for their homework assignment, and once again success was guaranteed if students made the effort. The homework (making a similar list of microhabitats found around their house and the organisms encountered in each) not only served as a further introduction to scientific observation, but also provided information to be used for the next lesson. By beginning Lesson 4 with a discussion of their homework observations, I helped them to understand that many organisms live in many different microhabitats and that all of these together are defined as its habitat. In the example above, the habitat of grasshoppers would include both sunny grass and under leaves, as well as any other place in which they were found.

In my lesson I then used a given definition of habitat to introduce "all the conditions that enable it [an organism] to live," i. e., the necessities of living organisms, which I then solicited from my students. As I review this lesson today, I realize it would probably have been better if I had approached this differently. Rather than defining habitat, I should have first solicited from the students why they had found individuals of the same species in different microhabitats. From this discussion we could have then derived the different necessities of living beings, and from that point come up with our own definition of habitat.

I then reviewed with them the habitats of two very different animals, a jaguar and a centipede, to assure they understood the concept and to emphasize the relationship of an organism's habitat to its necessities. In this way I not only checked for comprehension, but assured that my students knew how to apply the concept "habitat."

As can be seen, the conceptualization of the term "habitat" was based upon the students' background knowledge, and their investigations. By beginning with their observations of microhabitats, it became clear to them that most animals can be found in different microhabitats. This then lead them to ask the question "why," and to understand that different microhabitats provide different necessities. From this understanding the further understanding of "habitat" follows. It should be noted that this construction of knowledge by the students did not require a large conceptual change for most, and thus, is an example of assimilation.

My next objective was that my students understand the importance of being able to analyze the different necessities of an organism -- what is its source of nutrition, how does it protect itself, what sort of territory or home does it require, how does it reproduce itself, and so on -- not only to determine its habitat requirements, but also to determine its role ("niche") in nature. I knew from past teaching experience that this concept was much more difficult to understand and that it would probably necessitate at least some change in former beliefs (accommodation). The difficulty of the concept "niche" is, I believe, due to two factors:

1. Many of the ecological roles that organisms have are not obvious, and sometimes seem counterintuitive (see discussion of leaf-cutting ants below).
2. Many behaviors of organisms and their importance are difficult to observe and/or know.

Therefore, to change these beliefs I knew I had to:

1. Challenge the adequacy of the beliefs held by the students with new information (or information they had not fully considered)
2. Present new ideas that would better satisfy the information they now possessed

I therefore used the example of a leaf-cutting ant and analyzed its requirements, how it protected itself, what was its habitat, and what ecological role it fulfills. My reason for choosing a leaf-cutting ant was two-fold:

1. It is very common and therefore was familiar to all my students.
2. It is generally despised by the populace because it destroys many ornamental and fruit trees.

By opposing my students' sociocentric belief in the destructiveness, and therefore "badness" of leaf-cutting ants, with the alternative perspective that they play a vital ecological role in decomposing leaves, fertilizing soil, and letting sunlight penetrate through trees to plants below, I was able to point out the importance of considering opposing viewpoints. Doing so also helped my students begin to conceptualize the "niche" (ecological role) of an organism.

The activity (choosing an animal and identifying its food, its method of self-protection, its habitat, and its niche) gave the students the opportunity to apply what they had conceptualized. Again, by reviewing the children's examples, I assured myself of the students' understanding of the concepts -- necessities, habitat, and niche. Each additional example helped to clarify the concept of "niche," as well as to juxtapose the ecological roles of different organisms (snakes, mice, and so forth) with common perceptions.

The concept of "niche" is not easily definable; however, through the use of a number of examples I believe it was understood by all. Fortunately, in Spanish it only has one meaning in ecology: the role which an organism plays in an ecosystem. In English it has two distinct ecological meanings! It can mean either the role an organism plays, as in Spanish, or the particular part of an ecosystem in which an organism can be found.

Finally, the homework assignment (to use their daily observations of a non-domestic animal to make a similar list of those things they can observe) again encourages the students to apply what they have learned about the necessities of organisms and how they fulfill them. It also introduces them further to the process of making scientific observations. In so doing, perhaps the most important thing the students learn from these two lessons is they <u>themselves</u> can make valid scientific observations of things that exist in their environment.

<u>Rocks</u>. The next lesson I would like to discuss in detail is Lesson 10 (Rocks). Again, although the objective of this lesson is to learn about the origins of different kinds of rocks and their uses in Costa Rica, on a more basic level the lesson was written to help the students understand what geologists do and how they obtain information -- to look primarily at the <u>process</u> of geology. Rather than solely present them with the ideas of

others, I wanted to have them understand, at least in part, how geologists arrive at those ideas.

Starting with the rocks I had asked the children to bring to class, I asked my students to state ways in which they might be classified. We discussed several of these to make sure that all students at least had a starting point. I then asked them to classify their rocks, using these and other criteria and make lists of their classification scheme(s). When they had finished, I told them that what they had done is essentially the initial process of geology -- the classification of rocks.

Having engaged them in the process of classification, I then asked them "WHY? -- What are the reasons these rocks have these different characteristics?" We then analyzed each of the characteristics which we had used to classify our rocks and decided which of the following was its principal cause -- the composition of the rock, its origin, or its "experience." Again, in doing this, I further emphasized the process and objective of geology -- to interpret the distant past by examining rocks -- their formations, composition, origins, and positions.

This was also a natural lead-in to a discussion of the various origins of rocks, which I then explained and illustrated by drawing the Rock Cycle. I gave examples of various types of rocks (igneous, sedimentary, and metamorphic), which are classified broadly according to their origin, and also explained some of the sub-classifications, that are made based on the different types of origins within each group.

In the following discussion, I indicated other ways the children might classify their rocks -- relative hardness and the presence and/or absence of calcium carbonate (which is indicated by reaction with an acid [e.g., lemon juice]) -- and gave them ideas for future investigations they might make on their own. Although I tried the latter in several classes with some rocks they had collected, there was no reaction. Since, in general, there was to my knowledge little or no limestone in the area, and since I did not possess any limestone or marble, I discontinued this demonstration in other classes.

Finally, I connected the lesson to the framework we had been making, and I introduced the uses of rocks, i. e., their ecological role. It was important that I point out that a person's use of rocks to form a house was ecologically similar to an animal's use of a rock cave as a shelter. This helped them to understand the importance of analyzing occurrences from different viewpoints. I also made certain that my students understood that soil was formed through the gradual breaking down of rocks, thus, establishing the connection to our next topic, soil.

Air [Carbon dioxide - Oxygen]. The next lesson I would like to discuss is my first lesson on non-living things -- Lesson 8 (Air [Carbon dioxide - Oxygen]). I use this discussion to illustrate how within a lesson (in this case, on the role of oxygen and carbon dioxide in our environment), one can introduce a number of critical and creative thinking skills and dispositions -- logical reasoning, dialogue, assumption of others' viewpoints, judgment of data presented, and reasoned judgment -- and also have students use these to discuss real world political problems.

As I have stated previously, I began this lesson by looking at the uses of air (rather than its structure). The children were asked to brainstorm ideas and these ideas were then written on the board. Having done this, I then solicited from them the constituents of air. Next, I used the percentages for nitrogen and oxygen to provide a different type of mathematical exercise that required logical reasoning (determine the approximate amount of carbon dioxide using inexact ["more than"] figures). We then decided which constituents of air are used for the various uses they had brainstormed, and classified these actions as to whether they use nitrogen, oxygen, carbon dioxide, or some combination of them. [In some classes I lit a candle and then covered it with a glass to discuss combustion; in others I merely talked about blowing out birthday candles.]

I then drew the oxygen-carbon dioxide cycle to help them create a conceptual framework for the interchange of these gases. I emphasized that the processes of photosynthesis, respiration, and combustion serve to maintain the relative balance of these gases (oxygen and carbon dioxide) in the atmosphere.

All of the above was rather a straightforward review of concepts previously discussed (photosynthesis and respiration), with the only new information being the introduction of combustion (the chemical equivalent of respiration). But there was an important reason I both reviewed these concepts and discussed the oxygen - carbon dioxide cycle. It was necessary to assure that all students had the same minimal understanding before they could, as a class, address the problem posed in a critical fashion.

The problem I pose in the lesson requires that the students apply their environmental understanding to a political problem, which I summarize as follows: I state that observed levels of carbon dioxide have been increasing and that this increase has been attributed to the increased combustion of factories and automobiles. I further state that some individuals have suggested we should reduce these levels by planting trees to counter the effects of combustion, and we should do this in the tropics, since trees grow more rapidly there. A political suggestion has been made through the United Nations that since this increase in carbon dioxide levels has been principally caused by the developed countries and their industries, these industrial companies should pay tropical countries to plant trees and maintain the forests they presently have. In return, these industrial companies will be given pollution credits (i.e., have their anti-pollution requirements lessened).

I then ask the students to discuss this situation and come up with a decision -- whether or not pollution credits should be given. As can be readily seen, this discussion can serve as the basis for the use of many critical and creative thinking skills and dispositions. Through discussion and role plays, the students assume other viewpoints, and examine the issue taking into account those viewpoints -- judging the reliability of the data presented -- and make a reasoned judgment whether the proposed solution follows. The students also have to evaluate the issue, and form an opinion whether the proposed solution is fair and just. Finally, however, they need to confront the implications of the decision. [Let's consider one example: If I, as an industrial company, am paying you to grow and maintain these trees, then I should also be able to receive the profits from any products (e. g., macadamia nuts) harvested from them.]

In examining this lesson, one other point is important. By posing a real world problem, the teacher helps the students to understand the direct relationship between what they are learning in school and the world outside of school. It is also more likely their education will be more meaningful and effective as they grapple with these issues that will affect their lives. The second homework assignment (responding to a question about the possible effects of the increased burning of forests in the world) is a further investigation into the real world problem of increasing carbon dioxide levels. It is also a synthesis of the students' understanding of the role trees play, their use of carbon dioxide, the necessities of life, and the farming practices normally used in their country.

Finally, although I could not do this with the students due to my weekly schedule, I suggest a simple demonstration (covering plants completely with plastic bags) the teacher or students can make to show how plants use both oxygen and carbon dioxide. [The teacher can easily make this into an experiment as well, by having the students compare the growth of plants covered with plastic bags with that of uncovered ones. Watering/not watering of uncovered plants may also provide additional data to be considered in the students' analysis of the experiment]. I also suggested a class project (a terrarium) which the students could undertake and continue throughout the year.

program of studies. I discuss it here because, in addition to being an example of how to integrate critical and creative thinking skills and dispositions into a lesson, it is a also good example of how to introduce competing moral perspectives.

A follow-up activity by a teacher after one of my lessons was part of my inspiration for this lesson. During my lesson on habitat and niche I had emphasized the important ecological role that leaf-cutting ants play. As a follow-up, he had had his class enact a mock trial with leaf-cutting ants as the defendants, charged by farmers with the destruction of their crops. I decided to use a similar mock trial, but this time to help the children explore the dimensions and implications of a much broader topic -- ecological equilibrium.

The introduction to this lesson (as for many of my lessons) is the homework preceding it. After having discussed the roles of various parts of ecosystems that "maintain balance" within those ecosystems, the teacher would have pointed out that the world and all ecosystems are indeed constantly changing. Therefore, their assignment had been to write an essay and evaluate whether ecological equilibrium does indeed exist. The purpose of the introductory discussion of the homework is to try to come to an understanding of the different viewpoints that can arise on this issue (depending on the time frame used, and perspective taken).

The activity is simple. The students enact a mock trial, in which human beings are accused by the rest of nature of "destroying and still destroying nature." However, to bring issues into sharper relief I stipulate that "the only penalty that can be given for this crime is forced extinction of the guilty species, i.e., human beings."

Most of the students take sides ("nature" or human beings) and have to assume the viewpoint of their side. [It may be better if the teacher assigns sides -- that way, students may need to assume a different viewpoint than their own.] Each side must as a group decide on their strategy -- what arguments they will present, who will be their witnesses, who will take the role of their lawyers, and what sorts of questions they will ask of their witnesses and the opposition's witnesses.

Judges are also chosen. Their role will be to listen carefully to all arguments, ask whatever questions they feel are necessary to clarify and/or examine further these arguments, evaluate the validity and strength of the arguments presented, and finally make a reasoned judgment taking into account all of the arguments that have been presented.

The trial is then conducted and the judges make their decision. After the judges have made their decision, the students are then encouraged to discuss what happened. During the initial discussion the teacher merely facilitates, allowing the students to explore the issues on their own and decide whether the judgment was fair.

But the teacher does not relinquish her role. She finally enters the discussion and helps the students to categorize their thoughts, enumerate the problems humans cause, and debate the fairness of such an extreme penalty. She helps them understand that these actions which harm nature, while they may have more rapid effects than actions by other organisms, may or may not be as destructive. Furthermore, she helps them to understand that these actions by humans have been taken to benefit themselves and should be judged as we would judge other actions in the natural world. [Much as a jaguar kills an animal to survive, human beings cut down trees to plant crops so they can survive].

Finally, having introduced the necessity of making more critical evaluations and looking at issues from competing moral perspectives, the teacher then poses this question for the students to evaluate: Do our actions to benefit ourselves inevitably have to cause harm to nature? The teacher then forms and assigns groups to address various environmental problems, in the light of the question. The students then explore the issue for their homework as they conduct investigations (analyze) and suggest solutions (synthesize) to various environmental problems.

After the students have completed this assignment, the teacher may want to explore these issues further. In my lesson I suggest a series of videos (made in Puriscal) she can use which discuss deforestation and reforestation of their area. These can also help to focus discussion on more complex moral issues such as:

1. Do human beings have the right to cut down trees and/or destroy forests?
2. Can we recreate forests and/or should we?

CHAPTER 7

EVALUATION OF STUDENTS IN MY PROGRAM

Introduction

My program of studies in environmental education was designed to implement Costa Rica's Ministry of Education (MEP) 1995 Curriculum Guidelines for Science in the Upper Elementary Grades (See Appendix 3). I have already stated my feeling that these guidelines were more progressive in their call for the use of more critical and creative thinking skills, to replace an outmoded system of mostly rote education. At the same time, however, I knew these guidelines presented teachers with the need to introduce many new (or previously less-developed) concepts. Thus, I designed my program of studies to provide a larger conceptual framework, ecology, within which to incorporate all, or at least the most important, of these concepts.

If one looks at these guidelines, one can see that the program I have designed covers topics that are supposed to be taught in 4th, 5th, and 6th grades. Indeed, I might have designed this program to be taught over a series of three years. In this way, within an ecological framework more time could have been devoted to covering the given topics, and additional related topics in the guidelines could have been taught as well. [It is probable, however, that to teach it over three years would have necessitated some changes in the order of the guidelines].

Instead, although the program covers topics from 4th and 5th grades as well, it is designed primarily for 6th grade. The reasons for this are both practical and theoretical. On the practical side, I felt it was more feasible to design a program that an individual teacher and/or principal could decide to implement as a different way of helping their 6th grade students review and better understand topics in the natural sciences. The curriculum guidelines for 6th grade themselves do this at least in part. [In Sixth Grade Theme C: Environment, Human Population, and Development, the sections on the Ecosystem and Ecological Equilibrium are new ways to conceptualize previously learned materials, at the same time adding some additional complexity (MEP 1995, 9-10).] But there were theoretical reasons as well, as outlined below:

1. It was my feeling that since some of these concepts (from 4th and 5th grades) were most likely covered in isolation, it is probable they were not fully comprehended before.

2. My program is meant to incorporate much previously learned information in part to better conceptualize that information, and in part to review it for sixth graders, who will be taking comprehensive exams at the end of the year to graduate from grammar school.

3. The major thrust of my program is to encourage students to learn that they should investigate issues for themselves and draw their own conclusions. It is designed to give them practice in the development of both critical and creative thinking skills. Thus, for sixth graders it can serve as a preparation for high school in which they will be further called upon to utilize their own thinking on issues.

It may be, however, that 25 lessons (or more) is too much time out of the school year to devote to reviewing these concepts. In that case I would hope that teachers and principals would see the benefit of spreading my program of 25 lessons over more than one year. Of course, there is also nothing to prevent teachers of lower grades from utilizing some of the lessons and/or ideas presented, modifying them as necessary.

In the first part of this chapter I analyze the program of studies which I developed and show how it satisfies many of these curriculum requirements. However, as I wrote my program I also hoped to provide a better method for teachers to evaluate their students -- through a "portfolio-type" method of assessment. [I write this in quotes because at the time I designed the program I had not conceptualized it in this way. It is only now, after having thought about it and read articles on portfolio assessment, that I define my method that way]. Thus, in the second part of the chapter I discuss how I incorporated portfolio assessment, relating it to some of the literature on its use in science classes.

Since my return from Costa Rica I have also explored in much greater depth issues of learning and science education, with a particular emphasis on conceptual change theories, which I discussed in Chapter V. As I have studied these theories, I have examined the lessons I taught and later revised and wrote as my program of studies while in Costa Rica-- sometimes seeing how these lessons incorporated good methods; other times recognizing how they ignored student alternative conceptions and/or made unwarranted assumptions about students' understanding. In the third part of this chapter, I examine in depth some of these lessons, pointing out their strengths and weaknesses, especially in light of conceptual change theory.

Ultimately, however, the final evaluation of any program of studies is made by how the students respond to it and/or how others who use the program find it. Therefore, in the last part of this chapter I comment on student reaction to my program and quote some of the teachers with whom I worked.

Evaluation Using the Science Curriculum Guidelines

As with any program of studies, there should be some method of evaluation. I did not specifically give guidelines on evaluation in my program, as these are set forth in the general science curriculum guidelines published by the Ministry of Education in 1995. A perusal of those guidelines will show that in general terms the teacher's evaluation should include the children's understanding of concepts, participation in both class activities and those outside of class, and attitudinal changes as evidenced by their participation. Although formal tests may help in the evaluation of the students' knowledge and understanding, my feeling was that a much better indication of their learning and incorporation of that learning in their lives would be given by their class and homework assignments -- the amount of effort expended, their originality, the interest they show, and the critical thinking employed.

The purpose of this part of the chapter will be to cite examples of the ways, other than formal tests, in which this program could be evaluated according to the published guidelines cited above. My program creates many opportunities within class to actively investigate the environment and corresponding opportunities to judge students' attitudes as demonstrated by their participation. Likewise, effort expended in tree planting projects, trash clean-ups, and other environmental campaigns or activities can also be used to gauge students' levels of participation and, to a degree, their attitude changes. Even more indicative of attitude changes, however, will be greater use of trash baskets and a cleaner environment around the school, especially if close to a local *pulpería* (a small "Mom and Pop" grocery store). This, of course, is more difficult to gauge, although it should be noticeable over time.

Specific Lessons - Criteria for Evaluation of Students

As I designed this program I viewed the homework assignments and, to a lesser degree, those done in class, as the best indication of a student's interest and learning. I have already stated that many of the homework assignments require that the students show their understanding of a topic already discussed by writing their own explanation of it. [For example, in Lessons 6-10, students are asked to describe in their own words, respectively, a food web, and the cycles of water, oxygen-carbon dioxide, nitrogen, and rocks). This is a good way for the teacher to evaluate the students' understanding of concepts. However, in general, the purpose of most of my homework assignments is to encourage further investigation and thought by the student. [In the following discussion, all references are to the MEP Science Curriculum Guidelines of 1995 which are printed in Appendix 3; I will only reference them if I directly quote them.]

The first homework assignment (Lesson A -- Observation), in which students are asked to observe a particular non-domestic animal (or group of animals), if carried over for several weeks, should give the teacher a good indication of the students' commitment and diligence with which they pursue their studies. If the teacher checks the homework near the beginning of the assignment and periodically thereafter, she can clarify it for those who may not understand it and/or help those who have problems with it. Reading these observations will also help her to distinguish between those students who are engaging themselves in the homework activity and are truly interested in making these observations and learning from them, and those who are simply "filling in the blanks," i.e., merely doing it as an assignment. Although this homework assignment does not call for a great deal of originality, it does require a sustained effort by the students and careful observation, one of the most important critical thinking skills.

This display of "scientific curiosity" and concern for "rigor and objectivity" in seeking information that students should demonstrate in making observations in Lesson A is also called for in Lesson 3 (Microclimates and Microhabitats) and Lesson 4 (Habitat, Niche, and the Necessities for Living Things). The teacher can use these lessons to evaluate students' "scientific curiosity . . . learning about the variety of living things" and their "rigor and objectivity in the search . . . [for] information." (MEP 1995, Appendix 3, 296)

The combined class and homework assignments of Lesson 1 (Biodiversity) fulfill almost the entire "Values and Attitudes" and "Criteria for Evaluation" sections of the 4th grade guidelines which relate to awareness and appreciation of Costa Rica's biodiversity. Furthermore, the homework assignment -- to state the positive ways in which Costa Rica's biodiversity contributes to a particular aspect of its society -- will also be a very good indication of the student's effort expended and critical thinking skills employed. Other requirements of this section of the guidelines (students should be able to identify the niche and habitat of species, and understand and observe the different adaptations organisms have made to survive) will be confirmed by the class and homework assignments of Lesson 4 (referred to above).

The class and homework assignments of Lesson 2 (Climate) can be used to evaluate the children's understanding of atmospheric conditions and how they affect our weather and climate. Student performance on them will also clarify if students do indeed understand the difference between weather and climate. Similarly, assignments from Lessons 7 (Water), 8 (Air [Carbon dioxide - Oxygen]), and 9 (Nitrogen) will serve to help evaluate the students' understanding of the benefits which we receive from the hydrosphere and atmosphere and their importance. The above-mentioned topics are also part of the Grade 4 curriculum.

The teacher can also use the classroom discussion during Lesson 5 (Plants and Their Importance) to evaluate her students' understanding of photosynthesis and its role in nature. Although I have not included the assignment, she might also request that they write a summary of the process of photosynthesis. Both of these would serve to evaluate students' understanding of this important process. Evaluation of another fifth grade requirement (understanding of the interrelationships of all organisms in the web of life) could be made by examining the homework assignments from Lessons 12 and 13 (the two lessons that introduce the concept of ecology). These assignments would also clarify the students' understanding of the importance of this concept, which is a sixth grade requirement.

The lessons and homework assignments on rocks and geology (10 & 10A) provide ample opportunities for teachers to evaluate students with respect to their understanding of issues related to the changing Earth -- issues which are included in both the 5th and 6th grade requirements. Similarly, the lessons on soil and soil conservation (11 & 16) will enable teachers to evaluate students' understanding and actions regarding soil sedimentation and erosion.

Looking at the "Values and Attitudes" and the "Criteria" sections for 6th grade, one can see that many of the lessons' class and homework assignments can be used as sources for evaluation. For example, Lesson 6 (Food Chains/Webs) can be used to evaluate students' understanding of this topic and the different roles of producers, consumers, and decomposers. Lessons 3-14 all provide opportunity for the teacher to evaluate the students' understanding of the importance of various biotic/abiotic components of ecosystems. This, of course, should not be surprising, since the basis of the course is ecology and the study of the interrelationships and roles of all living and non-living things in nature. Knowledge and understanding of the different types of ecosystems can be evaluated by examining assignments from Lesson 14 (Ecosystems). The teacher can also utilize the class and homework assignments from Lesson 15 (Ecological Equilibrium) to evaluate the students' understanding of that concept.

Finally, Lessons 16-19 (Soil Conservation, Pesticides, and Trash and Garbage) all offer opportunities to evaluate the students' understanding and attitudes with respect to human actions and their effects on the environment, while Lessons 15 and 20 (A Community Seeking Employment) can be used to evaluate the students' conceptions of sustainable development, the problems that tourism might present, and the importance of national parks.

Overall Values/Attitudes

Of course, not all of a student's values and attitudes may be perceived or judged accurately on the basis of only one lesson. Many of these criteria require an analysis based upon the student's overall performance in and out of class. Examples of these would be the student's value of and respect for the diversity and biological richness of Costa Rica and her defense of the environment and participation in campaigns to protect it, both of which are 6th grade requirements.

Homework Assignments

The above gives a general idea of the ways in which the lessons I designed are related to the curriculum guidelines and can be used to evaluate students' fulfillment of their criteria. However, I have also previously indicated the extra importance I placed on homework assignments. I would now like to discuss why I wrote them, how the teacher can use them to evaluate her students, and how these assignments are similar to a portfolio assessment. Following that, I examine in greater depth some of the homework assignments and how they should be evaluated.

Criteria for Evaluation

The first year I taught I did indeed review homework assignments and (despite my sometime inability to understand what my students had written for their assignments-- due to both my Spanish and their handwriting) found the students, for the most part, responded favorably and showed interest and initiative in their assignments. This was especially true in classes where teachers participated. However, since one of the goals of my program was to share ideas and methods with teachers and try to involve them more, I purposely did not review the students' assignments the second year, but instead left that to the teachers. Thus, I cannot judge how effective these assignments were the second year, although I suspect, unless the teacher required them, most were undone.

Although I know that students will still be given formal tests, and that 6th grade students in particular will have to memorize a large amount of material to pass their final exam, I designed the homework assignments in my program of studies specifically to give teachers a different means whereby they could evaluate their students and at the same time get significant feedback on their teaching. [These assignments can also be used by the students as a form of self-evaluation, to know what concepts they need further clarified by the teacher.] This evaluation would not be based on the ability to memorize or solve simple problems, but instead on the initiative and interest, creative and critical thought, and, most important of all, the progress demonstrated by the students. By never having homework assignments that require more than is possible (given the students' resources), but at the same time making the assignments (often essays) increasingly more thoughtful, the teacher can observe the progress of her students and through timely intervention and advice help them to improve their understanding.

Almost every lesson has one or more homework assignments. Usually one involves an investigation, interview, or experiment; sometimes there's a review essay question; and sometimes there's a question that requires the student to think critically in some fashion. I included a number of assignments in each lesson for several reasons:

1. Having the children conduct investigations outside of class allowed me to ground their classroom learning within their daily experiences.
2. I wanted to assure that every student could have success with at least one assignment (an investigation, experiment, or interview).
3. Generally, the assignments for each lesson are progressively more complex; in doing the first one the student is better able to do the next, and so forth.
4. I wanted to give the teacher many different ideas, some of which she might want to integrate into other subjects.
5. Often one (sometimes more) is a preview of the next class, or requires that the student do something to prepare for the next class.

Portfolio Assessments

One can see clear parallels between my use of homework assignments and the idea of portfolio assessment, which has been proposed as a method of assessment which gives more responsibility to students, emphasizes students' development and not just their end products, and is more consistent with present learning theories. (Gitomer and Duschl 1995) The assignments give the teacher a large number of varied measures by which to assess the students, and not merely ones based on objective answers. Many of the assignments involve the students in addressing issues in their lives, and expanding upon their own understanding. Most of these will be written, although some may involve artwork or other means of expression, but in any case, they can be kept and compared as the student progresses over the year. Thus, by reviewing the students' assignments over time, the teacher is able to evaluate the process as well as the product. In so doing she can also model the importance of the process for her students.

Gitomer and Duschl (1995) lay out three criteria for assessment in a "portfolio culture," which they define as "a learning environment in which students are engaging in learning activities consistent with current psychological, philosophical, historical, and sociological conceptions of the growth of scientific knowledge." (p. 300) They are the following:

1. Assessment should attend to knowledge and skills that are deemed important within the discipline.
2. Assessment should contribute to instruction and learning.
3. Assessment should contribute to an accountability process within an educational system.

In accord with Gitomer and Duschl, the homework assignments in my program of studies resemble a "portfolio culture" in at least two ways: (1) They assess students' understanding of important themes and procedures in environmental education, such as the construction of food webs and the importance of all organisms within ecosystems, as well as the importance of observation and the consideration of different viewpoints. (2) They also serve to help students construct their own knowledge as their own investigations lead them to ask and answer new questions, while at the same time they provide the teacher with information she can use to improve her teaching.

To a large extent, however, they do not meet the third condition of Gitomer and Duschl which is that assessment "should contribute to an accountability process within an educational system." (1995, 307) They do not do this because the major assessment tools still used to measure student progress (and to graduate from 6th grade) are objective tests. As long as students know that the main criteria by which they will be judged will be these tests, their learning will be directed toward the tests and not toward more basic understanding of the material.

I have already stated how when teaching I tried to make my "criteria public" (Gitomer and Duschl 1995) at the beginning of the year. I stated clearly to each class that what I most wanted from my students was that they participate and that they observe carefully and think about their observations. Although my criteria were public, the students knew they were not the only ones by which they would be judged. When teachers reinforced my statement by saying that they would also review these assignments and count them toward their grade, student performance on the assignments improved. [This problem was, of course, related to my status as a "visiting expert," who was not responsible for grading. A regular teacher would not have the same problem, if she were clear about her criteria.]

Thus, looking at education more generally, and not only in Costa Rica, it appears to me that my experience shows assessment portfolios (which require thoughtful reasoning and greater student responsibility) can be integrated into a science curriculum, even in systems where a major part of student performance is still judged by objective tests. To do this, however, teachers need to make clear the importance of thoughtful reasoning, provide their students with sufficient opportunities (activities and assignments) to engage in it, and state specifically that they will take into consideration the students' performance on these activities and assignments in determining grades. If teachers do this, their assessment of thoughtful exercises by the students will result in improved performance by both their students and themselves.

While this method of assessment can be effective, it also raises additional considerations for the teacher, namely, by what measures should these types of assignments be evaluated. Among the issues to be considered are:

1. The possibility of excessive external evaluation and the detrimental effect it may have on creative products (Amabile 1983 a,b)

2. Keeping the homework assignments from being done as if they were a test -- with excessive concern about having the "right" answer

3. How best to involve students to use their assignments as a self-assessment tool and guide to their progress

Specific Lessons

I have already shown that many of the assignments require the students' diligence in observing and recording their observations. Some of them also require students to interpret their observations or undertake further investigations, while others call upon them to think critically as they apply what has been discussed and/or learned previously. Such assignments are found in Lessons 7 and 8 (Water and Air [Carbon dioxide - Oxygen]), which respectively ask students to address issues of global warming and the burning of forests worldwide and predict their consequences.

Another type of homework assignment, that asks not only that students think critically and apply their understanding to a problem, but also asks them to state their opinion on that problem, can be found in Lessons 14 (Ecosystems), 16 (Soil Conservation), and 20 (A Community Seeking Employment). In the first two lessons, students are asked to write a response to questions about issues that will be examined in the next lesson, ecological equilibrium and pesticide use, respectively. In the third, having examined the issue of sustainable development, the students are asked whether the resources of national parks should be used by people for purposes other than recreation. There are no right answers for any of these questions; rather the students are asked to state their opinions and give their reasons for them. In reading these assignments, the teacher should evaluate: (1) whether the students' given reasons are factually correct and (2) whether they support the students' conclusions. The clarity and logic of their argument is the most important factor.

Similarly, the homework assignment for Lesson 15 (Ecological Equilibrium) asks students to address a particular ecological "problem." They must state whether they believe it indeed is a problem in either the country or their town, and also what they consider are the major reasons for the problem. Finally, they must propose a solution(s) for the problem. As in the previous assignments, the students must first state an opinion and then justify it. However, the assignment also requires that students analyze "cause and effect," which in some instances may mean confronting their own sociocentric views on issues and/or "accepted wisdom." The last question requires that the students present possible solutions to the given "problem."

In evaluating this assignment, the teacher should first consider whether the student really grappled with the problem. In evaluating the solutions proposed, she should not only consider their plausibility and potential likely effectiveness, but should also take into account the students' creativity in suggesting solutions. A similar assignment is again presented as the homework for Lesson 17 (Pesticides) in which students are asked to address the issue of trash.

A much different type of homework assignment is presented in Lesson 18 (Trash and Garbage) and Lesson 7 (Water). In Lesson 18 the students are given a choice -- to write either an essay or a story concerning the problem of trash. If they write an essay the teacher should use criteria similar to those she used above, namely, her assessment and/or judgment of the logic and plausibility of her students' predictions. However, if her students write a story for this assignment, or when they write a story about the travels of a water droplet for Lesson 7, she should be more concerned in her evaluation with their creativity -- their skill in presentation of the story, the mood adopted, their use of language and/or dialogue (if present), the setting of scenes, and the way in which the story unfolds.

Creativity in My Program

In Chapter V, I stated the difficulty of incorporating creativity into science. As can be seen from a perusal of my program of studies, while I have tried to be creative in my design of lessons, I have not emphasized that the children's work be especially creative. There are times I do ask for creativity in several of the assignments when I ask students to write stories, and I also indicated some lessons when the teacher might want to have her students make up dramatizations and/or puppet plays. The teacher can also integrate this program of studies with Language Arts (Spanish) or other subjects. [For example, the children could write a poem about the animals they have observed, or design a fantasy world in which there were no plants and no sun]. While my program as written, clearly requires students to use their critical thinking skills, it does not appear on the surface to emphasize the importance of using their creativity.

I would argue, however, that the program does encourage students to create their own learning through their own investigations and by relating those to their prior experiences. In this way their understanding is an act of creation, shaped by them with the help and guidance of their teachers. As they construct and sometimes restructure and sometimes reconstruct that learning, it is they who are the architects and the builders.

Nevertheless, even if one did not consider that style of learning an act of creation, I still do think that my program is based on and requires that students utilize their creativity, using the broader definition of creativity I have previously embraced. I refer the reader back to Davis' definition (Chapter IV) of creativity as "a lifestyle, a way of growing, and a way of perceiving the world." He further states that "being creative is developing a sensitivity to problems of others and problems of humankind." (Davis 1992, 7) Insofar as this program calls upon students to address problems from multilogical perspectives, to be sensitive to the needs of others, and to seek answers that benefit all, I would submit that it indeed passes the test of encouraging/requiring students to use their creativity.

For me thinking creatively is not only the use and manifestation of creativity (as it is narrowly defined); it is also the basis of morality. It is thinking directed toward an end -- the betterment of human beings (and affirmation of the individual) without destroying and/or damaging the world of which they are a part. That betterment may or may not be economic, and decisions made will take into consideration many factors other than simple economic ones (which, unfortunately, is not done often enough).

It is incumbent upon the teacher that in presenting this program of studies (or indeed any other), she must demand of her students that they justify their answers to questions and/or conclusions according to their moral perspective. If posed in this way, answers and/or conclusions will not come easily. Complexities will arise, and her students will have to grapple with them. However, if not done in such a manner, the children will either assume arriving at answers to questions is facile, or they will follow blindly what others say. Lack of practice in creative thinking in school will lead to its absence as they grow older. The result will be that instead of approaching new challenges creatively, they will make future decisions in their lives without benefit of their own creative thinking.

Effectiveness in Creating Conceptual Change

As I have previously noted in Chapter V, there are two ways in which new ideas are learned. The first method, assimilation, consists of either adding these beliefs to old ones and building upon them, or modifying the old ideas slightly to be in accord with the new ideas. However, if the new ideas cannot be easily integrated into old beliefs, accommodation or conceptual change must take place if learning is to occur. (Strike and Posner 1985)

I would now like to review my program and discuss its effectiveness in light of this new perspective, and trust that the reader will recall that I did not have this perspective when I designed the program. I discuss the program as a whole as well as specific lessons, pointing out its strengths and weaknesses. I also indicate parts I might change if I were to rewrite it.

Structure of My Program

As previously noted, this program was developed taking into account my experiences while teaching, and modified constantly even while being taught. During my first year in the schools, I realized that my students were not accustomed to use their own observations to learn in school, nor to a great extent to read to obtain information, much less to read critically. As a result, much as I had felt it necessary to make public my criteria of assessment (WHAT I wanted from my students), I also felt it necessary to introduce clearly HOW I wanted my students to learn. If I wanted my students to construct their own knowledge, I needed to make sure they knew how to do it. I thus designed the four lessons (A-D) which focus on observation and reading, and suggest in my preface to the program other skills which the teacher might want to inculcate, e.g. interviewing techniques.

The rest of the program was designed within the conceptual framework of ecology. I purposely did this so the students would have a framework within which to relate the different lessons and hopefully to construct their own understanding of ecology. The first lessons (1-14) are sequenced -- successively guiding the student to construct the concept of an ecosystem. After first beginning with a discussion of the biodiversity of Costa Rica and its importance, these lessons look at the various components of *La Naturaleza* before recombining them to form ecosystems. The next six lessons (15-20) then use the students' new understanding and perspective to first address the competing moral perspectives ecology presents and then examine real problems in light of both their scientific understanding and moral perspective.

The lessons are not only structured to help the students construct their own understanding and perspective, but are also based on the students' experiences. Almost all class investigations and homework assignments involve the students in activities that are local and relevant to their lives, to provide the greatest possibility that the students be able to construct their own knowledge.

The underlying learning principle for connecting the first lessons (1-14) was assimilation. Each lesson adds new information, which is connected to previous understanding, and often leads to new ideas to be presented in the next lesson. I believe that overall this is an effective strategy in bringing a number of varied concepts together. My experience was that for most lessons concepts did flow together and students did show increased understanding.

Problems with Misconceptions

However, there were times when this desired understanding was not achieved, most notably in my discussion of photosynthesis (Lesson 5). I have already discussed that one reason children may have a problem understanding photosynthesis is their tendency to personify plants. (Hatano and Iganaki 1994) It is possible this may have been a factor which contributed to their confusion -- their prior conception being that plants obtain their "food" through their root systems, as has been found in studies of photosynthesis. (Smith and Anderson 1984; Roth 1984)

Nevertheless, it is my feeling that a more probable explanation for the confusion that was apparent in my students was that their conception of matter was not molecular, and thus they did not understand my chemical formulas. Not only that but their intuitive understanding of states of matter was also a problem with which I had not reckoned. Lee et. al. (1993) cite the alternative conceptions that children have concerning the different states of matter. These are:

1 Gases are often not even classified as matter.

2. Properties of states of matter are often attributed to individual molecules, instead of being due to different arrangements and motions of molecules.

The second alternative conception would lead children to believe (even if they are aware that states of matter can change [e.g., ice melt or water freeze] due to temperature changes) that a particular type of matter had a natural state at a particular temperature. Thus, even if my students had been exposed to molecular concepts, the proposition that water, a liquid, is composed of two gases, or that carbon dioxide, a gas, partially consists of a solid, carbon, must have seemed completely counter-intuitive.

As stated in Chapter V, Strike and Posner (1985) emphasize the importance of challenging alternative conceptions in initiating conceptual change. They state that there must be dissatisfaction with the prior conception before a new idea can take root. Furthermore, they conclude that even when a prior conception is seen as unsatisfactory, adoption of the new idea is gradual, as the two ideas "compete" in the mind of the learner. What might cause this dissatisfaction to occur, and how can teachers successfully challenge alternative conceptions? I would submit there are four different methods, which I list below in order of their effectiveness, from least effective to most:

1. Present an alternative theory
2. Present contrary facts (unknown to the students)
3. Present contrary exceptions (known to the students)
4. Have students discover for themselves an anomaly or discrepancy through some observation or activity

Using these as a guide, I would now like to examine some specific lessons.

Introduction of alternative theory. This method does not directly confront alternative conceptions, which is why constructivist theories of learning do not recommend it. However, there is a possibility for its success in education, and it sometimes may be the only method available. Students (in lower grades especially) generally trust their teachers; therefore, they may not dismiss an alternative theory out-of-hand. Since accommodation theories "compete for favor," the alternative theory may eventually be seen as more correct and plausible, and so be adopted.

There may also be times when, although students do not have sufficient knowledge to judge a theory, it may be useful to state the theory first and then provide students with the evidence for it. In this case, the teacher should clearly state the theory is a theory, and she should invite the students to examine its evidence critically as they encounter that evidence in their studies.

In Lesson 4 (Plants and Their Importance) I present an alternative theory. I present as fact that scientists have determined that plants produce their own food through the process of photosynthesis, and I describe that process and its components. To provide partial justification for the process' components, I then show how the molecules of water and carbon dioxide combine to form glucose and oxygen. Additionally, I work out the equation for two other reasons: (1) to show that oxygen is a byproduct of photosynthesis and (2) to establish the reverse equation (oxygen and glucose combine to form carbon dioxide and water) and introduce the concept of respiration.

In defense of this approach, I would state several factors. First, since photosynthesis is in the 4th grade curriculum, the students should already be familiar with the process. The primary purpose of this program, which was designed for 6th grade, is to connect disparate parts of ecology. An important one of these parts is photosynthesis. The lesson assumes that the concept has previously been introduced to the students, and tries to reinforce the concept by providing the ecological context. Second, it is critical that students realize the role of plants as producers and as the first level of food chains; failure to recognize this role has been cited as a major reason for the lack of understanding of the importance of food webs and of how energy is distributed throughout ecosystems. (Gallegos, Jerezano, and Flores 1994) Third, the introduction of the process of photosynthesis lays the groundwork for understanding the oxygen-carbon dioxide cycle, which is crucial to understand the issue of global warming.

There are two other possibilities that lead me to retain this lesson format using molecular explanation. One possibility is that students will hold the theory of photosynthesis in their mind and it will gradually become accepted. The second is that it is possible the teacher might have discussed molecular theory in class previously. This may or may not have been done effectively, but it is possible that some remnant of the idea remains in the students.

Of course, a similar problem -- presenting a lesson in terms of molecular theory occurs in Lesson 8 (Air [Carbon dioxide - Oxygen]) and Lesson 9 (Nitrogen). In these lessons the problem is not as crucial to the lesson, and thus, probably can be avoided to a greater degree. However, as I examine my lesson on photosynthesis, which is basic to my program, I am still not sure that there is a way to avoid this "presentation of alternative theory" method of introducing the topic totally.

I have considered several ways in which the method could be reinforced, however, and the prior alternative conception that plants take in food from the soil through their roots could be at least partially challenged. One way is by the teacher raising contrary examples with which the student is familiar (See #3 above). The most obvious examples with which the students of Costa Rica are familiar would be the many epiphytes that grow without soil. Unfortunately, many students believe epiphytes are parasites. Thus, the teacher who uses epiphytes as a means to create a discrepancy in her students' minds, needs to also cite examples of epiphytes which grow on telephone wires and other inanimate objects to counter this alternative conception that epiphytes take their food from other plants. [In reviewing this lesson, I recall that, although I did not write this in the lesson, I did indeed use this type of example when discussing photosynthesis].

The teacher could also cover plants completely with plastic bags at the beginning of the program, a demonstration (See #4) I suggest at the end of the lesson on oxygen-carbon dioxide. She could then challenge her students to explain how the plants survived without water. Alternatively, she could grow seeds in a closed plastic bag on a wet paper towel, again challenging the "soil as food" alternative conception. These examples and demonstrations could challenge the above "food" alternative conception. However, I'm not sure how easily one can challenge the "nature of matter" one (the impossibility of believing that substances in one state [such as a liquid] can combine to form a substance in a different state of matter [such as a gas]). Nevertheless, for me the importance of photosynthesis necessitates that it be taught, whether or not all the alternative conceptions can be challenged.

An even more difficult problem is offered by the introduction of plate tectonic theory in Lesson 10A (The Geology of Costa Rica). I felt (and still feel) that if I am going to introduce the topic of geological forces and their effects on Costa Rica (which are required by the curriculum), I needed to be honest by presenting the latest theory. I needed to state what scientists believe and to state some of the evidence (rock formations and their locations) for their beliefs. In doing so, I purposely did not challenge religious beliefs ("misconceptions"). However, in accord with the recommendation of Gitomer and Duschl (1985), I did stress that I was presenting a <u>theory</u>. I further stated that this particular theory was relatively new, by pointing out that in high school I had learned a different theory. In this way, I did at least make clear the fluidity of scientific thought while presenting this alternative theory.

<u>Presentation of contrary facts</u>. This method does challenge alternative conceptions. However, since the facts presented are previously not known to the students, its effectiveness is dependent on the students' trust in the teacher, and thus is generally not as strong in countering prior alternative conceptions as methods based on direct experiences.

Nevertheless, it can be an effective method to challenge alternative conceptions, especially if they are very wrong.

Perhaps the two best examples of this method in my program are my two "open competitions" in Lesson 1 (Biodiversity in Costa Rica) and Lesson 18 (Trash and Garbage). In each I challenge students' alternative conceptions with alternative figures, and it is obvious as the "competition" progresses that the students' estimates change and approach that of the teacher. The effect and actual conceptual change is most noticeable in Trash and Garbage (18), when as a result of longer and longer decomposition times for inorganic materials, the students come to realize that some trash lasts forever! Of course, whether this understanding becomes "real," i.e., affects their behavior to a great degree, I cannot say.

Presenting contrary exceptions. In presenting contrary exceptions the teacher reminds students of things they know or have observed and/or experienced, for which their prior conception cannot account. This impetus to conceptual change is more effective because it is based on student's "hidden" knowledge. The teacher can use it very effectively if she is familiar with her students and/or their circumstances.

I feel the lessons dealing with niche (4) and ecological relationships (12 & 13) successfully use this method. By "reminding" students of other factors (the soil of leaf-cutting ant nests is extremely fertile; snakes eat mice that eat grain), the teacher can (as I did) help students confront their typical alternative conceptions that some organisms in an ecosystem are not important (Munson 1994), and the more specific one that some organisms in an ecosystem only have "negative" value (i.e., only cause harm and therefore, can and should be eliminated). Similarly, challenging students to carefully examine relationships in ecosystems, also challenges their alternative conceptions, as the following examples show:

1. When a mouse eats corn and then deposits some of the seeds from that corn in another location, does it harm or help the plant?

2. If a caterpillar eats the leaves of a plant, is there any way in which the plant might benefit? (Does its butterfly also pollinate the same plant?)

In this way the teacher can help her students to realize that many relationships in nature, which may at first appear antagonistic, are in fact symbiotic (mutually beneficial) on a species level.

The presentation of contrary exceptions is also successful in challenging a basic alternative conception in the activity part of Lesson 6 (Food Chains/Webs). The classification of insects and other small animals as predators (e.g., spiders) confronts the basic alternative conception of children that carnivorous animals are big and ferocious. (Gallegos, Jerezano, and Flores 1994) As we have seen in the other examples, the contrary exceptions serve to unveil the children's "hidden" knowledge (things that are known, but generally not recognized).

Discovering for themselves. Self-discovery is perhaps the most effective way for students to challenge a prior conception and accommodate a new idea -- discover an anomaly for themselves through their own observation and/or experience. It is the most effective because the change relates directly to the students' experience and is generally also initiated by them. Unfortunately, however, unless the anomaly created is great or the student is very perceptive, she may make an observation and/or perform an activity, but not sense the anomaly. For this reason, teachers must be ready to help their students perceive anomalies that occur.

I have previously listed some of the alternative conceptions associated with food chains and/or webs in Chapter V. Below is printed the complete list as reported by Griffiths and Grant: (1985, 430-32)

Misconceptions found related to food chains and webs:

1. "The interpretation of food web dynamics in terms of a food chain."

2. "In a food web, a change in one population will only affect another population if two populations are directly related as predator and prey."
3. "A population located higher on a food chain within a food web is a predator of all populations located below it in the chain."
4. "A change in the size of a prey population has no effect on its predator population."
5. "If the size of one population in a food web is altered, all other populations in the web will be altered in the same way."

Looking at this list we can see that the most basic alternative conception is that food web dynamics can be interpreted in terms of simple food chains. The authors state their feeling that this alternative conception is so strong because of the way in which food chains are typically taught well prior to food webs, which are themselves merely described as a more realistic model than the previously taught food chains. Gallegos, Jerezano, and Flores agree and (as I noted in Chapter V), emphasize that food chains need to be taught "as an interactive population embedded in an ecological context." (1994, 268) They also state the importance of emphasizing the producer role of plants as the transformer of energy.

How do my lesson plans address these alternative conceptions? I have already mentioned that in my lesson when I first present photosynthesis I emphasize the role of plants as producers. I also state clearly that sunlight (solar energy) is necessary for the process and emphasize in my initial discussion of food chains and food webs that they all begin with the energy of the sun. Furthermore, I introduce the role of decomposers as well, so the children can see there are other relationships other than predator-prey ones.

I also try to directly confront the alternative conception that simple food chains suffice by introducing food webs in the lesson immediately following the introduction of food chains. I noted in Chapter VI how I did this, and how in having children represent different animals and join a simple food chain, I quickly showed the complexity of a web. The physical representation of an ecosystem in Lesson 14 (also cited in Chapter VI) furthered the perception of food webs as not only being complex, but also belonging to much more intricate ecological systems. Once more by visually constructing a web of relationships, which the students themselves created, the students' alternative conceptions were altered. Constructing the web of interrelationships also challenged a second alternative conception (See #3 above) cited by Griffiths and Grant (1985), that a population higher on a food chain is a predator of all populations lower on that same food chain. The children could easily see (by the strings indicating the relationships) that this alternative conception was false.

However, although I emphasize the complexity of the ecosystem, and the importance of sunlight and the role of plants as producers of food, my lessons do not urge teachers to emphasize the ways in which population changes of one species can affect the sizes of other populations in the same web, directly or indirectly (nor did I do this when I taught). Thus, it can be seen that the other three common alternative conceptions cited above are not addressed.

This is instructive, because they easily could be -- the model of the ecosystem is laid out and the wherewithal to attack these alternative conceptions is present. A perceptive observer might even note the anomalies that the constructed web reveals, but generally these anomalies will go unremarked upon, and thus the students will maintain their alternative conceptions. Once more we see that one of the most important roles of teachers in helping their students construct their own learning is to help them in "diagnosing and correcting errors in their thinking." (Strike and Posner 1982, 239) The ability of teachers to do this will be directly related to the degree that they understand their students, and their cultural, and educational backgrounds.

Student and Teacher Perceptions

I have tried to analyze what I believe are some of the most important strengths and weaknesses of my program, both as I taught it and as it is written, especially in the light of conceptual change theories. But ultimately, the best judges of an educational initiative are those it affects -- the students, and to a lesser degree, the other teachers. To the degree that my students found classes interesting and were active participants, I find satisfaction and believe the program was helpful in awakening important thinking capabilities in many of them. The homework assignments I analyzed also showed that at least some of my students were being challenged to think about issues in different ways. Parents told me that their children found my classes informative and interesting. The interest shown by other teachers also gives me hope that they learned something from me, as I know I learned much from them.

I would like to close this chapter with two very literal translations quoting from two letters that were sent to me by teachers with whom I worked. The first cites the value of my work there; the second is by a teacher who talks about my program which she has been using.

> Reforestation has greatly increased in the watershed of the Picagres River with the help of international and local organizations such as the Puriscal Farmers Cooperative. In other regions of our country they are also reforesting. There is a good climate to do this at the present. You were a pioneer in environmental education in our region. Thank you. (Enrique López Jiménez, pers. comm.)

> During the last trimester you have been very present in my mind. I have been using your program and the article about the turtles. I worked using your methods. The children have played games, drawn, and rolled around on the ground. Do you remember? Today I was teaching the different types of nutritional relationships among living things (classes of animals, herbivores, etc.), and the class went well. Monday, I am going to use your game with the ball of string.
> (Lucia Acuña Quesada, pers. comm.)

CHAPTER 8

CONCLUSION: TO TEACH IS TO LEARN

I titled this thesis "Cross-Cultural Teaching and Learning . . ." because I believe that teaching is also a process of learning, as I confirmed in my experience as a Peace Corps volunteer, and as I have tried to convince the reader here. In my introduction I stated the questions to which this thesis is addressed -- the questions I was pondering before I left for Costa Rica. I have reprinted them below to refresh the reader's memory:

1. How does a teacher bridge the cultural gap that often exists between her and her students?

2. How does she help her students empower themselves to construct their own understanding, make decisions in their lives, and take into account the needs and/or desires of others as well as of themselves?

3. What should her role be and how should she perform it?

4. What attitudes and dispositions should she have, and how can she encourage similar attitudes and dispositions in her students, and develop as well their critical and creative thinking skills and abilities?

The body of this thesis has been a careful examination or case study of the ways in which I addressed those questions as a Peace Corps volunteer in Costa Rica. It is my hope that this case study may serve as a guide for other teachers who find themselves facing a cultural gap in their classrooms (or wherever they teach). In this conclusion, I would like to briefly summarize some of the points I discussed.

Bridging Cultural Gaps

I would state that one of the two most important factors in cross-cultural education is that the teacher understand the background of her students -- cultural, historical, and educational. I have indicated the investigation I made into Costa Rican culture and my students' background as a model of the type of investigation teachers might make. Another teacher may not be able to immerse herself in the culture as much as I, as a Peace Corps volunteer, was able to do. However, the greater she understands her students, the more effective will be her teaching and the better the educational experience in her classroom. She will be able to design lessons and ask questions that relate to her student's experiences, which will better enable them to construct their own learning. Additionally, she will be able to learn from her students and the culture of the classroom will be enriched. Multiple cultural backgrounds of students will only serve to further enrich the classroom.

But the second factor is equally important. The teacher must examine herself. She must not only understand her cultural background, but also her "hidden curriculum." If she does not, she will not be aware of the way her "hidden curriculum" may get in the way of the educational experience she is trying to create. Her underlying perspective will hinder her in understanding and/or responding to the needs of her students.

Educational Philosophy

Education must challenge students and it must help them to explore new ways of thinking, both critically and creatively. It should encourage them to move outside of their viewpoints and consider things from multiple perspectives. Diverse cultural backgrounds in the classroom can be used to create a climate for this type of thinking.

Students can only learn if they construct their own knowledge. Thus, sufficient opportunity must be provided for them to observe, explore, question, discuss, and also to re-observe, re-explore, re-question, re-discuss, and so on. They must have the opportunity to examine and see the inadequacy of prior viewpoints and be given the guidance which will enable them to embrace new ones.

In so constructing their own understanding students can be empowered to make decisions in their lives. They will become confident in their reasoning powers and learn how and where to seek information when needed. As they construct, restructure, and sometimes, reconstruct their knowledge they will lay the groundwork for further understanding and further empowerment. The teacher should in her lessons and behavior encourage the self-empowerment of her students. However, as she guides them to self-empowerment, she must also guide them to use multilogical reasoning -- to think outside their normal frame of reference as well -- when making decisions.

Teaching Techniques

Several important techniques and strategies have been illustrated that teachers can use to increase the enthusiasm and participation of their students. Games and "open competitions" can be used not only to get students to participate, but also as a "bridge" for students to construct their own knowledge and/or challenge alternative conceptions.

Investigations and observations, as well as other class activities should be related as much as possible to the students' experiences. Students should also be encouraged to engage in further explorations of topics which interest them. Interviewing exercises can make clear the importance that life experience has, and that much of what we can learn cannot be found in books, but in the learning of others, who might not be considered "experts."

Teachers should make clear the criteria by which students are to be judged and then follow these criteria. If they want children to practice thinking skills or engage in thoughtful exercises, they must ask challenging questions. At the same time they must not demand of their students more than they are capable of doing. One way to assure that assignments do not go beyond student capabilities is by relating them as closely to student experiences as possible. Also, having assignments that examine student experiences will help them to construct their own learning.

In science education, especially, it is important that teachers challenge students' that students have in their teacher, and on whether their future experiences will confirm these new ideas. More effective ways to challenge these alternative conceptions are presenting contrary exceptions (which are known to the student), and in helping the student discover anomalies in their conceptions through their own experimentation and/or investigation. The last method can be very effective, but it may well require that the teacher guide the student to recognize the anomaly.

Role of the Teacher

Throughout my thesis I have tried to put forth my idea of what should be the role of the teacher. In brief, I think she should play at least five different roles at various times.

First, she should be a facilitator. She needs to create a classroom climate that encourages critical thinking, examination of ideas from multiple perspectives, open discussion, and creativity.

Closely tied to her role as a facilitator is her role as a guide. She must guide students not only to perceive anomalies (as mentioned above), but also to explore different viewpoints, to look for relevant information, and organize their thoughts. She must be alert to her students' needs and be able to guide them in addressing those needs. While not the architect or the builder of the learning that the students construct, her help is essential in the "pre-design stage," and she must help her students construct a good foundation.

Third, a teacher should be a model. She must model not only the classroom behavior she expects of her students, but also how to think critically and creatively. If she expects her students to be observant, curious, careful, entertain multiple perspectives, and so on, she too must model these same behaviors.

Related to being a model is her role as a learner. The teacher who teaches to empower her students, not only models for them she learns from them. As she learns from them she is also able to better teach them. One could actually say that even as she empowers her students, they in turn empower her.

The fifth role I want to emphasize is that of a sharer. Sharing is different from learning -- it is more mutual and it need not change one's beliefs, although it will definitely change one's way of thinking and attitudes. It is especially very important that teachers share their moral perspectives and values with their students. In this way, both she and her students will be able to examine their perspectives in a different light. The sharing of cultural values can also be a wonderful way in a classroom to help engender new attitudes, and break down stereotypes and existing attitudes. Again, the teacher in the multicultural classroom has many opportunities to do this.

Finally, I would like to conclude my thesis with the following thought, something we may not as teachers always feel:

To be a teacher in any society is to be privileged, no matter at what level, for the teacher has the opportunity to share in the educational experiences of her students. But to be a teacher on the grade school (or even lower) level is to be specially privileged, for the teacher at these levels shares not only in the educational experience of the child, but also truly shares in her development as a human being and member of society. In this the teacher also shares a great responsibility. The teacher may not know when the child leaves her classroom what her final effect on that child will be; all she knows for certain is that there <u>will be</u> a final effect.

APPENDIX 1

ENVIRONMENTAL EDUCATION PROGRAM
FOR UPPER ELEMENTARY GRADES

Designed by

Craig L. Jackson

Peace Corps Volunteer

Puriscal, Costa Rica

TABLE OF CONTENTS

Introduction -- Environmental Education Program (Upper Elementary) -- Costa Rica

During 1993-1995 I began to implement a program of environmental education in some of the schools located in the Canton of Puriscal, Costa Rica. The purpose of this program was to encourage and give to the students the ability to investigate their own environment. In this way, they would be empowered as citizens to make their own decisions concerning their environment in the future.

The basis of this written program (which is based upon the program I taught) is the concept of ecology ["the study of the relations between the species that inhabit this earth and their environment" (Chacón et. al., p. 5)]. The program begins with the biodiversity of all of Costa Rica, to introduce concepts that the students can then apply to their own location. In 1995 I revised the program of the previous year. Since I was in each class only once per week, I could only use one lesson for each theme. However, I have included other lessons and ideas or sources for other lessons to amplify each theme. I have also included other additional activities that teachers can use in their classes.

I hope that this program and these lessons will prove useful to the teachers of this country. Although in my second year I principally taught children in 4th and 5th grades, I believe the program is most apt for 6th grade. In this grade it could be used as a brief review of environmental concepts already learned and also as a basis for the exploration and investigation called for in theme "C" of the new program for 6th grade science, "The Environment, Human Population, and Development." It is my hope that the use of this program in 6th grade will prepare children to study, investigate, and analyze their course materials in high school with an environmental consciousness.

The methodology of my program is based on these suppositions:

1. Children know many things about their own environment (where they live); however it's possible they are not aware of this knowledge.

2. Children can understand only those things which are related to their prior knowledge.

3. Active learning is better than passive learning.

The teacher can also use this program to augment other subjects. The written homeworks are good for Spanish. Environmental problems can also serve as a focal point for discussions concerning the history of the country, social changes, and ethical values.

This program is designed for semi-rural and rural communities located around the city of Santiago de Puriscal. Although the activities and lessons relate to this region of the country, many if not all of these lessons and activities may be adapted to other semi-rural and rural communities in the country. My assumption is that these schools do not have many books, other than textbooks (and often these are in short supply as well). Therefore, the ability of students to investigate ideas through books independently is very limited. On the other hand, the students and their families have had a lot of direct experience with the natural world, through their work and where they live.

Therefore, instead of asking the students to look for answers in books, it is preferable that they do their investigations by means of interviews with the people of their communities, or through their own observation. For this reason the majority of activities/lessons refer to local things.

The teacher may want to help the students to understand how to observe and conduct interviews. S/he can begin with the observation activities (Lessons A & B) or use them when s/he wants to emphasize these skills. S/he can also assign other activities that require that they interview the people of their community. [I used the earthquake that occurred in Puriscal in 1990 and the Civil War of 1948 as themes for these investigations].

Another idea for getting the students to practice interviewing techniques is to have them make a report on the history of their community. [It is best to divide this history in three parts -- natural, social, and political]. You can also give to different students in each group different eras -- one recent, one during the childhood of their parents, and one during the childhood of their grandparents. During the class report of their investigations, the teacher may want to draw parallel time lines to relate the sequence of events.

For each lesson I have given at least one homework assignment. These assignments are not only to review lessons learned in class, but also to increase the student's learning through their own investigation. Often, the assignments include activities to help them understand better the following lesson. The teacher should assure that students do the assignments, but even more important is that they be stimulated to make their own investigations.

I have arranged these lessons according to my own ideas of how to teach these themes. However, the teacher may use them in another order or replace or add lessons. For example, as noted above, s/he may want to use the lessons on observation (A & B) and/or on reading (C & D) as an introduction to investigative methods, or as a way to review these methods. Also, some lessons such as "The Tree" are apt for special days or activities. [If the teacher wants to look for lessons to add to these, there are many to choose from in Ambiente en Acción].

I would like to give my sincere thanks to the principals and teachers of the schools in which I have taught the last two years; to the staff of MIRENEM, in particular Róger Delgado; and most especially to Lucia Acuña Quesada, Enrique López Jiménez, and Harys Regidor Beltrán, who helped me in the revision of this curriculum. Nevertheless, whatever errors may remain are my responsibility.

Craig Jackson

Peace Corps Volunteer (1993-95)

Puriscal, Costa Rica

Outline of Environmental Education Program

I. How we learn
- A. Observation -- using all our senses
- B. Investigation
  - 1. How to read for information
    - a. Analysis, evaluation
  - 2. Experiences and knowledge of people
    - a. Oral history
    - b. Practical knowledge
- C. Experimentation
- D. Contemplation

II. Costa Rica's Biodiversity
- A. Definition
- B. Is it high or low?
- C. Causes
- D. Importance

III. Costa Rica's Climate
- A. Definition
  - 1. Elements of climate
- B. What determines climate?
- C. Different climates of Costa Rica
- D. Relationship of climate with biodiversity

IV. Living things
- A. Animals around us
  - 1. Microclimates and microhabitats
    - a. Definition
    - b. Investigation
  - 2. Habitat and niche
    - a. Definition
    - b. Daily observations
- B. Plants around us
  - 1. Photosynthesis
    - a. Definition
    - b. Components
    - c. Importance
- C. Other living things
  - 1. Bacteria, Protozoa, and Fungi
  - 2. Importance
- D Food chains
  - 1. Definition
  - 2. Different parts and their role
    - a. Producers
    - b. Consumers
      - 1. Herbivores
      - 2. Carnivores
      - 3. Omnivores
    - c. Decomposers

V. Non-living things
  A. Water
    1. Water cycle
    2. Importance
  B. Air
    1. Components
    2. Cycles
    3. Importance
  C. Soil
    1. Components
    2. Cycles
    3. Importance

VI. Nature and ecosystems
  A. Definitions
  B. Components
  C. Relations between components
    1. Living -- living
    2. Living -- non-living
  D. Biological equilibrium

VII. Natural disequilibrium
  A. Natural causes
    1. Non-living -- natural processes
      a. Geothermal/geological
        1. Volcanoes, earthquakes
      b. Erosion, sedimentation
    2. Living
      a. Disease
      b. Environmental changes
        1. Examples -- succession, beavers, cattle, humans
      c. Predation
  B. Unnatural causes -- caused by humans
    1. What's the difference?
    2. Problems
      a. Pollution
        1. Air
        2. Water
        3. Soil
      b. Deforestation
      c. Loss of natural resources
      d. Extinction
      e. Overpopulation

VIII. Solutions -- Advantages/Disadvantages
  A. Conservation
  B. Reforestation
  C. Laws
  D. Education
  E. Sustainable development

Lesson A -- Observation of a Living Thing

I.Objective:

Children will better their ability to observe the natural world with care and record their observations.

II. Materials:

1. Part of a plant -- a branch, flower, etc.
2. Blackboard and chalk

III. Introduction:

Write on the blackboard the following words: observation, supposition, explanation, and conclusion. Show part of a plant -- a branch, fruit, dry leaf, etc. to the class. Then ask your students "What can you observe about this?" Write the answers on the board. After they have answered, emphasize that the only observations they can make are that of form, color, size, and possibly its composition. Explain that other ideas, such as that it is a fruit, or a flower are suppositions based on our knowledge and prior experiences.

To help them understand this, draw a spider web on the blackboard and in your own words explain the following: "We suppose that this is a spider web, but in fact we cannot observe that it is. We can only observe the form, size, and color of this type of web. Having seen spider webs that look like it before, we suppose that this too is a spider web. If there is a spider on it, we would have an explanation for the web, but unless we see a spider making the web we cannot say for sure that it is indeed a spider web.

Although this difference may seem to be minute, in reality it is important to understand that science begins and is based solely on observations, and that afterward suppositions and explications are made that are later proved through more observations. We need to base our conclusions on our observations, not on our suppositions, if we want to learn the truth."

Emphasize that the foundation of science is observation (the use of all the senses), and that the children many times can make their own observations. Finally, explain to them that if what we are observing is living, we can also observe its behavior (what it does); but if we want to observe the actions of living things we need to be quiet and still.

IV. Activity:

After this explanation, tell them that each of them should go outside, look for an animal and observe this animal for 10 minutes, noting their observations in their notebook. When they return discuss some of their observations. Assure that they understand which were observations, and which were suppositions, etc. Afterward, tell them that they should make a list of all the observations they made during the remaining class time.

V. Homework assignment:

Tell your students they should choose an animal or group of animals (such as a wasp nest), and make observations of this animal every day, noting the date, time, and duration of each observation. Emphasize that this animal should not be domestic and should be easy to observe (preferably near their house). They should continue their observations for several weeks.

VI. Comments/Suggestions:

This homework could be difficult for the children if they do not understand well the concept of observation. Therefore, it is important that the teacher review the lists of observations (made during class). It is also recommended that the teacher examine the diaries frequently to assure that the students understand the purpose of the assignment.

After this lesson the teacher should give the lesson of the senses (Lesson B) to emphasize the children should use all their senses to make observations.

The teacher could use the ideas in Ambiente en Acción (p. 7) to use these lessons as an introduction to the scientific method.

Lesson B -- The Senses

I.Objective:

The children will learn it is important to use all their senses to observe nature.

II. Materials:

1. Two or more branches of each type of tree (three or more types). Each branch should be about 30 cm. long. (It's also better if they're thick -- at least 5 cm. across).
2. Blindfolds (4-5 -- one for each group)
3. Blackboard and chalk

III. Introduction:

Ask the children the names of the different senses. Write their answers on the board in a chart like this:

Table 2. Chart of senses

	smell	vision	touch	hearing	taste
1.					
2.					
3.					
4.					

Discuss with them that different animals use different senses primarily. Form groups of students to discuss and decide upon animals which use each of the senses as their principal one. After about 5 minutes ask each group to tell you which animals should be in each column and write them on the board.

Afterwards discuss their answers and try to decide with them which are correct. [For some animals it's possible that you will not be sure; emphasize that many times we need to make further investigations (by observing or reading) to understand the behavior of animals].

IV. Activity:

Begin the activity by saying "We are going to see what it's like for an animal that does not use its vision." Then, form groups for a competition (approximately 4-5 persons per group), and have one person in each group blindfolded.

Afterward choose some branches -- some pairs, some singles, others more than two of one type. Put these branches in turn in front of each blindfolded person and note how many seconds it takes for them to separate them by type. Allow a maximum of 120 seconds to do so.

Write the number of seconds for each group on the board and then have the next members of each group blindfolded. Change the number and some of the branches for each blindfolded group and note the amount of time they take to separate them by type.

At the end of the competition, add up the number of seconds for each group. The group with the least total time is the winner, the second least the second winner, etc. When announcing the winners, applaud each in turn. [It's important that the teacher indicates second, third, etc. winners. Doing so helps maintain more interest in the activity, and most importantly increases the self-esteem of most of the children.]

It's probable that the children will only use their sense of touch for this activity. If so, afterward you should remind your students that although they were unable to use their vision, they had forgotten their other senses. To demonstrate you could bang different types of branches on the ground -- some might have distinct sounds. You could also demonstrate that some have different odors.

V. Comments/Suggestions:

When I did this activity the children had a lot of difficulty when there were unpaired branches. If there is time it would be better for each person to have two different opportunities -- one with only pairs; the other with a different grouping.

It might be good to leave the branches and blindfolds in class. That way the children could conduct the competition on their own or just practice.

The teacher can also use or design other competitions/games that require the use of the other senses. The above activity is an adaptation of Activity C on page 13 of Ambiente en Acción. Ideas for the other senses can be found on pages 12-14 in the same book.

Lesson C -- "Guajipal" (How to read for information)

I.Objective:

The children will learn how to read an article to look for information, understand meaning and context, interpret, analyze, and draw conclusions.

II. Materials:

1. Blackboard and chalk
2. Copies of the article "Guajipal" from Guía de Campo de las Especies Más Comunes del Parque Nacional Tortuguero by José A. Solano

III. Introduction:

Explain to your students that many times we cannot make our own observations and we need to seek information from books. Tell them they are going to read an article that discusses *guajipales* (caimans) a type of animal that they cannot observe in their part of the country. Tell them also that after reading it they will form groups to answer questions which you will give them. [See the accompanying article].

IV. Activity:

As a class read the article orally giving turns to each student, helping them to pronounce and understand difficult words. Afterwards form groups and write on the board the following questions and below each the number of answers for each. [I have included the answers in parenthesis].

1. Describe a *guajipal.*
   1.1.(measures between 1m and 1.5m)
2. Of what materials are the nests of *guajipales* made?
   2.1.(grass, leaves, branches, and soil)
3. How do *guajipales* know when to liberate their young from the nest?
   3.1.(they know when they hear the young making a special noise)
4. What do *guajipales* eat? the young?/adults?
   4.1. (the young eat aquatic insects)
   4.2. (adults eat fish, amphibians, and other small vertebrates, such as armadillos and birds)
5. What animals eat their young?
   5.1. (fish like the *gaspar* [garfish?])
   5.2. (birds like the *pato aguha* [anhinga])
   5.3. (mammals like *mapaches* [raccoons] and *zorros* [opossums])
6. What are the differences between *guajipales* and *cocodrilos amarillos* (crocodiles)
   Compare the two using your answers above.

Table 3. Comparison of *guajipal* and *cocodrillo amarillo*

	guajipal	*cocodrilo amarillo*
length	(1.0 - 1.5 meters)	(greater than 1.5m, up to 5m)
nest composition	(grass, leaves, twigs, soil)	(sand)
head		(much longer than *guajipal*)
jaws		(narrower than *guajipal*)

7. Which is more common?
    7.1. (the *guajipal*)
8. What is this essay about?/Why was it written?
    8.1. (The author wants to give a brief description of the two animals and compare them.)
9. Do you know where you can find *cocodrilos* near here?
    9.1. (In the Tárcoles River near the ocean)
10. How do humans use *guajipales* or *cocodrilos*? (What is the importance of the *cocodrilo* family for humankind?)
    10.1. (Sale of skins)
    10.2. (Tourist attraction)
    10.3. (Food?)

Give each group time to answer the questions before discussing them. In your discussion emphasize the following for each question:

1. This article does not give a good physical description of either a guajipal nor a cocodrilo. The drawings are an integral part of the article.
2. Read for details.
3. It's necessary to read carefully.
4. Read for details.
5. Read for details.
6. This necessitates analysis.
7. You need to infer this from the essay.
8. This question relates to the author's bias and purpose for writing. Emphasize that every author has their own bias.
9. Some children may already know this. However, it's also possible that the answer may make them aware of the possibilities for tourism that cocodrilos may present.
10. These answers require the students to infer, analyze, and interpret.

V. Comments/Suggestions:

This activity could be done with any type of article about the natural world. What is most important is that the questions include different processes: seeking information, analysis, inference, interpretation, comprehension, and determination of an author's bias.

This article and activity is much easier than "Tortuga Verde" (Lesson D). The teacher can use both sequentially or choose one or the other depending on the ability of their students.

guajipal *Caimán crocodilus*

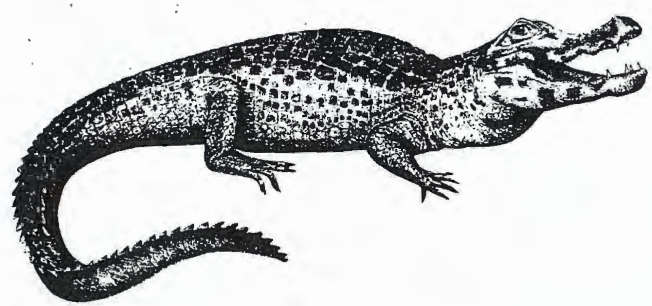
El guajipal es uno de los cocodrilos más pequeños del continente americano y, a la vez, el más abundante. Mide entre 1 m y 1,5 m. Está amenazado por el comercio de su piel, pero es factible criarlo en cautiverio. En esta especie, el cortejo comienza cerca de tres meses antes del período de anidación. Los machos adultos establecen y vigilan territorios acuáticos temporales. Los nidos son hechos de zacate, hojas, ramas y tierra. La descomposición de esta materia orgánica mantiene el interior del nido a unos 60 °C.

El período de incubación es de 73 a 75 días. La voz que emiten las crías que están todavía dentro del huevo atrae a los adultos y los estimula a liberarlas. Los depredadores de las crías son peces como el gaspar, aves como el pato aguja y mamíferos como los mapaches y los zorros. Las crías se alimentan de insectos acuáticos, en tanto que los adultos comen peces, anfibios y otros vertebrados pequeños y medianos, como armadillos y aves. El guajipal se distribuye desde el Pacífico Sur de México hasta el sur de Ecuador, y del occidente de Honduras hacia el este y el sur, hasta la Cuenca del Amazonas y el centro de Brasil.

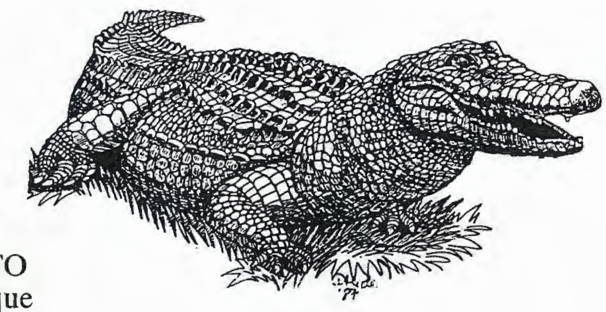
Su similar, el cocodrilo amarillo (*C. acutus*), es mucho mayor, de hasta 5 m. de longitud y habita cerca del mar. Hace sus nidos en arenales, donde el calor solar facilita la incubación de los huevos.

La cabeza del cocodrilo amarillo, en comparación con la del guajipal, es mucho más alargada y las mandíbulas más estrechas. El cocodrilo amarillo se aventura en ocasiones al mar abierto. Puede alimentarse de cualquier animal de hasta 30 o 40 kg de peso y es, aparentemente, el principal predador de las crías de manatí.

Este animal es poco común en la zona, pero cualquier cocodrilo de más de 2,5 m pertenece con seguridad a esa especie.



guajipal



cocodrilo

Figure 5. Guajipal -- Reproduced with permission of PACTO from Guía de Campo de las Especies más comunes del Parque Nacional Tortuguero by José A. Solano

Lesson D -- "Tortuga Verde" (How to read for information)

I.Objective:

The children will learn how to read an article to seek information, comprehend, interpret, analyze, and make conclusions.

II. Materials:

1. Blackboard and chalk
2. Copies of the article "Tortuga Verde" from Guía de Campo de las Especies más Comunes del Parque Nacional Tortuguero by José A. Solano

III. Introduction:

Explain to the children that many times we cannot make our own observations, but instead must seek information from books. [If this lesson is a sequel to Lesson C, introduce it as a continuation of that activity, but one that requires greater thought to answer the questions]. Tell them they are going to read an article that discusses *tortugas verdes* (green turtles) a type of animal that they cannot observe in their part of the country. Tell them also that after reading it they will form groups to answer questions which you will give them. [See the accompanying article].

IV. Activity:

As a class read the article orally giving turns to each student, helping them to pronounce and understand difficult words. Afterwards form groups and write on the board the following questions and below each the number of answers for each. [I have included the answers in parenthesis].

1. Describe *tortugas verdes.*
   - 1.1. (forward flippers are very large)
   - 1.2. (head is short and rounded)
   - 1.3. (measures 150 cm in length)
   - 1.4. (weighs 250 kg)
2. What do *tortugas verdes* eat?
   - 2.1. (marine grasses)
   - 2.2. (some invertebrates)
3. Where can we find *tortugas verdes* ?
   - 3.1. (in tropical seas throughout the world)
4. Describe their migration and nesting in Tortuguero.
   - 4.1. (each individual migrates every 2-3 years)
   - 4.2. (they remain in Tortuguero for 4 months)
   - 4.3. (each female lays eggs every 15 days)
   - 4.4. (each female lays a total of about 300 eggs per year)
   - 4.5. (*tortugas verdes* make about 20,000 nests in Tortuguero each year)
5. Approximately how many eggs are there in each nest in Tortuguero?
   - 5.1. (37-38 eggs per nest)
6. What are/were some of the relationships between humans and *tortugas verdes*?
   - 6.1. (food)
   - 6.2. (protection)
   - 6.3. (tourism)
   - 6.4. (cultural use -- ceremonial, decorative, etc.)

7. Why is Tortuguero important?
    7.1. (it's the site of one of the largest colonies of *tortugas verdes* in the Caribbean)
    7.2. (*tortuga verde* is a species in danger of extinction)
8. What is the principal subject of this article?
    8.1. (the nesting of *tortugas verdes* in Tortuguero)

Give each group time to answer the questions before discussing them. In your discussion emphasize the following for each question:

1. This article does not give a good physical description of a *tortuga verde*. If there were not a picture, it could be like the drawing to the right. The principal purpose of this article is not to give a physical description of a *tortuga verde*.

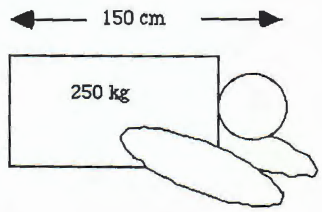


Figure 6. Tortuga Verde (imaginary)

2 & 3. It's necessary top read carefully.
4. Read for details.
5. This question is not easy. The answer is not 300 eggs!
6 & 7. It's necessary to infer these answers from the essay and from background knowledge.
8. This question relates to the author's bias and purpose for writing. Emphasize that every author has their own bias.

Figure 6. *Tortuga Verde* (imaginary)

After discussing their responses, tell your students the following:

"Pretend that we are all deputies in the Legislative Assembly. I am the deputy from Limón and want to change the law to permit the human consumption of the eggs of *tortugas verdes* from Tortuguero.

My argument is the following: Today there are approximately 20,000 nests on Tortuguero each year with 37-38 eggs in each one -- a total of around 750,000 eggs each year -- which is a very large number of eggs. In addition, today it is legally permissible to consume the eggs of another type of turtle, the *tortuga carpintera* or *lora* (Pacific Ridley), which nests in Ostional. Thus, I feel that the law as written is discriminatory against the people of Limón.

Now it is up to you to decide if you are going to vote in favor or against my proposed change, and you must give your reasons."

Afterwards take a vote (be sure that everyone votes, including you the teacher) and write both the results and the reasons on the board. Discuss these with your students.

V. Comments/Suggestions:

When I did this lesson, in all of my classes only one group could resolve the mathematical problem (question #5). Therefore, it may be necessary to help them by first asking the following questions:

1. How many eggs does each female lay in one year at Tortuguero?
2. How many nests are there in one year at Tortuguero?
3. How many nests does each female make in one year?

Alternatively, the teacher might want to emphasize when giving the problem that the answer is <u>not</u> 300, and then see if they can figure it out. The teacher could also extend this into a regular math lesson, possibly supplementing it with data on the nesting of other types of sea turtles.

The most important part of the voting activity is that the children understand there can be valid reasons for both positions. Many times it's necessary for people to choose between options, both of which may be justifiable. It's also important to understand that every argument is prejudiced by the bias of the person who makes it.

This activity could be done with any type of article about the natural world. What is most important is that the questions include different processes: seeking information, analysis, inference, interpretation, comprehension, and determination of an author's bias.

This article and activity is more difficult than "Guajipal" (Lesson C). The teacher can use both sequentially or choose one or the other depending on the ability of their students.

tortuga verde *Chelonia mydas*

El nombre de esta tortuga proviene del color de su grasa, que es verde. Sus aletas delanteras son muy largas y su cabeza es corta y redondeada. Llega a medir 150 cm y a pesar 250 Kg.

La tortuga verde se alimenta fundamentalmente de pastos marinos y, en menor grado, de algunos invertebrados. Se distribuye por los mares cálidos de todo el mundo. En el Caribe tiene dos colonias importantes: la Isla Aves en Venezuela y Tortuguero en Costa Rica.

Esta es una especie migratoria, que recorre grandes distancias desde su sitio de alimentación al de anidación. La migración individual ocurre cada 2 ó 3 años. Esta especie permanece en Tortuguero por 4 meses, de julio a octubre y los apareamientos se producen en aguas del Parque Nacional. Las hembras salen a anidar cada 15 días y ponen 300 huevos o más por año de puesta, luego no vuelven a poner, hasta dos o tres años después. En las playas del Parque Nacional se registran más de 20.000 nidos al año.

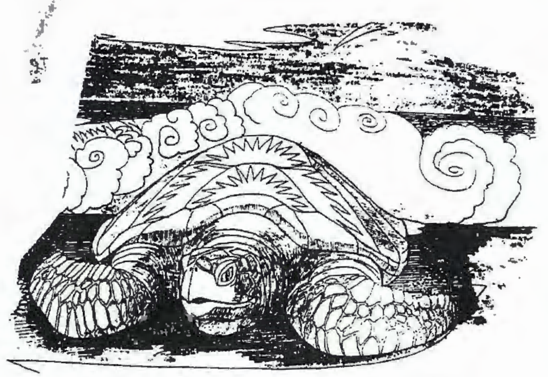
La tortuga verde ha sido utilizada como alimento desde hace mucho tiempo. De hecho su presencia en la zona fue el atractivo para los primeros asentamientos humanos en esta costa. En todo el mundo es una especie amenazada, tanto por la pesca de ejemplares adultos como por el saqueo de sus nidos para el consumo humano. Desde el establecimiento del Parque Nacional, en 1975, los nidos son protegidos, por lo que las poblaciones ya podrían estar recuperándose. En señal de respeto a una tradición de muchos años, se permite a los pobladores de Tortuguero capturar dos adultos por semana (para todo el pueblo), pero sólo después del desove y asegurando que se trate de individuos que están heridos o mutilados por tiburones.

La observación de estos gigantes cuando salen del mar a desovar es uno de los espectáculos más emocionantes que ofrece la naturaleza en Tortuguero. Sin embargo, es necesario observar ciertas normas:

*Dentro del Parque, sólo se puede visitar las playas en compañía de un guía autorizado.

*Las lámparas de mano y cualquier otra luz artificial asustan y desorientan a las tortugas, por lo que está prohibido su uso en el Parque; el visitante deberá acostumbrar sus ojos a la penumbra y caminar sin luz.

*Tampoco están permitidos los perros en la playa, ya que son depredadores de nidos.



tortuga verde

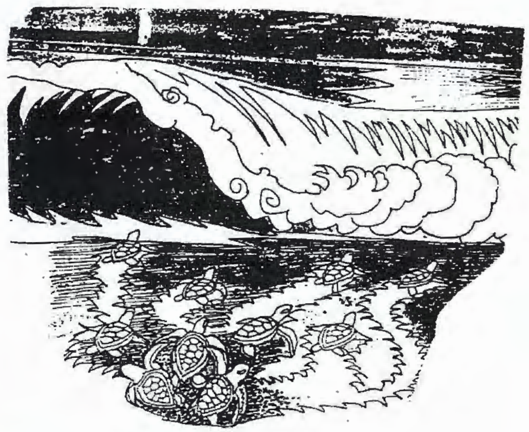


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Figure 6. Tortuga Verde-- Reproduced with permission of PACTO from Guía de Campo de las Especies más comunes del Parque Nacional Tortuguero by José A. Solano

Lesson 1 -- Biodiversity in Costa Rica

I. Objective:

The children will understand the concept of biodiversity and will realize that Costa Rica has a very high biodiversity. They will also investigate the importance of this high biodiversity for their country.

II. Materials:

1. Blackboard and chalk
2. Posters showing the flora, fauna and activities of the different regions of their country
3. Books and magazine articles that discuss the topic of biodiversity
4. Maps of Costa Rica and the world or a globe

III. Introduction:

Write on the blackboard the following, not including the numbers in parentheses (which are the answers for the competition):

Table 4. Biodiversity competition

	Costa Rica	World
# mammals	(201)	4,000
# reptiles	(199)	6,300
# amphibians	(150)	4,200
# birds	(850)	9,000
# butterflies	(1,200)	12,000
# insects		750,000
# orchids	(1300)	
# trees	(1500)	
Total # of species	(4% of total)	10-50,000,000

To begin say to the children, "First we want to define what is a species. Who can tell me what is a specie? [You may want to write down a number of their ideas before analyzing them (i.e. brainstorm first). Afterward discuss them and come up with a definition. Guide the discussion if necessary, particularly to distinguish between examples of species and the concept of species, using different examples to generate the concept. The use of examples such as horse, donkey , and mule can also help to make clear the importance of reproductive viability in defining a species (while two different species may be able to produce a hybrid, a hybrid of two different species cannot reproduce)].

After defining a species, ask them if they know what are mammals, amphibians, reptiles, etc. Give brief definitions again using some examples.

After these questions discuss the relative size of Costa Rica in comparison with the rest of the world, using a map or globe to emphasize that Costa Rica is very small in comparison.

When the children understand this continue by saying, "But Costa Rica has many different types of animals and plants, right? Let's see how many different species exist in Costa Rica in comparison with the rest of the world.

IV. Activity -- Biodiversity competition

Tell them that they are now going to have a competition concerning biodiversity and explain what you have written on the blackboard. "These numbers show how many species of each of these classifications exist in the world. I want you to guess how many species of each exist in Costa Rica." Then you should seek 5 answers from the children for each classification. After each and before continuing to the next indicate which answer is closest and write the correct answer on the board. (See the answers in parentheses). [You may want to comment on their wrong answers to help them think more realistically, e.g., reminding them of the very small size of Costa Rica].

V. Discussion:

After you have finished the competition, ask your students, "What is the significance of these figures?" Although with 6th grade it's possible to determine the percentages first, it may be better, especially with younger grades, to only emphasize that although Costa Rica is a very small country, it has a relatively high number of species. Therefore, we say that Costa Rica has a very high biodiversity. [If you want to discuss percentages emphasize that although Costa Rica's land area represents only .04% of the total world's land area, it contains 4% of the total # of species in the world, and in some classifications, e.g., birds and butterflies, much higher percentages].

To emphasize the high biodiversity, you might want to emphasize the following facts, using your map and/or globe:

1. Costa Rica has more species of birds than all of North America, not counting Mexico.
2. Costa Rica has more species of butterflies than all of Africa.

When you have finished this discussion, ask the children to write in their notebooks definitions of "species" and "biodiversity," and also to write a sentence about the biodiversity of Costa Rica. [You may want to have some children read them aloud or just check their notebooks later].

Afterwards, ask them the following: What is the importance for Costa Rica of its high biodiversity? [Is it helpful, e.g.?]. Make a list of their answers on the board, guiding them if necessary to come up with answers. Possible answers: (tourism; scientific investigation; medicine; source of work, food, and income; quality of life)]. After each answer solicit comments or examples that explain each answer, using local examples if they exist.

VI. Homework:

In groups have the children investigate each one of the answers given above. They should make a report that shows how the biodiversity of their country is important for Costa Ricans, in terms of that particular topic. They should also include how this high biodiversity helps the people of their community, in relation with this topic. The teacher should suggest that the children not only investigate using books and magazines, but that they should also interview the people of their community.

VII. Comments/Suggestions:

Originally, I taught lessons 1 & 2 together, but I observed that it was too much material for the children.

I suggest you begin the assignment in class or give the children time to do at least some of it, using the materials which are in the classroom.

The figures in the competition should be updated if you can find newer figures.

Lesson 2 -- The Climate of Costa Rica

I. Objective:

The children will understand the concept climate, what are its elements and its determinants. They will also understand the large diversity of climates one can find in Costa Rica is one of the most important reasons for its high biodiversity. They will demonstrate their understanding of its importance by indicating which are the characteristic flora, fauna, and commercial activities of each type of climate in the country.

II. Materials:

1. Blackboard and chalk
2. Posters showing the flora, fauna, and activities of the different regions of the country
3. Books and articles from periodicals which discuss biodiversity of the different parts of the country
4. Large school map of Costa Rica (with elevations)

III. Introduction:

Explain to the students that in our past lesson we examined the biodiversity of Costa Rica and that today we are going to continue by examining the principal cause for this high biodiversity.

Begin by asking them: "Why does Costa Rica have such a high biodiversity?" Write all the responses on the board. [Some possible answers: (country has a tropical climate; there are laws to protect species; the presence of national parks; environmental consciousness of the people; etc.). If your students don't say something similar to climate, try to solicit it from them by other questions]. Continue by saying let's examine the concept of climate. Begin by assuring your students understand the difference between climate and weather. Then ask the following:

1. What are the elements of climate? [answers: temperature, humidity, wind, atmospheric pressure, rain (or more generally precipitation), and solar intensity].
2. What are the factors that determine climate? [answers: latitude, elevation, general relief of an area, the disposition of mountains, proximity to sea, and the direction and speed of the wind].

Take time to discuss and explain how these cause differences in the climate of an area. [For example, the differences in the general wind direction during different parts of the year, combined with the disposition of the mountains causes the Pacific slope to have distinct dry and wet seasons. In contrast, the general direction of the winds on the Atlantic slope is constant throughout the year, which generally results in relatively constant rainfall throughout the year, with no dry season].

After this discussion, explain to your students that Costa Rica has five different types of climate: tropical wet, tropical very wet, tropical dry, intermediate or temperate, and cold. Show them the map (Figure 1) which illustrates in what parts of the country one can find each type of climate. [You could draw this on the board, or using different colored chalks mark the different climates on a large map of Costa Rica (the school map with different elevations is ideal for this].

Ask your students if they can explain why different regions of the country have these different climates. [See answers above]. Use the map to illustrate how mountains, elevation, direction of winds, etc. determine the climate. Emphasize where their town is located and what type of climate it has.

Figure 8 Climate zones of Costa Rica

IV. Activity:

Divide the class into five groups, one group for each type of climate. Each student should investigate one of these types of climate and answer the following questions:

1. Where do you find this type of climate in Costa Rica? (What do we call these regions?)
2. What are the characteristic flora and fauna of this type of climate? (of these regions?)
3. What are the principal commercial activities of these regions?

V. Homework:

The children should finish this project.

VI. Comments/Suggestions:

The children can do this work in groups, but if they do so, divide the responsibilities. [For example, some can make a map of the regions, others investigate the flora, others the fauna (can divide into birds, mammals, etc. if necessary), and others the commercial activities].

Lesson 3 -- Microclimates and Microhabitats

I. Objective:

The children will understand the concepts of microclimate and microhabitat and will demonstrate this understanding by constructing a chart showing the animals which can be found in different types of microhabitats.

II. Materials:

1. Blackboard and chalk
2. Notebooks
3. Magnifying glasses, if you have them

III. Introduction:

Review the five different types of climate in Costa Rica and that climate is the "conjunction of atmospheric conditions of a place." Then ask your students if anyone knows the meaning of the word "microclimate." To help them, divide the word like this: micro/climate and ask them if they know any words that begin with "micro."

Help them to understand that a microclimate is the "conjunction of atmospheric conditions of a very small place," whereas a macroclimate is that of a much larger place. [For example, Costa Rica has a tropical macroclimate because it's located within the tropics].

Afterward, ask them where, around the school, could be found different microclimates. It's possible you will need to give clues or some examples (like, "under a rock," or in the foliage of a tree," etc.). Finally, tell them that a place where one encounters a microclimate is called a "microhabitat."

IV. Activity:

Tell your students they should go outside, seek ten animals around the school, and write in their notebooks in what type of microhabitat each animal could be found. It's important that you go outside with your students and help them if they have problems. After about 15 minutes, the children should return to the classroom to discuss what they found.

V. Discussion:

When they return to the classroom, ask your students what types of microhabitats they found; write the name of one on the blackboard , and below write which animals were found in that microhabitat. Then do the same with the different types of microhabitats, depending on the amount of time you have. When you have finished, you will have on the blackboard a list of the microhabitats around the school and the animals which were found in each.

Explain that although some animals can be found in many types of microhabitat (they can live in different types of microclimates), others can be found in less or only one type of microhabitat.

VI. Homework:

The children should make a similar list of the microhabitats around their house and note which animals they found in each one of these microhabitats.

VII. Comments/Suggestions:

You could give to each child the responsibility to regularly examine a sample of land and note which animals were found in this area. (Possibly two or three times per day during a week). [See <u>Métodos de Educación Ambiental</u>, p. 72 & 114].

Lesson 4 -- Habitat, Niche, and the Necessities of Living Things

I. Objective:

The children will understand the concepts of habitat and niche and will demonstrate this knowledge by making daily observations of an animal.

II. Materials:

1. Blackboard and chalk
2. Magnifying glass, if you have them

III. Introduction:

Begin with a short discussion of the homework (microhabitats around the house and the animals found in each). Then discuss how you can find some animals in different microhabitats and introduce the concept of "habitat" ("the different places in which you can find a particular type of living thing").

Write the following definition on the blackboard:

habitat - "the place which a species occupies in a community." Within its habitat a living thing has available "all the conditions that enable it to live.

(Chac6n et al, p. 12)

Now ask your students, "What are the necessities of all living things?" Write them on the board. [Answers: food, air, water, territory or a home, and a means to protect and to reproduce itself]. Emphasize again that within its habitat, a living thing can satisfy all these necessities.

Continue by asking, "What is the habitat of a jaguar like? Is it large or small?" Then ask them, "Why does it need such a large habitat?" or "Why aren't there any jaguars near here?" [Answers: a jaguar needs a large territory to find sufficient food and also to hide from humans, who want to kill it and are its major predator]. Now ask the same about a centipede or some other very small animal. Compare the habitats and the necessities of each.

IV. Activity:

Before beginning this activity, write on the blackboard the name of an animal (such as a leaf-cutting ant). Discuss with your students its food (fungi which it cultivates), its manner of protection (biting and its anthill), its habitat (its anthill, trees, and the soil on which it walks), and its niche (it decomposes leaves and fertilizes the soil). Then ask your students to choose an animal (non-domestic) that lives in Costa Rica and write in their notebooks the following: 1) What is its food? 2) How does it protect itself? 3)What is its habitat? and 4) What is its niche? (its role in nature?).

V. Discussion:

Ask your students to tell their answers. It's probable you will have to help them, especially to understand what is an animal's niche. Discuss each of the children's examples, emphasizing that each animal has its own niche in nature, and is important in maintaining natural balance. [For example, squirrels, mice, and many birds propagate seeds; snakes and toads control pests (mice and insects, respectively); insects eat plants and provide food for many animals which cannot receive nutrients from plants, etc.]. In this way, by giving examples, the children will begin to understand the concept niche. When your students understand the concept, write the following definition on the blackboard:

niche -- "the function which a species carries out in an ecosystem" or "the role of a living thing in nature" (Chacón et al, p.11)

VI. Homework:

The children should make daily observations of a non-domestic animal (or group of animals) that lives near their house, noting on what it feeds, how it protects itself, what is its habitat, and if possible, what is its niche.

VII. Comments/Suggestions:

If the teacher wants to amplify this lesson, s/he could try the activity in Ambiente en Acción, p. 54. It would also be good to plan a small field trip to talk about and show the habitats of different animals.

Lesson 5 -- Plants and Their Importance

I. Objective:

The children will learn the importance of plants as the base of food chains. They will also understand the process of photosynthesis, and how plants replace oxygen in the air and use up carbon dioxide.

II. Materials:

1. Blackboard and chalk
2. 36 cards -- 6 with the letter "C"; 18 with the letter "O"; and 12 with the letter "H"
3. Tape

III. Introduction:

Begin by asking the children, "What things in this classroom are made from wood?" Write the answers on the board. (If possible, ask each child for at least one answer). Then ask them where wood comes from. Establish that wood products are an important use of plants for humans.

Afterward, tell them although wood is an important use of plants, they have other uses as well. Ask them for other uses and make a separate list on the board. [Possible answers: adornment, medicine, shade, wind breaks, living fences or barriers, prevention of erosion, base of food chains for living things (if the children forget this answer, solicit it from them using questions, such as, "Do you like to eat corn?"].

Emphasize that of all these uses, perhaps being the base of food chains is the most important since plants are the only living things that can produce their own food (nutrients). Ask your students if any of them know the name of this process and of what it consists. If nobody knows, you can solicit part of the answer by asking, "What are the necessities of plants?"

In this way you should try to solicit the following: Plants need sunlight, water, and carbon dioxide to produce their food (glucose). Following this, you should introduce the chemical symbols for these molecules: (water = H_2O ; carbon dioxide = CO_2 ; glucose = $C_6H_{12}O_6$) and afterward write on the board the following partial formula:

$$\underset{\text{water}}{H_2O} + \underset{\text{carbon dioxide}}{CO_2} \longrightarrow \underset{\text{glucose}}{C_6H_{12}O_6}$$

Explain that each letter signifies an atom of an element and that these combine to form molecules of different things (in this case, water, carbon dioxide, and glucose). Then explain that this formula shows how glucose (a type of simple sugar) is formed in plants, which the plants use as their food.

IV. Activity:

Depending on your class (its size and behavior) you can do this activity using the children or only the cards. Explain that they are going to produce glucose, which is what plants produce. Choose two children -- one to represent the sun, and the other chlorophyll. Then tell the other children that first they need to form molecules of water and carbon dioxide using the cards. Form groups and give out the necessary cards to the different groups [You will probably need to show them how to do so at first].

When they have formed all the molecules, tell them that now their plant is going to make glucose. Ask them to bring the molecules of water and carbon dioxide to the front of the classroom. [Each child could represent a molecule or you can just tape the molecules to the board].

When all the molecules are in front, ask them to count how many of each type there are. Write these numbers in front of the symbols in the above formula like this:

$6H_2O + 6CO_2$

Then ask the children who represent the sun and chlorophyll to create a molecule of glucose, arranging in a different way the atoms of water and carbon dioxide. [Again, it may be necessary to help them do this]. When they have finished, they should have one molecule of glucose ($C_6H_{12}O_6$) and twelve atoms of oxygen (O).

Tell your students, "Now we have formed a molecule of glucose, but we have left over oxygen atoms. What can we form with these? Help them to understand that with twelve atoms of oxygen we can form six molecules of oxygen ($6\ O_2$).

Now write the rest of the formula:

$$\text{water} + \text{carbon dioxide} \xrightarrow[\text{chlorophyll}]{\text{sunlight}} \text{glucose} + \text{oxygen}$$

$$6H_2O + 6CO_2 \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$$

When you have finished, tell your students that this formula represents the process of photosynthesis and write down the following definition:

"Photosynthesis is the process in which plants, with the aid of sunlight and chlorophyll, convert water and carbon dioxide into their own food (glucose) and oxygen."

V. Discussion:

After discussing this definition, ask your students to tell you two reasons why photosynthesis is very important for living things. [It's the source of all food and through the process plants increase the quantity of oxygen in the air, while at the same time reducing the amount of carbon dioxide].

Emphasize that the process of photosynthesis complements the process of respiration in that each uses the products of the other -- photosynthesis uses water and carbon dioxide, the products of respiration; meanwhile, respiration uses glucose and oxygen, the products of photosynthesis. Assure they understand that without either of these two processes, life on this planet would be impossible.

Afterward talk a bit about how plants serve as basic food for all living things, and explain in simple terms the concept of a food chain.

VI. Homework:

The children should draw a food chain and write a paragraph explaining it.

VII. Comments/Suggestions:

Although the process of photosynthesis could be difficult for the children to understand, the concept is very important since it is fundamental in ecology and serves as the base of many of the relations in any ecosystem. It's therefore worthwhile to take the time to assure that your students understand the concept.

If your class is well-behaved, you could use children to represent the different molecules. If not, it's better to use only the cards.

Lesson 5A -- The Tree

I. Objective:

The children will understand the functions of the different parts of a tree.

II. Materials:

1. Blackboard and chalk
2. Plastic bags for seedlings
3. Seeds
4. Soil (a mixture of good soil and rice husks)

III. Introduction:

Begin by asking your students what are the different parts of a tree and write them on the board. Then have them tell you the function(s) of each part and write down these next to each part. [It's probable you will need to help them remember some of the functions]. When you are done you will have a list like this:

roots -- sustain the tree, absorb water and minerals
leaves -- respiration, produce food via photosynthesis, shade
bark -- protect the tree
flowers -- reproduction (through pollination)
fruits -- distribution and germination of seeds
trunk -- sustain the tree

IV. Activity:

After discussing the functions of the various parts of a tree, construct a tree with the children acting as parts of the tree (See "El Arbol Conversa," Ambiente en Acción, 46), but add leaves, making up a motion to signify the action of photosynthesis.

V. Discussion:

Review each part of the tree and ask your students to tell you its function.

VI. Homework:

1. The same day or another, the children should fill bags with a mixture of soil and rice husks and plant a seed in each bag. You can use these bags to start a school tree nursery or the students can take them home to their houses to care for them.
2. There are different types of trees -- fruit trees, leguminous trees, ornamental trees, trees from which we obtain lumber, etc. Divide the class into groups. Each group should investigate a type of tree and make a list of the trees of that type which are most common in their region.

VII. Comments/Suggestions:

You can also do this activity with young children. If you do, it's best to also have them draw a picture of a tree showing its parts in their notebooks.

This activity is recommended for Día del Arbol (Tree Day) or before beginning a school tree nursery. If the school has or is going to have a nursery, you could give to each child the responsibility to regularly note the height of "their" seedling, how many leaves it has, the size of its leaves, etc. The children could then construct a chart which shows the growth of their tree.

Lesson 6 -- Food Chains/Webs

I. Objective:

The children will learn how the transfer of energy between living things is in fact a food web or network and not just a simple chain. They will also understand the different roles of producers, consumers (herbivores, carnivores, and omnivores), and of decomposers. They will demonstrate this understanding by classifying different living things by their role in a food web.

II. Materials:

1. Blackboard and chalk

III. Introduction:

Begin by discussing the homework of the last lesson. Ask your students to tell you the parts of their food chains and write some of them on the board. Explain that each chain is an explanation of how energy is transferred -- each living thing receives its energy from its food source, and in turn is the source of energy for another living thing. Emphasize that the origin of energy in all of the food chains is the sun. This solar energy is transferred into glucose by plants through photosynthesis; animals then obtain this energy either directly or indirectly, and finally, fungi and bacteria return this energy back to the soil, for plants to use as nutrients.

Using the children's examples, label each part of their chain as producer (principally the plants), consumer (principally the animals), or decomposer (fungi and bacteria). Distinguish the different types of consumers (herbivores, carnivores, and omnivores), again using their examples.

You should also explain that at each level of a food chain, there is less energy (the living thing has used part of it). Therefore, there are less predators at each higher level, since at each level it's necessary to consume more to survive. Thus, the biomass (total quantity [by weight] of living things) of the producers is the highest, that of herbivores is the next highest, etc. , until the level of the largest predators of which there are relatively few. [There are very few jaguars compared to the number of plants in a forest].

Finally, tell your students that unfortunately, in reality the transfer of energy does not occur in a simple chain; rather, it 's more accurate to say that it occurs within a web or network.

IV. Activity:

To demonstrate this final point, choose one of the food chains written on the board. Ask several of your students to come forward and represent different parts of the chain. To represent the transfer of energy (food), the children should hold the hand of those from whom they obtain energy.

Now ask the other students what other animals might obtain energy from different parts of the chain. If a child gives an answer add them to the chain to represent that animal. By doing so, you will soon see that instead of a chain, a web or network is being formed, which is much more complex than the original food chain. Emphasize that this -- the formation of food webs -- is what really occurs in nature.

Now, tell your students they are going to have a competition. Write the names of 20 living things on the board (although the majority should be common, include some which may be less familiar to the children). Tell them they need to classify each living thing by its role in nature, whether it is a producer (P), herbivore (H), carnivore (C), omnivore (O), or decomposer (D).

After about 15 minutes have them exchange papers. Ask for the answers and tell them if they are correct or not, and why. Discuss any which present problems to the children. They should mark which are correct, and at the end determine the winners. [Have more than one winner -- the first winner, the second winner, the third winner, etc.].

V. Discussion:

Review the different parts of food webs, emphasizing again that the higher a living thing (predator) is on a food web, the greater amount of prey it requires to obtain its energy. Solicit definitions of each part from your students, and write them down, modifying them if necessary.

VI. Homework:

The children should construct a food web of a farm or a pasture. This should include at a minimum: 5 producers, 3 herbivores, 3 carnivores, 3 omnivores, and 2 decomposers. They can make a drawing if they wish. In addition, they should write a paragraph or more explaining what occurs in their food web and what role each living thing plays in it.

VII. Comments/Suggestions:

The teacher can divide this lesson into two parts, if desired -- one part introducing the concept of a food web, and the other discussing the different roles played by living things within food webs.

The teacher should review the roles played by different living things before the competition. Some are not obvious!

These concepts are well explained in Biología Integrada -- Los Seres Vivos y Su Ambiente.

Lesson 7 -- Non-living Things -- Water

I. Objective:

The children will learn about the importance of water for our daily life, and about the water cycle. They will also appreciate the necessity to conserve our water.

II. Materials:

1. Blackboard and chalk

III. Introduction:

Begin by saying that until now we have been studying living things and review what these are. Then tell your students we are now going to study non-living things. Solicit from them a definition of non-living things and examples of them [inorganic substances; elements of climate; and some organic substances which are produced by living things, but themselves do not have the capability of life]. Make a list of them which should include air, water, rocks, etc. Tell them that today we are going to study one of these -- water.

Ask them to tell you all the different uses of water. Write them on the board. [Possible answers: photosynthesis, watering plants, drinking, washing clothes and other things, bathing, making solutions, cooking, operation of toilets, use in industry (such as coffee extraction plants), habitat for animals, medium for transportation/shipping, etc. (It's possible you will have to help them with some of these)].

Now ask them, "What kinds of water can we find in the world and where do we find them?" [Answers: salt water -- ocean, estuaries; fresh water -- streams, rivers, lakes, underground, rain, snow, clouds, water pipes, holding tanks, etc.; polar ice caps -- polar regions]. Then on your list of uses, indicate which kind(s) of water are used for each.

When you have finished ask your students, "Where does our fresh water come from and what happens to it?" Solicit that it comes from rainwater. Again ask, "And from where does rainwater come?" [Answer: clouds]. Continue questioning them until the children have defined the water cycle in reverse. [It's much easier to solicit answers if you draw in each part of the cycle as they mention it (See Figure ?)].

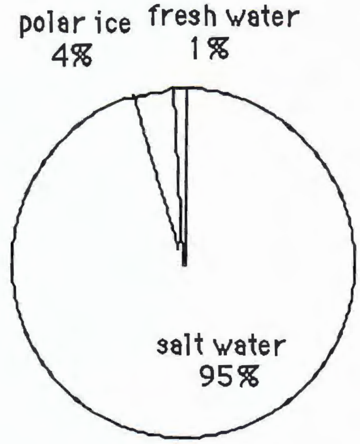
After you have drawn the whole cycle, review it with your students and discuss how the water changes. [The sun shines upon the salt water in the ocean. Slowly the water is evaporated, leaving behind the salt and other minerals that are in it. This fresh water vapor rises into the air where it forms clouds. The wind blows the clouds over the land. The clouds rise over mountains and as a result of cooling can hold less water vapor. The excess water vapor changes to water and falls down in the form of rain. This rain is used by living things, some is absorbed into the ground, and some flows directly into rivers. Eventually, all the water will flow into rivers in which it dissolves new salts and other minerals. Finally, this water will flow again into the ocean, where it will again be in the form of salt water].

IV. Activity:

Have your students make a quick drawing of the water cycle. See Figure ? Give them approximately 20 minutes to quickly copy the drawing on the board, telling them they will use this drawing as a guide for one of their homework assignments

V. Discussion:

When they have finished sketching the water cycle, draw a large circle on the blackboard and divide it as shown in the drawing below. Tell your students this circle represents all the water which exists in the world, with the three divisions representing the three types of water (salt water, fresh water, and polar ice). Ask them to guess which parts represent which types of water. When they have finished guessing, tell them that almost 95% of all water is salt water; about 4% is polar ice; and only 1% is fresh water. Label the different parts of the circle as shown.



Discuss with your students the implications of these figures in connection with our uses of water (our use of fresh water for most things). Emphasize the serious problem which contamination of our fresh water sources presents and the necessity for us to keep our fresh water clean.

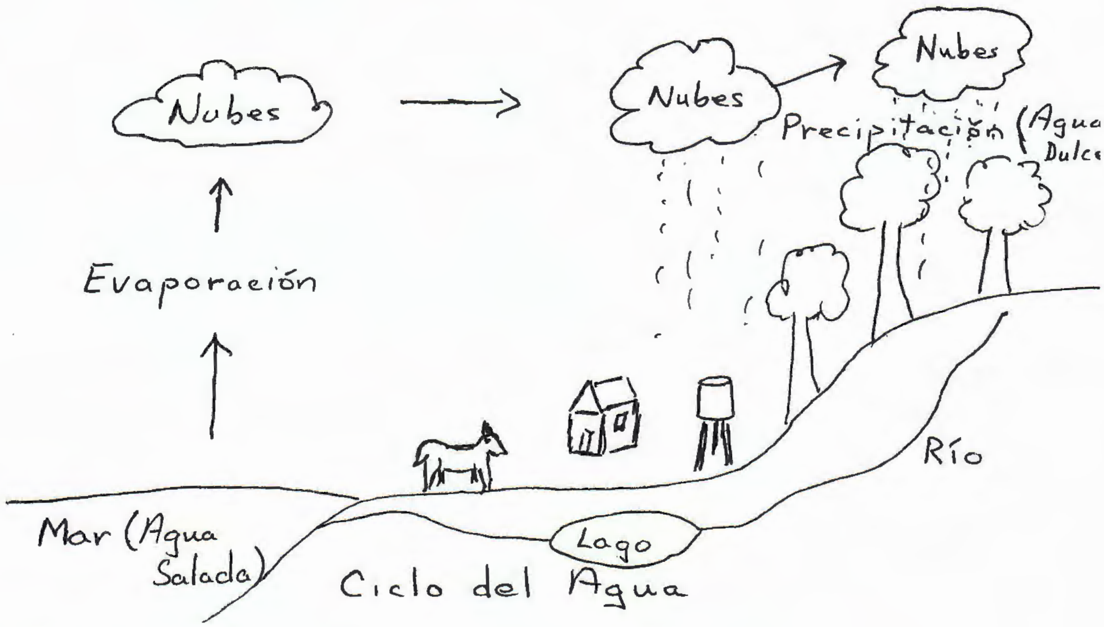


Figure 9. Water cycle

VI. Homework:

1. The children should make a good drawing of the cycle of water, including in their drawing some of the different uses of water. They should then write an explication of their drawing and how it illustrates the water cycle.
2. They should write a story about the "travels" of a water droplet.
3. They should write a response to the following question: "If the climate of the Earth is warming up, as many scientists believe, what effects would this have on the Earth and on living things; and specifically, what effects would it have on Costa Rica?"

VII. Comments/Suggestions:

If the teacher wants to include other activities relating to water, there are other lesson ideas in Ambiente en Acción , p. 17-25.

Lesson 8 -- Air (Carbon-dioxide -- Oxygen)

I. Objective:

The children will learn about the importance of the oxygen and carbon dioxide which are found in our air. They will also begin to understand the importance of the increase in carbon dioxide in our air -- "The Greenhouse Effect." Finally, they will discuss the possibility that Costa Rica and other tropical countries could receive monetary help from more developed countries as payment for "exchanging" their carbon dioxide for Costa Rica's oxygen.

II. Materials:

1. Blackboard and chalk

III. Introduction:

Ask your students, "For what is air used?" and write their responses on the board. [Possible answers: respiration, photosynthesis, wind mills, production of energy, sailboats, balloons/other inflated things, flight (kites, airplanes, living things), and combustion. (If your students don't mention respiration, photosynthesis, and combustion, solicit these answers with questions)].

Then ask them if anybody knows what air is composed of. [Answer: principally nitrogen, oxygen, and carbon dioxide]. Then ask them if they can guess what percentage of air is composed by each gas. After their guesses, write the following: ">78%" and ">21%" and explain what ">" means. Then tell them these percentages are those of two of the three gases and ask them which are those gases. Finally, write the following for nitrogen and oxygen:

Table 5. Percentage of gases in the air

nitrogen	(N)	--	> 78%
oxygen	(O_2)	--	> 21%
carbon dioxide	(CO_2)	--	[< 0.03%]

Before you write down the figures for carbon dioxide, ask your students if they can calculate the amount.

After you have done this, ask your students which part of air is used for each one of the uses they listed above, and write the symbol for it next to each use. Discuss the importance of oxygen and carbon dioxide for the processes of photosynthesis, respiration, and combustion.

IV. Activity:

Make a quick drawing of the cycle of O_2 - CO_2 (See Figure ?). Explain each part, and then have your students make a quick sketch of it to use as a model for their homework assignment. Once again, allow about 15-20 minutes to do so, emphasizing they will do a better one at home.

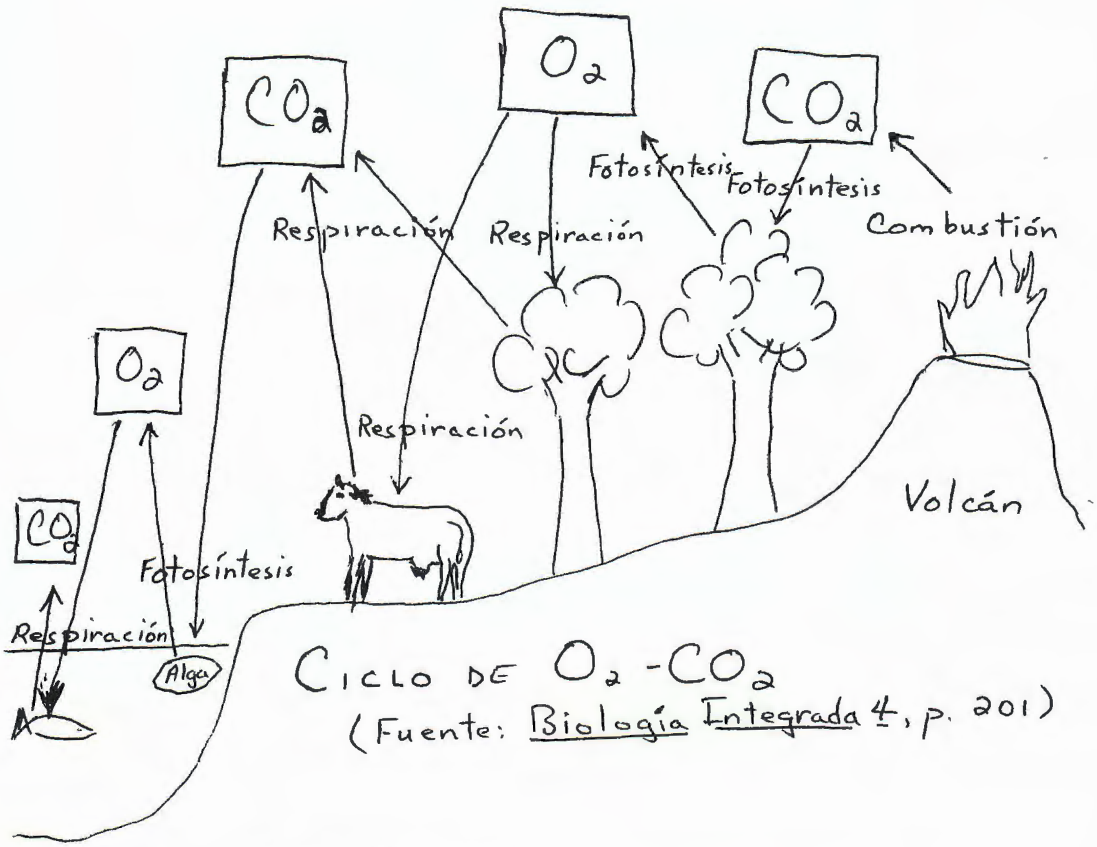


Figure 10. Oxygen-carbon dioxide cycle

V. Discussion:

Review with your students the complementarity of photosynthesis and respiration using their respective formulas [The formula for respiration is the reverse of photosynthesis]. Explain that combustion is similar to respiration in the sense that it too uses oxygen and produces carbon dioxide. Discuss the importance of forests which use up carbon dioxide and produce oxygen. Emphasize how photosynthesis and respiration in combination maintain the balance of gases in the air.

However, you should now explain that the level of carbon dioxide has been increasing due to high levels of combustion principally caused by industry and cars. One idea to counter this increase and improve the situation is to plant many trees which can absorb this excess carbon dioxide. Given that trees grow much more rapidly in the tropics, it has been suggested that developed countries should pay tropical countries to plant and maintain trees to compensate for the increased levels of carbon dioxide produced by the developed nations, and thus, maintain the equilibrium of gases which is necessary to sustain life.

Discuss with your students these ideas. Have them represent different nations, companies, etc. Debate whether this concept is fair or just.

VI. Homework:

1. The children should make a drawing of the O_2 - CO_2 cycle and write an explanation of it.
2. They should write a response to the following question: "If we burn too many forests, what could be the effect on living things?"

3. Explain to them as of yet we have not discussed the role of nitrogen, but will address it in our next class. In preparation, they should ask their parents or other farmers which type(s) of fertilizer they use and for which crop(s).

VII. Comments/Suggestions:

The teacher may want to demonstrate the ability of plants to use both oxygen and carbon dioxide. Place a plastic bag completely over a plant. In several days have the children examine the plant and write down their observations of what has occurred. [The plant will have survived because although it absorbs oxygen and releases carbon dioxide (process of respiration), it also uses the carbon dioxide to produce oxygen (process of photosynthesis). They should also note that water droplets have formed inside the bag -- since water is also a product of respiration].

The teacher and students can also construct a terrarium which contains small animals as well as plants. Although the terrarium is completely covered, the living things within it can survive because there is a continual interchange of oxygen and carbon dioxide.

Lesson 9 -- Air (Nitrogen)

I. Objective:

The children will understand the importance of nitrogen in the air and how it is used by leguminous plants as fertilizer. They will also learn how it is possible to use natural fertilizers instead of artificial chemical ones.

II. Materials:

1. Blackboard and chalk
2. Science text book - - Rocap - Ciencias 5

III. Introduction:

Review with your students the percentages of various gases in the air:

Table 6. Percentage of different gases in the air

nitrogen	(N)	--	$> 78\%$
oxygen	(O_2)	--	$> 21\%$
carbon dioxide	(CO_2)	--	$< 0.03\%$

Tell your students although nitrogen is by far the largest constituent of the air, up until now we have not discussed its importance. Ask if anyone in their investigation had learned its importance. If not, ask them which types of artificial fertilizers the farmers of their community use. Write the numbers of the fertilizers on the board (5-10-5, 10-15-10, etc.). Again, ask them if they know what is the significance of these numbers. If nobody knows, explain that these represent the respective proportions of nitrogen, phosphorus, and potassium compounds in each fertilizer.

Explain that plants need to use nitrogen to grow, but that they cannot use it directly from the air. They can use nitrogen only when it is within compounds called nitrates. Often, the soil does not contain enough nitrates; crops and other plants have used them up. Therefore, farmers will add artificial fertilizers in which these compounds are present to enrich the soil.

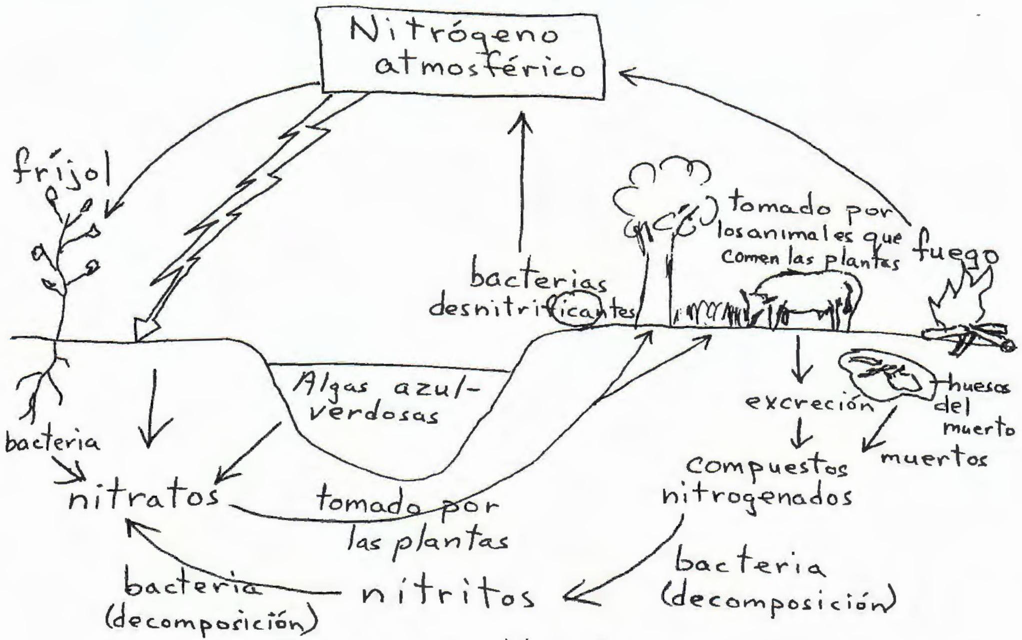
Now ask your students to tell you for which crops each of the different fertilizers are used. Make a chart on the board which shows the crop and fertilizer used. Leave space for another column. When you have finished filling in the chart, ask them if any of the farmers with whom they talked used natural fertilizers and for which crops they used them. Write these in the last column.

Explain that natural fertilizers can be found in nature. The principal natural fertilizers are the leguminous plants. With the help of the bacteria that are in their roots, these plants are able to "fix" the nitrogen from the air into the soil (convert it into nitrates), which plants can then use as nutrients. [Electrical discharges of lightning and the action of some bacteria and blue-green algae can also convert nitrogen into nitrates].

Finally, explain that, although in modern times people often use artificial chemical fertilizers, for many thousands of years indigenous peoples have used this ability of leguminous plants to fertilize their crops. [In Central America and Mexico beans have traditionally been cultivated and used as natural fertilizer in combination with corn].

IV. Activity:

Make a quick drawing of the nitrogen cycle (See Figure ?) and explain it to your students. Have them quickly sketch it, again to use as a basis for their homework assignment.



Ciclo del Nitrógeno
(Fuente: Biología Integrada 4, p. 200)

Figure 11. Nitrogen cycle

V. Discussion:

Review with your students the nitrogen cycle. Begin with an explanation of how leguminous plants fix nitrogen in the soil, and how later plants and animals can use it. Discuss with them as well how nitrogen is returned to the soil. Finally, discuss the different roles that bacteria play in the cycle.

Discuss ways in which farmers can use leguminous plants as fertilizer for their crops. Conduct a discussion on the relative advantages of each type of fertilizer -- natural or artificial.

VI. Homework:

1. The children should make a good drawing of the nitrogen cycle and write an explanation of their drawing.
2. They should investigate further the use of natural fertilizers and make a list of the leguminous plants in their region that are used in this way.
3. For the next class, they should bring between 5 and 10 different types of rocks.
4. If your school has the book, they should read pages 176-197 in Rocap - Ciencias 5, and answer in writing the questions #4-13 on page 198.

VII. Comments/Suggestions:

The teacher could invite a farmer or a representative of MAG (the Ministry of Agriculture) to talk about the use of natural fertilizers. The class could also visit a coffee plantation or farm to observe the use of *poró*, *madero negro*, and other leguminous trees.

Lesson 10 -- Rocks

I. Objective:

The children will learn the origins of different types of rocks. They will also have some understanding of their importance and uses in their country.

II. Materials:

1. Blackboard and chalk
2. The rocks which the children have brought
3. Different types of rocks, as examples
4. Lemon juice

III. Introduction:

Tell your students that, as they probably found when looking for their rocks, there are many different types of rocks. Show them different types of rocks which you have previously collected.

Form groups with 2-3 children in a group. Ask them in what ways they could classify their rocks. Discuss some of these (e.g., size, hardness, color, etc.). Give them about ten minutes to make lists classifying the rocks of their group in different ways.

When they have finished, write their answers on the board -- the different ways in which they classified their rocks, and what types were present in each classification. [Form, color, size, hardness, texture, stratification, brightness, density].

IV. Activity:

Now ask them, "What are the reasons for these differences in rocks?" Help them to understand the differences are the result of three things: 1) Composition 2) Origin and 3) "Experience" (what has happened to the rock since it was first formed -- erosion, increased pressure, temperature changes, etc.).

Review the list of classifications and discuss which are the principal causes for each classification. [For example, color is principally caused by composition].

Now make a drawing on the board of the Rock Cycle (See Figure ?) and explain it to them. Give them time to make a quick sketch as a basis for their homework assignment.

V. Discussion:

Show your students they can determine the relative hardness of the minerals which are present in their rocks (by seeing which scratches which). If you have limestone or a piece of marble, you can also show them the reaction of acids (use lemon juice) with this type of rock.

Review the different origins of rocks. Afterward, make a list of the different uses of rocks in your country. Make sure the students include the formation of soil in their list. [Solicit this answer if necessary].

VI. Homework:

1. The children should make a good drawing of the rock cycle and write an explanation of it.
2. They should investigate the uses of minerals in your area or make a map which shows which minerals can be found in the different regions of the country.
3. If they want they can look for other types of rocks and experiment with them.
4. For the next class, the children should bring samples of different types of soil in jars (2 or 3 samples).

VII. Comments/Suggestions:

The teacher can divide this activity if there is not enough time. The class can also make a field trip to a quarry (if nearby) or to some place where rocks are exposed to the air (preferably different types).

If the teacher is not going to use Lesson 10A (which is optional), s/he may want to discuss the geologic origin of their region (the source of most of their rocks).

The teacher can find more information or ideas for activities concerning rocks and minerals in <u>Rocap - Ciencias 5</u>, p. 176-197; <u>Ciencias Naturales 5</u>, p. 58-71; and <u>Ciencias de la Naturaleza 6</u>, p. 202-212.

The town of Piedras Negras in Puriscal is one of the few places in Costa Rica where obsidian is readily found.

Figure 12. Rock cycle

Lesson 10A -- Geology of Costa Rica

I. Objective:

The children will learn the difference between Volcanism and Orogeny. They will also have a basic understanding of how both of these are a result of the movement of continental plates. Finally, they will learn how Costa Rica was formed.

II. Materials:

1. Blackboard and chalk
2. Large school map of Costa Rica (with elevations)
3. Student school map of Costa Rica

III. Introduction:

Ask your students if they have ever heard about the Plate Tectonics Theory. Discuss with them these basic concepts of this theory. [Source: La Diversidad Biología de Costa Rica].

1. The most external rocky layer of our planet is divided into pieces or "plates," some of them gigantic, others medium-sized, and others much smaller.
2. These pieces, the tectonic plates, are in constant movement -- colliding, sliding by, or moving away from each other -- depending on the forces being exerted.
3. These plates form the lithosphere, (whose depth varies, and may be as much as 200 kilometers, depending on the region).
4. The lithospheric plates rest upon a layer of molten rock, the asthenosphere (at a depth of 100 kilometers or more), whose energy and fluidity make possible these movements.
5. The form and position of the present-day continents have not always been as we know them as present.
6. The principal interactions of neighboring plates are:
   - A. Subduction -- When the two plates "converge" (are moving against each other), the heavier plate slides under the lighter one. This process produces a large amount of heat and pressure which can have two results:
     - 1) Volcanism -- This heat can melt rock where the two plates slide by each other. This melted rock or "magma" can then rise in finger-like projections through cracks in the plate which is above. If these projections reach the surface, they will form volcanoes; if they do not, they will solidify in the interior and will become intrusive igneous rocks (like granite).
     - 2) Orogeny -- The pressure of subduction can cause the upper plate to be compressed along the line of interaction. This causes the plate to "buckle" rising up along this line and forming mountains.
   - B. Accretion -- During the process of subduction some portions of the lower plate remain attached to the upper plate.
   - C. Ocean-floor spreading -- Within the ocean, where plates are separating (moving in opposite directions), magma (molten rock) flows out from very great depths, solidifies and fills in the spaces left by the spreading plates. In this way these rocks are "born" or originate in zones of expansion and move out toward the zones of subduction. These movements are known as tectonic movements.
   - D. Faults -- These occur when one plate slides by another creating a zone of friction. This friction may cause tremors and sometimes earthquakes.
7. The tectonic effects in Costa Rica are principally the result of the convergence of the Cocos and Caribe Plates, and the subduction of the Cocos Plate below the Caribe

Plate. [Show the approximate positions of the two plates on the map of Costa Rica].

[The teacher can easily demonstrate how the students can simulate the processes of subduction and orogeny, and the action of faults. For subduction: Tell your students to put their fists together and press them against each other. Eventually one or the other fist will slide below the other; at the same time the opposite wrist will rise up (forming mountains by orogeny). You can also explain that often this pressure can produce enough heat to melt rock producing magma, which may rise all the way to the surface and form volcanoes. For faults: Tell your students to press their open hands together. Eventually, one or the other or both will slip rapidly, causing a "tremor" or even an "earthquake."]

IV. Activity:

Tell your students that you are now going to help them apply these concepts to the formation of Costa Rica. Use the large map to show them, but it would be better if you also draw it on the board and color it when you talk about the different geological reasons. [See the drawing at the end of this lesson].

Begin by telling them that up to about 30-40 millions of years ago there existed a strait between North and South America. [The part of Central America, which includes Costa Rica, the southern part of Nicaragua, and the western part of Panama, did not exist before this]. Rather, instead of this isthmus, there was a series of volcanic islands, each being born through volcanism before disappearing through the processes of erosion, only to give way to new islands. Some of these rocks formed during that era were deposited in layers, forming sedimentary rocks, which later on joined themselves to the new isthmus through the process of accretion. Today one can find these rocks in Santa Elena, the Nicoya and Osa Peninsulas, and in the zones of Herradura and Burica. [Draw with a colored chalk some islands between Nicaragua and Panama on the map on the board. Then erase them to signify their erosion. Draw others. Erase them again, but this time leave some in the aforementioned regions. Write the key (see drawing) in the same color].

Afterward (around 30-40 million years ago) pressures generated by the subduction of the Cocos Plate under the Caribe Plate caused the formation of the Talamanca Mountains through orogeny. When these mountains rose, they also fractured allowing magma to rise. However, it did not reach the surface (thus, no volcanoes were formed in this region); instead, it solidified beneath the surface forming intrusive rocks. [Using a different color, draw the Talamanca Cordillera on the board and write the key in the same color].

Following this, continue with the formation of the Tilarán Cordillera and the hills of Aguacate. [I believe this includes the region around Puriscal; at the least it includes Cerro Turrabares]. This region was formed about 10 million years ago by intensified volcanic action to the northeast of the Talamanca Cordillera, although today there are no active volcanoes in this region. At the same time part of the northern Pacific region rose. The result was that there now existed a narrow strip of land which connected North America with South America. [Using a different color draw the Tilarán Cordillera, the hills of Aguacate, and the land bridge formed during this era. Write the key in the same color].

Now continue with the most recent volcanism -- the formation of the Central and the Guanacaste Ranges. These mountains were formed by extensive volcanic action which began about 2 million years ago and still continues today. [Using a different color, draw these mountain ranges and write the key in the same color].

Finally, continue with the formation of the Atlantic coastal regions (llanuras), and the rising of the Pacific Coast. These began about 2 million years ago and lasted for about one million years. [Draw these regions and write the key in a different color].

Now make the graph which shows the relative ages of each stage of the process.

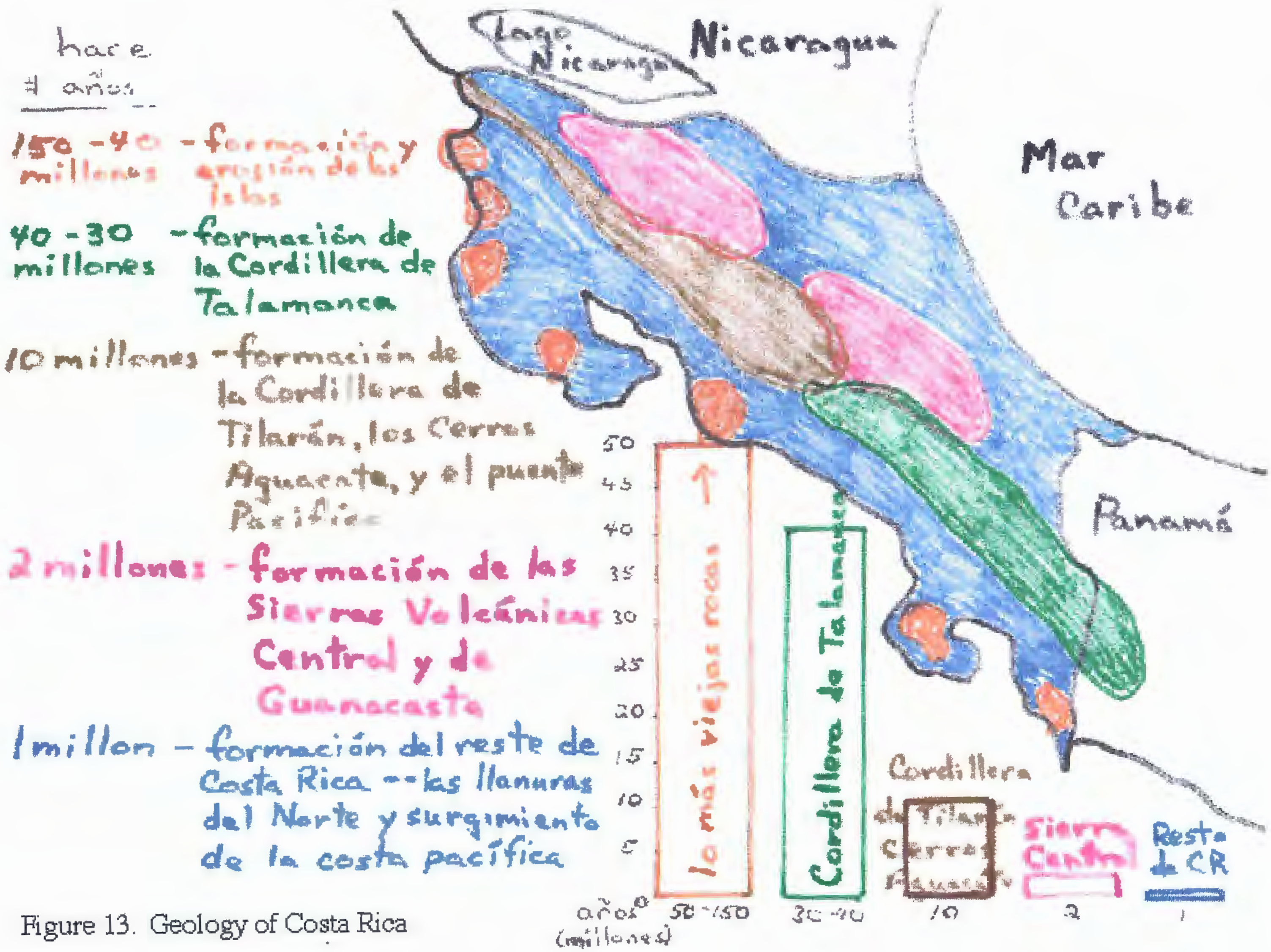


Figure 13. Geology of Costa Rica

V. Discussion:

Ask your students what effects the geologic formation of Costa Rica had on its biology. Discuss. Some ideas:

1. There were no dinosaurs in Costa Rica. Dinosaurs disappeared about 65 million years ago, before Costa Rica was formed.
2. Until about 150 million years ago the majority of the biofauna of North and South America evolved separately. When islands began forming in what had been a large strait, there was a small possibility of interchange. But it was only about 10 million years ago, with the formation of the Central American land bridge, that a full interchange was possible. A large number of new species colonized Costa Rica.
3. With the formation of the mountain ranges the biofauna of the Pacific and Atlantic regions were separated and began to evolve separately. This process of separate evolution continues today as these mountains serve as biological barriers for both land and oceanic species of the Atlantic and Pacific sides of Costa Rica.
4. One result of the above considerations is that Costa Rica has a high biodiversity [See Lesson 1: The Biodiversity of Costa Rica].

VI. Homework:

1. Write in your own words a description of the geologic history of Costa Rica and how it affects the biodiversity of Costa Rica.
2. For the next class, the students should bring some samples of different types of soil in jars (2 or 3 samples).

VII. Comments/Suggestions:

I have included a large amount of technical information in this lesson. [The majority is from La Diversidad Biológia de Costa Rica, p. 53-73]. The teacher can use whatever part s/he desires and explain it in their own words (depending on their students).

This lesson is optional. If you give this lesson, omit homework assignment #4 from Lesson 10; instead give it this lesson (#2) as preparation for the next class on soil.

You can use this class as the basis for your discussion on ecological equilibrium (Lesson 15).

Lesson 11 -- Soil

I. Objective:

The children will learn what is the origen of soil, of what it consists, and its importance. They will also know different types of soil and their relative importance for the crops of their region.

II. Materials:

1. Blackboard and chalk
2. Samples of soil (brought in by the students)
3. Pamphlet #4 -- "The Soil" (by PRODAF/GTZ)

III. Introduction:

Review with the children that you have already discussed with them that one of the most important uses of rocks is the formation of soil (Lesson 10). Tell them that even as there are many different types of rocks, there are also different types of soil and that these differences are in part caused by which types of rock formed the soil.

IV. Activity:

Tell your students they are now going to investigate their samples of soil. Form groups being sure that each group has approximately the same number of samples. [It's better to form groups with few members (2-3)]. Explain that each group should construct a chart detailing the characteristics of each of their samples, as shown below:

Table 7. Analysis of soil samples

	Sample	Color	Compactness	Moistness	Composition
#1					
#2					
#3					
#4					

Explain to them each group should first decide for each sample its color, how compact, and how moist it is, according to the following criteria:

Compactness: Very compact, Compact, Medium, Loose, Very loose
Moistness: Very moist, Moist, Medium, Dry, Very dry

After classifying the different samples according to these characteristics, they can then separate each sample to determine its different components.

V. Discussion:

Ask the children if there are differences in their samples. Discuss that each type of soil has its own characteristics, but in general the soils are characterized as clay, mixed and sandy depending on their compactness. [clay: rock particles extremely compact; sandy: rock particles totally loose; and mixed: a mixture of clay and sandy soils]. You should also emphasize that the organic parts (twigs, leaves, etc.) which they found in their samples are going to decompose to form humus, the organic part of the soil, which helps the growth of plants.

VI. Homework:

1. The children should interview their parents and other farmers concerning the different types of soil in their community, and which are the best/worst for which crops in their community.
2. Write a report of your interview.
3. For the next class, write a paragraph or more on what you feel is signified by the concept "nature."

VII. Comments/Suggestions:

The teacher can arrange a brief visit with the class to a place where several meters of soil are exposed and discuss with them how the soil is formed.

The children can act out the formation of soil as in Ambiente en Acción, p. 28, or the teacher can use other activities in this book (p. 28-37).

You can experiment with different soils. [For example, the ability of each type to absorb water; or an experiment to compare how much time each one can retain water (How much time it takes to dry?). Discuss the benefits/drawbacks of each type for farmers and life in general.

Lesson 12 -- Ecology: Populations and Their Relationships

I. Objective:

The children will learn about the concept of ecology and demonstrate their understanding of the different types of relationships which exist within populations.

II. Materials:

1. Blackboard and chalk

III. Introduction:

First discuss with the children their concept of nature and write some of their ideas on the board. [Although in these lessons we have not discussed the other kingdoms of living things -- monera (bacteria), protozoa, and fungi, be sure your students understand these too are a part of nature]. If nobody says that human beings are also a part of nature, ask them why not and discuss.

Afterward, say to your students that in general we have been studying both living and non-living things as individuals, but in reality they do not exist as individuals but rather they in relation with each other. Tell them the scientific study of these relationships is called ecology. Define ecology as "the study of the relations between species that inhabit the land and their environment." (Chacón, p. 5).

Before continuing review the following: Ask the children what is an "individual." Discuss and write the word on the board with a definition which you have derived with them. Continue with the word "species." It might be well if you follow up the discussion with the following definition or words to that effect: "living things which can reproduce themselves and whose young can also reproduce themselves." Explain this definition if necessary, using examples such as a mule to introduce hybrids which are incapable of reproduction, and thus by definition their progenitors are separate species. If necessary you can contrast dogs which can be cross-bred and maintain reproductive viability.

You are now ready to discuss the concept "population." It's easier to begin with the popular definition (the number of inhabitants of a place (town, city, county, country, the world)) before extending the definition. For example, continue with "What is the population of the sixth grade?, of our school?, of your house? Now, follow up with the population of cat/dogs in your community, before introducing the population of jaguars, etc. in a forest.

Be sure they understand a population in scientific terms is composed of only one type of species. [It is not possible to have a population (in the scientific sense) of different types of domestic animals]. Now, you can write down the definition of a population: "the number of individuals of the same species that live in the same place."

Ask the children what sorts of relations exist between different individuals within a population. Discuss examples and write them on the board. After you have a number of examples, classify them together by the type of relationship which is shown. Eventually, show them they can classify these into four broad categories, which can exist within populations: cooperation, competition, neutralism, and depredation.

Write on the board the following table and explain it to them:

Table 8. -- Relationships within populations

Benefit	A?	B?	Type of relation	Examples
		+	+	Cooperation
		o	o	Neutralism
		-	-	Competition
		+	-	Predation

Now with their help fill in this chart with their examples, which have been written on the board.

IV. Activity:

Tell your students they should now go outside the school and write in their notebooks the different relationships they can observe within different populations. They should be as specific as possible. Give them 10-15 minutes to do so, and help them if necessary.

V. Discussion:

Afterwards, discuss their examples and classify them according to the schema cited above. Do this jointly and write the classification on the board.

VI. Homework: [It's probably best to do this in groups]

1. The children should choose a small spot in their town (a pasture, a farm, a river, etc.). They should then mark off part of it (at least 3 square meters).
2. They should make a list of the different populations which they find within this marked-off area. [If possible they should distinguish by species -- if they do not know the exact species name, instead of "butterfly," they should note down "green butterfly" or "black-and-red butterfly," etc.]
3. Note down the relationships within the populations that you observe, and classify them as to the schema already discussed.

VII. Comments/Suggestions:

Although you can teach this and the next lesson together, I believe it is better to separate them. In this way it is much easier to construct the concept "ecosystem" little by little.

Lesson 13 -- Ecology: Communities and Their Relationships

I. Objective:

The children will learn the meaning of the concept "community," and how it is used in science. They will also understand the different relations that exist between different populations which exist in a community. Finally, they will begin to understand the meaning of the term "ecosystem."

II. Materials:

1. Blackboard and chalk

III. Introduction:

Review their homework with the children. Write on the blackboard the different populations which each group found under a word which describes their site (for example, pasture land, farm, forest, etc.). Then explain to them that all the living things (all the different populations) in that site form a community. [If necessary use the word "community" as used to describe where they live to better explain that a community not only contains men, women, and children, but also the dogs, cats, chickens, etc., and also the trees, the plants, the flowers, etc.] Then write on the blackboard the following definition of a community: "A community is the totality of all the living things which live in a place."

Now explain that even as there are relationships within populations, there are also relationships between populations. Some of these relationships are similar; others are very different (e.g., commensalism). Write again the chart from the previous lesson, but this time label it between different populations

Table 9. -- Relationships between different populations (partial)

Benefit	A?	B?	Type of relation	Examples
		+	+	Cooperation
		o	o	Neutralism
		-	-	Competition
		+	-	Predation

Help them to fill this chart with examples of relations between different populations (different species). Then continue with the following:

1. Tell them that scientists use a different word instead of "cooperation" when there are different populations (species) that both benefit from the relationship -- the word -- "mutualism." Change the word in the chart.
2. Begin with predation and ask your students. What word would we use if the species that benefits is much smaller? (Parasitism). Write this word underneath predation and ask for examples to fill in the chart.
3. Now explain that we use the word "predation" when a larger or similar-sized animal eats another, and "parasitism" when the animal which benefits is much smaller; but if the animal eats plants, we have other words to describe this relationship: "grazing" if they eat grasses or other herbs; and "browsing" if they eat twigs, branches, or parts of bushes or trees. Write these words in the chart.

4. Finally, point out to them that in the chart only two combinations of A and B are missing (o,+) and (o,-). Write these on your chart. Then ask them if they know any examples in which one species receives benefit, but the other does not receive either benefit or harm. [Some of the most common examples in Costa Rica are epiphytes. The nest building of some birds is also, but be careful!]. Tell them if one species receives benefit while the relationship is neutral for the other, we use the term "commensalism" to describe the relationship. Write that term on your chart. Finally, tell them there are some examples in which one species is harmed, while the other is neither harmed or benefitted. This relationship, which is less common, is called amensalism. Write it on the chart as well.

Now you should have a chart like Table ? below filled with their examples:

Table 10. -- Relationships between different populations

Benefit	A?	B?	Type of relation	Examples
		+	+	Mutualism
		o	o	Neutralism
		-	-	Competition
		+	-	Predation
		-	+	Parasitism
		+	-	Grazing
		+	-	Browsing
		+	o	Commensalism
		-	o	Amensalism

Now ask your students to classify these relationships into two groups: 1) where there is benefit to at least one species, but no harm to any of them 2) where there's harm to at least one species. Give them time to do this. When they have finished they should have two groups, with "neutralism" not classified.

Table 11. -- Relationships between different populations classified as to whether either species receives harm

Symbiotic	Antagonistic	Neutral
Mutualism	Competition	Neutralism
Commensalism	Predation	
	Parasitism	
	Grazing	
	Browsing	
	Amensalism	

1 "symbiotic" relationships if there is no harm; these relations include both mutualism and commensalism
2. "antagonistic" relationships if there is harm to at least one species
3. "neutral" relations.

Emphasize that although there are less types of symbiotic relationships, these relationships are very common in nature, because evolution favors them.

Review all of the above before continuing with the following competition:

IV. Activity: A competition

Tell your students that now they are going to have a competition to see if they can decide which type of relationship exists between different populations. You can divide them in groups if you wish, or not [I think it's better to divide them]. Write down a statement of the relationship for each question. Begin with a very easy relationship. After each one, give them time to respond and discuss their answers; if necessary explain the answers before continuing. The questions should increase in difficulty each time.

Below is an example of a series of questions that you might ask, with the answers in brackets.

1. A snakes eats a mouse?
   [Predation -- The snake benefits; the mouse loses its life.]
2. A bee gathers pollen?
   Mutualism -- The bee receives nourishment; the flower is pollinated.]
3. A mouse eats corn?
   [Mutualism -- The mouse receives nourishment; the corn seeds are dispersed by the mouse, and as a result have a better opportunity to grow.]
4. A hawk builds its nest in a Guanacaste tree?
   [Commensalism -- The hawk benefits by obtaining a place and protection for its young; there is neither harm nor benefit for the tree.]
5. A *Yigüirro* (a type of robin) builds its nest in a Higuita tree?
   [Mutualism -- The *Yigüirro* obtains a home and protection for its young, and nourishment from eating the fruits; the tree benefits because the seeds are dispersed by the *Yigüirro.*]
6. A caterpillar eats the leaves of a plant?
   [It depends: Mutualism, if the adults (butterflies or moths) of this type of caterpillar pollinate that plant; if not it is a form of grazing.]
7. A woodpecker makes its nest in a tree?
   [It depends: There is definitely harm to the tree, but if the woodpecker eats larvae, caterpillars, and other insects which cause more damage, it's possible the net result of this relationship could be positive as well for the tree. Therefore, it can be mutualism.]

V. Discussion:

Review the above to clarify questions. Emphasize that many times it is not easy to decide if there is benefit or harm. For example, many birds destroy the seeds when they eat fruits. Therefore, they are not seed dispersers; in fact they are seed predators!

Afterward, explain to them that in each ecosystem there are many examples of each type of relation. Ask them to tell you the names of different types of ecosystems and write them on the blackboard (forest, pasture, beach, farm, city, sea, river, etc.).

VI. Homework:

Divide the children into groups and give to each group a type of ecosystem to investigate.

1. For each ecosystem the children should write:
   a) 10 living things (specific names) which live in that ecosystem
   b) 5 antagonistic relationships (specific) within that ecosystem
   c) 3 symbiotic relationships (specific) within that ecosystem

   Emphasize that the children should use specific names and should not use more than two examples of any of the nine different types of relationships.

2. Make a drawing of your ecosystem. Write the names of the different living things on your drawing.

VII. Comments/Suggestions:

If you want you can introduce the term "inquilinism" This is a special form of commensalism in which the home of one organism is inside that of another. [I have not included it because I am not sure what "inside" means -- within the physical body (in the cells?), or is a nest inside a tree in this sense?].

For a brief explanation of the most important relations, see Santillana, p.42-5.

Lesson 14 -- Ecosystems

I. Objective:

The children will understand the concept "ecosystem" and the relations which exist within them, between living things, but also between living and non-living things.

II. Materials:

1. Blackboard and chalk
2. Ball of string
3. Tape
4. Cards with the names of living and non-living things of a particular type of ecosystem (preferably one that can be found near the school)

III. Introduction:

Review the homework and ask the children to state some of their answers for each one of the ecosystems. Write the answers on the board. When you have written some of these lists, ask them what's missing in these lists? If necessary, give them hints so they will remember that there are also non-living things in each ecosystem.

Then tell them the three characteristics which define an ecosystem. [You might want to solicit these answers.] An ecosystem contains the following:

1. A defined place
2. All living and non-living things within that place
3. All the relationships which exist between all things in this place

Be sure the children understand that we can define the place almost arbitrarily -- large or small. By convention it's defined "mid-way." Therefore, we can have micro-ecosystems and macro-ecosystems. However, our definition of a place can determine the utility of the concept. [For example, it does not make much sense to speak of the ecosystem of Puriscal, but it does make sense to speak of the ecosystem of the Picagres River watershed].

Tell them that even as there are relationships between different living things, there are also relationships between living things and non-living things, some of which they have already studied. Ask if they can remember any of them and write down their responses. [They will probably remember feeding, respiration, and possibly photosynthesis]. Help them to also think about protection, temperature change (sunning, seeking shade, etc.), transportation (swimming, flying), the use of materials for construction, etc. Be sure the children understand many of these relationships before beginning the activity.

IV. Activity:

Go outside. Give to each child one (or more) cards and tape it to their chest. Form a circle. Tell them that each of them represents one (or more) of the living and non-living things which one can find within the _______________ ecosystem (depending on what ecosystem you chose).

Then tell them they are now going to represent some of the relationships which exist within this ecosystem by uniting with a string the different things which are related. Each person, when it is their turn, should throw the ball of string to another person after having said out loud one relationship she has with that person, while still holding on to the string. [Although it is difficult to explain this in words, it is much easier to demonstrate it].

When the children understand the game, you can make it more difficult by limiting the type of relation (for example, commensalism, grazing, competition, etc.). [You may need to help them sometimes.]

When all have had at least one opportunity, tell them the web they have constructed with the string shows many of the relationships which exist within this ecosystem. This web includes the food web they have already studied, but is much larger and complicated, as they can see, because it not only includes nutritional relationships, but all other types as well. Before unraveling the web suggest they study the web and answer the following questions:

1. Which things in this ecosystem seem to be the most important?
2. Which the least?
3. What would happen if a part of this ecosystem was damaged or contaminated?

After discussing these questions, disentangle the string little by little, but in reverse order until you arrive at the beginning, repeating what were the relationships between each part of the web.

V. Discussion:

After returning to the classroom, review the questions above. Ask them why some parts of the ecosystem seem to be more important than others. Discuss what might happen to the ecosystem if there's damage/contamination/a large reduction (or a large increase) to part of that ecosystem.

Emphasize that the situation is actually even more complicated, because instead of having only individuals, as in their game, within an ecosystem there are entire populations of individuals. Finally, tell them that normally the populations of an ecosystem remain relatively stable in the short term, if there are no rapid changes within that ecosystem. We call this concept of stability in nature -- "Biological Equilibrium."

VI. Homework:

1. The children should <u>observe</u> their marked locations (the same as for Lesson 12), note all the relationships they <u>can observe</u>, and classify these relationships by type.
2. Since all the world is changing, including nature, what do you think: does biological equilibrium really exist or not? Write a paragraph or more exploring this theme.

VII. Comments/Suggestions:

It's possible that it would be better to play this game inside the school. When there's a lot of sun or it's too hot, it's difficult to keep the attention of the children long enough for this entire activity, and you might not be able to discuss the questions and/or disentangle the string, which are both valuable parts of the lesson.

It's also probable you will need to explain the second homework assignment with questions beforehand which deal with volcanic eruptions, erosion, earthquakes, sedimentation, etc. The chief purpose of the second homework assignment is to stimulate discussion for the next lesson.

Lesson 15 -- Ecological Equilibrium (2 classes)

I. Objective:

The children will gain a better understanding of the concept "ecological equilibrium," and how it is broken in nature. They will also understand that changes caused by humans, although they can be very serious and disrupt that equilibrium, are nevertheless natural. Finally, they will have a better understanding of the problems maintaining that ecological equilibrium.

II. Materials:

1. Blackboard and chalk

III. Introduction:

[If you have previously used the optional lesson (10A -- The Geology of Costa Rica), you can refer to that lesson. Otherwise, you can use their general understanding of geology.]

Ask them to discuss their thoughts/answers to the homework assignment, i.e., if ecological equilibrium exists or not. Write down their comments on the board and discuss them. In the discussion be sure to emphasize the following (bring these up if your students did not):

1. Nature is always changing. Sometimes these changes (geologic, climatic, geothermal, etc.) are the result of natural processes which are caused by non-living things. Sometimes the changes are caused by living things: evolution, sickness, changes in the environment resulting from the actions of living creatures (beavers, cattle, human beings, etc.).
2. All of these cause changes in the environment -- some are large and rapid, others slow and gradual, even if the net effect is immense (e.g., erosion of mountains).
3. One could say that instead of equilibrium existing in nature, in fact there is "disequilibrium" -- it's all relative with respect to time.

Be certain that your students understand that changes caused by human beings are also natural. The problem is that often our technology causes rapid changes -- which are too rapid to allow evolutionary and/or behavioral adaptations of many species.

IV. Activity:

Tell your students they are going to enact a mock trial for the next class. The accused are human beings; the plaintiffs the rest of nature. The general accusation is that "human beings have and still are destroying nature." The only penalty that can be given for this crime is forced extinction of the guilty species, i.e., human beings.

Divide the class. Some will be the accused; some the plaintiffs, and some (at least three) judges. [Explain that in this trial the judges have the right to ask questions of witnesses for both sides -- in addition to weigh the evidence given.

Each group will then have the rest of the class to plan their strategy, who will be their lawyer(s), their witnesses, what questions they will ask, etc. They may also continue their preparation as homework.

Next class: the trial

The students will conduct the trial.

V. Discussion:

After all testimony, arguments, and rebuttals have been made, give the judges time to consult and make their decision. After the decision is made, have the children discuss what happened: what did they think of the decision, the process, etc. [As teacher you should not participate at this stage, but merely facilitate the discussion.]

When they have finished, you, the teacher, can now participate. Ask them if they thought the trial was fair? the accusation? the penalty? Help them if they still have not done so to enumerate the problems in nature which are caused by human beings and write these on the board. Ask them why we have these problems. In other words why do humans commit these actions if they cause problems? Are humans benefitting from these actions?

Help them to understand through the discussion that most often the problems result from actions which humans have taken to better their lives. For example, deforestation or the destruction of forests originally occurred because humans developed agriculture -- a better way to guarantee their sustenance than hunting and gathering. Today forests are still being cut so that humans can use wood for construction and many other things; they are also using the deforested land for raising both dairy cows to provide milk and beef to provide meat.

Discuss the significance and consequences of these issues. [Many actions by humans create damage to the environment at the same time they provide benefits to humans. The problem is how (or if) we can still receive the benefits without causing the damage.]

VI. Homework:

1. Divide this list of topics between your students: overpopulation; urbanization; air and water contamination; hunting of wild animals; deforestation
2. Each individual in each group needs to write an essay on the problem including at least answers to the following questions: [You may want to have them give an oral report as a group after this assignment].
    a. Do you think this is a problem in Costa Rica? / in your town? -- Yes or no? Why?
    b. How bad is this problem in Costa Rica? in your town?(if it is a problem).
    c. What are the principal causes (reasons) for this problem?
    d. How could you avoid the bad effects of these causes? / solve the problem?

VII. Comments/Suggestions:

You could use a less extreme case for your trial, but I don't think it would be as effective. It's also important that the children are given sufficient time both to prepare for the trial and to discuss its implications afterwards.

After this lesson, I recommend that you show (if you can) the series of videos by PRODAF/GTZ: "Planting for the Future," "Planting in the Schools," and "From Forest to Farm." This series begins with the destruction of forests in Costa Rica. The second video continues with the problem of deforestation in Puriscal and shows what children can do to help alleviate the problem.

But for me the most important video is the third. It begins with the relationships that one can find in a natural forest, "The Cangreja" (a forest reserve in the canton of Puriscal). It then continues by explaining how we can use these ideas to reproduce more natural conditions within our system of agriculture and our cattle industry. The video is very clear -- although we cannot recreate our natural forests (or better said, we can't if we want to have agricultural products, cattle, etc.), there are ways to avoid some of the problems that these cause by creating "natural" conditions (through the implementation of agroforestry and *silvopastoral* systems).

This video can also be used as a good introduction to sustainable development.

Lesson 16 -- Soil Conservation

I. Objective:

The children will understand the importance of trees and how they can prevent the erosion of soil. They will also learn about other methods of soil conservation.

II. Materials:

1. Blackboard and chalk
2. Shovel, bucket, soil and water

Before class make four mounds of soil outside of the classroom. The first should be left as is with only soil. On the second, put a lot of grass and other leafy plants or weeds. On the third, dig drainage ditches going up and down the mound. And on the fourth, make contour levels around the mound. (See Ambiente en Acción, p. 37).

III. Introduction:

First ask the children if they know the four ways that trees help prevent soil erosion. If they don't know, help them to understand the following four different ways that trees prevent erosion:

1. The roots sustain (hold onto) the soil.
2. The leaves protect the soil from receiving the strong direct impact of the rain, which breaks it up more easily.
3. The leaves also provide shade, which keeps the soil moist and thus more compact.
4. Finally, the leaves which fall also keep the soil moist, because they act like a sponge on top of the soil.

IV. Activity:

Explain to your students there are also other ways to avoid or diminish soil erosion. Have them bring their notebooks outside and show them the four different mounds of dirt.

Tell them that each mound represents a different method of cultivation in hilly areas. Explain the different methods: 1) after harvest leave the ground bare 2) keep a vegetative cover on the soil 3) having ditches run down the hillside 4) the construction of contour levels.

Tell them they should observe what happens to each when there is a strong rain. Pour some water from a bucket in succession. Ask them to write in their notebooks what happens to each mound.

V. Discussion:

Discuss what happened to each mound and what are the implications for farmers of this demonstration. Discuss what different types of products are grown in the community and which methods of soil conservation your students think would be best for these agricultural products.

VI. Homework:

1. Conduct interviews with farmers to determine what types of products they grow, and what they do to limit soil erosion.
2. For the next class:
   Costa Rica uses a large amount of chemical pesticides. What do you think about their use? Write your response. Also, conduct interviews with farmers to find out what type of pesticides they use, for which products do they use them, and how do they apply them.

VII. Comments/Suggestions:

It would be a good idea if you could invite a farmer or a member of MAG (Agricultural Ministry), to come and explain different soil conservation methods. It would also be good to visit different areas where these methods are used.

Lesson 17 -- Pesticides

I. Objective:

The children will understand the dangers of using pesticides. But they will also learn how to minimize these dangers, and especially the importance of reading, understanding, and following the directions on etiquettes. They will demonstrate their learning in a group competition.

II. Materials:

1. Blackboard and chalk.
2. A mixture of etiquettes from different chemical pesticides. It would be good if you have an etiquette of each color (although it's difficult to obtain red ones).
3. Another group of etiquettes and advertisements for different pesticides (You need to have 3-5 or more of each type, depending on the number of students you have).
4. Copies of your question sheet (See Comments/Suggestions).

III. Introduction:

Ask your students to tell you the results of their interviews. Write on the board. Afterward, ask them to tell you their opinion on pesticide use. Construct a chart on the board which shows the advantages and disadvantages of chemical pesticide use. Discuss them.

Then ask them if they know what etiquettes are and what is their purpose. Show them etiquettes of different colors and ask them if they know what the different colors mean (red, yellow, blue, and green). Discuss. [Emphasize although some pesticides are more toxic than others, all are toxic!]

Afterward, explain to them that in addition to levels of toxicity, the etiquette also contains much more information about the pesticide. This information includes:

1. Brand name and generic name
2. Chemical composition
3. Precautions to take when using
4. Symptoms of intoxication, first aid measures, and the antidote, if any
5. Instructions for safe and effective use

IV. Activity:

Divide the class into groups depending on how many duplicate etiquettes and advertisements you have. [Each group should have one copy of each etiquette and ad.]

Then give each group a copy of the question sheet you prepared and tell them they are going to have a group competition. Emphasize they need to use all of the etiquettes and advertisements to answer the questions, which they should do as a group. Give them time to look for the answers and write them down. When they have finished, determine the winners, second winners, etc.

V. Discussion:

Discuss the answers and why they are correct if there are questions. Also discuss why many people do not read the etiquettes (difficult to read -- letter size, and many words are technical, some people don't know how to read, etc.).

Afterwards, begin a discussion on the safe use of pesticides. Ask them what precautions their parents take and if they feel they are adequate. Discuss reasons why people, in general, do not use protective clothing, and if they know of any more comfortable alternatives. At the end of your discussion write down their ideas on the safe use of pesticides. Be sure the list includes at least the following:

1. Seek help and read the etiquette.
2. Use protective clothing.
3. Wash yourself well after using pesticides.
4. Keep pesticides locked up out of the reach of children.
5. Use pesticides as a last resort.

VI. Homework:

The next class will focus on the problem of garbage and trash. To prepare for this class the children should write a short essay on the problem of trash, which includes at least the following:

1. How bad is the trash problem in your town? in Costa Rica?
2. How might we solve it?
3. What can you personally do to help better the situation?

VII. Comments/Suggestions:

I have included copies of some of the etiquettes and advertisements I used in my classes and also the question sheet. Although the answers are relatively easy, it is important to emphasize: if some pesticides only have advertisements, we cannot know which are the most toxic, because advertisements are not etiquettes and thus, don't have all of the same information. Their purpose is to urge people to use the pesticides; therefore it is possible and probable they will omit some of the information on the safety of the product.

You can inquire at a store that sells pesticides for copies of etiquettes and advertisements. Write the questions on your question sheet according to the information on the etiquettes and advertisements you can obtain. [It's better to use real etiquettes rather than copies; if you do need to use copies, indicate the colors of each in some way.]

This topic is a good one for dramatic presentations, puppet shows, etc. A theatrical example of this is in Ambiente en Acción, p. 84-85, but you and/or your students can write your own.

Etiquette questionnaire

1. What is the generic name of Graminex 20%?

2. Which of these pesticides are herbicides?

3. Which pesticide is the most toxic?

4. Which of these pesticides is/are toxic?

5. Which of these pesticides can be used for coffee?

6. What are the first aid measures one should take in case of ingestion of Tordon 101?

7. When should you not provoke vomiting in case of ingestion of Graminex 20%?

8. For which pesticide is there no time restriction on reentering an area in which that pesticide has been used?

Figure 14. Etiquette of fungicide Ridomil

¡ALTO! LEA ESTA ETIQUETA ANTES DE USAR EL PRODUCTO

PRECAUCIONES Y ADVERTENCIAS DE USO:
Siempre que maneje agroquímicos, utilice el equipo de protección completo sombrero, mascarilla, guantes, anteojos, delantal y botas de hule. No coma, beba ni fume durante estas labores. Báñese bien una vez terminada la labor y cámbiese de ropas. No lave las ropas que use en la aplicación junto con las ropas de uso normal. Entierre los envases vacíos después de usados a 30 cm del suelo, no contaminar lagos, ríos, fuentes de agua, abrevaderos, depósitos de alimentos, etc.

PRIMEROS AUXILIOS:
Ingestión: Si el paciente está consciente, provoque el vómito mediante una correcta dosis de jarabe de ipecacuana (15 cc para niños ó 30 cc para adultos) repitiendo hasta que el vómito fluya claro.
Inhalación: Retire al paciente a un lugar fresco, seco y aireado, manténgalo en reposo y vigile la respiración.
Contacto: Si entra en contacto con la piel o los ojos, lave bien las partes afectadas con suficiente agua por lo menos durante 15 minutos.

SINTOMATOLOGIA DE INTOXICACION:
El contacto prolongado con la piel causa ampollas y quemaduras. En las uñas puede causar quemaduras y caída, irritación de la piel intacta. Por inhalación causa estomatitis, dolor de cabeza, sangrado por la nariz, tos, irritación de la garganta. En los ojos causa lesiones de la conjuntiva y córnea. Por ingestión hay sensación quemante en la boca y faringe seguido de un intenso dolor abdominal, vómitos que pueden ser sanguinolentos y diarrea.

ANTIDOTO Y TRATAMIENTO MEDICO:
El Paraquat no tiene antídoto específico. Hacer lavado gástrico cuidadoso. Administrar suspensión de bentonita al 5-7%, seguida de un catártico salino como sulfato de sodio. Forzar la diuresis.

EN CASO DE INTOXICACION, LLEVE EL PACIENTE AL MEDICO Y DELE UNA COPIA DE ESTA ETIQUETA.

MEDIDAS DE PROTECCION AL AMBIENTE:
Una vez terminada la aplicación, lave bien el equipo utilizado, manteniendo sumo cuidado de no contaminar fuentes de agua, caños, ríos, lagunas, etc. así como cultivos vecinos con sobrantes de producto, caldo o aguas de lavado.

ALMACENAMIENTO Y MANEJO DEL PRODUCTO:
Transporte y almacene este herbicida en su envase original, bien cerrado y con su respectiva etiqueta debidamente adherida, aparte de alimentos, medicinas, utensilios de uso doméstico, insecticidas, fungicidas y fertilizantes. Almacénese bajo llave en un lugar fresco, seco y aireado, lejos del alcance de los niños, personas mentalmente incapaces y de los animales.

AVISO DE GARANTIA:
La compañía garantiza el contenido original de materia activa del producto, pero no responde en forma alguna por el uso que de él se haga.

AVISO AL COMPRADOR: Debido a que está fuera de nuestro alcance el control sobre almacenamiento, manipuleo y uso de este herbicida, nos es imposible asumir responsabilidades por posibles daños que puedan ocasionarse debido a estos factores. Nuestra responsabilidad alcanza únicamente a la composición química del producto tal y como se indica en esta etiqueta siempre y cuando el envase se encuentre sellado.

agrocosta

GRAMINEX 20% SA

HERBICIDA BIPIRIDILO

NOMBRE GENERICO: PARAQUAT

Composición química:
Ingrediente activo.

1,1-dimetil-4,4-bipiridilo	18.4% p/p
Solventes, emulsificantes, inertes	81.6% p/p
Total	100,00%

EL GRAMINEX 20% SA contiene el equivalente de 200 gramos de ion Paraquat por litro
a 20 °C la densidad del GRAMINEX 20% SA es de 1.15 g/cc

CUIDADO VENENO

ESTE PRODUCTO PUEDE SER MORTAL SI SE INGIERE, VENENOSO SI SE INHALA. PUEDE OCASIONAR DAÑO A LOS OJOS.

NO ALMACENAR EN CASAS DE HABITACION. MANTENGASE ALEJADO DE LOS NIÑOS, ANIMALES DOMESTICOS Y ALIMENTOS. DESTRUYA ESTE ENVASE DESPUESDE USAR EL PRODUCTO.

Contenido neto: 1 litro
Formulado por
FORMULACIONES QUIMICAS S.A.,
Chomes, Puntarenas, Costa Rica
Distribuido por:
AGROQUIMICAS DAF DE COSTA RICA
Tel. 31-7744
San José, Costa Rica

NO USE EL PRODUCTO EN FORMA DIFERENTE A LA RECOMENDADA

INSTRUCCIONES DE USO:
Durante la preparación del caldo y carga del equipo de aplicación, utilice el equipo de protección. No coma, beba ni fume durante estas labores. Evite todo contacto directo del producto o caldo con su cuerpo. Antes de cargar el equipo de aplicación cerciorarse de que está en perfecto estado de funcionamiento. Para preparar el caldo de aplicación, llene el tanque hasta la mitad con agua limpia, ponga el sistema de agitación a trabajar y vierta la cantidad requerida de GRAMINEX 20% SA terminando de llenar el tanque con agua limpia.

USO RECOMENDADO:
El GRAMINEX 20 es un herbicida con acción de toxicidad aguda (efecto quemante) sobre los tejidos no leñosos, no presentando ninguna acción pre-emergente a la maleza. El espectro de malezas que controla es muy amplio, y siendo su efecto de control por acción de contacto ha de tenerse en cuenta la posibilidad de la rebrotación en plantas perennes. Se recomienda para usar en cultivos tales como Banano y Plátano (*Musa spp*), Café (*Coffea arabica*), Cítricos (*Citrus spp*), Chile (*Capsicum frutescens*), para lo cual se utiliza una dosis de 1,5-3,0 lts de GRAMINEX 20% SA por hectárea. Si se desea limpiar áreas determinadas (bandas de fertilización, etc.) se usan dosis de 500-700 cc (excepcionalmente 1000 cc) por estañón. En casos de pre-emergencia temprana con poco desarrollo, para ser mezclado con pre emergentes con dosis de 350 cc por 200 litros de caldo. En todos los casos agregar un adyuvante. Puede mezclarse con otros pre-emergentes o post-emergentes, se utiliza una dosis de 2,0-3,0 litros de GRAMINEX 20% SA/ hectárea en pre-emergencia o 3 días antes de sembrar. Como post-emergente en aplicaciones dirigidas. En post-emergencia temprana con bomba de mochila se aplica en 570 litros de caldo/hectárea, 2,3 lts/ha. Para desecar caña se utiliza la misma dosis en tratamiento general.
En otros cultivos, tales como Algodón (*Gossypium hirsutum*), Papa (*Solanum Tuberosum*), Lechuga (*Lactuca sativa*), Arroz (*Oryza sativa*), Sorgo (*Sorghum vulgare*), Maíz (*Zea mays*), Repollo (*Brassica oleracea*), Cebolla (*Allium cepa*), Apio (*Apium graveolens*), Piña (*Ananas comosus*), Soya (*Glycine max*), se utiliza una dosis de 1,5-2,0 litros de GRAMINEX 20% SA/ha aplicado en presiembra y pre emergencia del cultivo. En suelos arenosos, se debe dejar un período de 3 días entre la aplicación y la emergencia o siembra. Este producto no se recomienda para desecación en ningún cultivo. En maíz la aplicación debe hacerse cuando esté encañado. Para áreas no cultivadas usar 3,5-5,5 lts/ha aplicado con post o pre emergentes necesarios.

COMPATIBILIDAD Y FITOTOXICIDAD:
Este herbicida es compatible con los plaguicidas de uso normal. Su efecto quemante lo hace fitotóxico a los tejidos no leñosos. En caso de gramíneas y plantas leñosas, se debe usar para su erradicación herbicidas específicos. Evite el uso de coadyuvantes iónicos ya que pueden disminuir su actividad. No hay restricción en cuanto al período de reingreso al área tratada.

País Costa Rica **Nº de Registro:** 2324 **Fecha:** 07 03 90

Lote Nº **Fecha:** **Permiso M.A.G. Nº** 63

Importado y envasado por:
AGROQUIMICOS DAF DE COSTA RICA S.A.

ALTAMENTE TOXICO

Figure 15. Etiquette of herbicide Graminex

Figure 16. Etiquette of herbicide Tordon 101

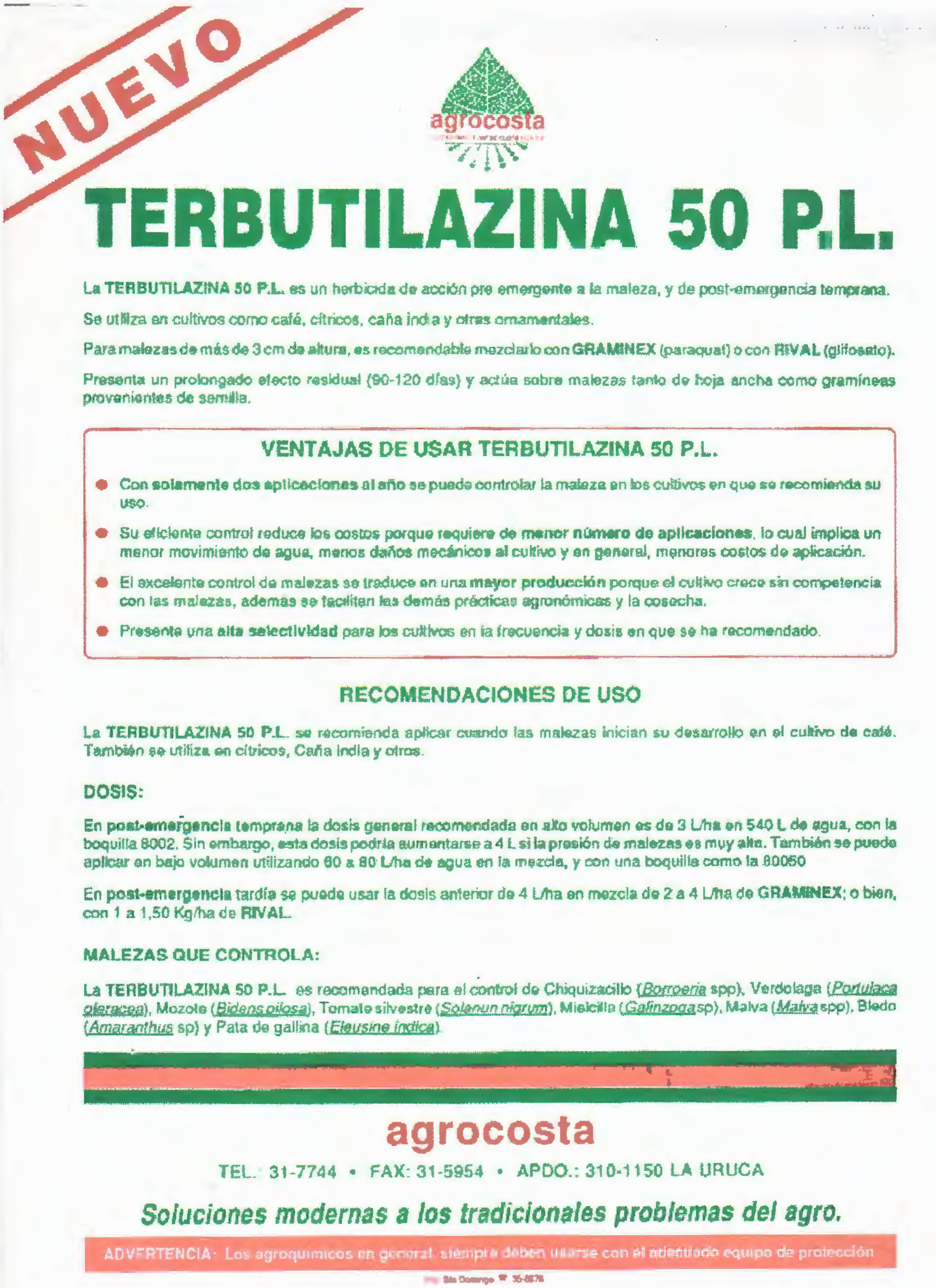


Figure 17. Advertisement for Terbutilazina 50 PL

Lesson 18 -- Trash and Garbage

I. Objective:

The children will learn the importance of classifying trash as a means to alleviate the problem of solid waste. They will also learn how long different types of garbage/trash last before decomposing.

II. Materials:

1. Blackboard and chalk
2. Poster -- How long does trash last? (You can either make this or only write it on the blackboard) [See Ambiente en Acción, p. 68 or Table ? below.]

III. Introduction:

Ask your students to tell you what they think people should do with trash; write on the blackboard all of their answers without commentary. [See the homework assignment from the last lesson.]

Then ask them to name all the different types of trash/garbage and write their responses on another part of the board. [Be sure they include at least the following: banana peel, paper, a tree branch, leather shoes, painted wood, a tin can, an aluminum can, plastics, a tire, and glass. They will probably give you most, if not all of these responses, but if not, seek them from them.] Announce they are now going to have a competition.

IV. Activity:

Tell them that now they need to guess how long each type of trash/garbage lasts. They need to write down the name of each type and then next to it write down their guess in pencil. Explain to them that how long trash lasts is the time it takes to decompose completely. Give them 10-15 minutes to do it.

Ask them for their answers and write them next to each type of trash. [Seek a number of answers for each one and try to give everybody a chance to guess at least one or two]. After you have written all the answers, ask them to comment on their answers and their significance (E.g., which last the longest?; which the least?; can they classify the trash into two different groups?).

In this discussion be sure they (or you if necessary) include that some things are organic and others inorganic, and that in general organic substances decompose faster. [Explain that plastic is in fact organic, but it lasts a long time as if it were inorganic.] Also emphasize the danger to the environment of burning plastics.

Now show them this poster with the answers or write them on the board.

Table 12. -- Average decomposition times for various types of trash and garbage

How long does trash/garbage last?

Banana peel	3 weeks
Paper	3 weeks - 4 months
Piece of wood	1-2 years
Leather shoe	3-5 years
Painted wood	10-12 years
Tin can	50-100 years
Aluminum can	350-400 years
Plastics	500 years
Tire	500 years
Glass	forever

V. Discussion:

Ask your students what is the best way to dispose of each type of trash on the list. Discuss why. Emphasize that for them and their community the best way for many inorganic substances is to reuse them; if they can't, to bury them. Explain the importance of the 4 R's -- refuse, reduce, reuse, and recycle -- and that they should treat trash in this order. [Recycling should be the last option.] Finally, discuss with them that the source of the trash problem is the use of many inorganic substances in our society, especially plastics, and whether the solution to the problem is laws which prohibit their use or at least reduce it.

VI. Homework:

The children should write an essay or story about what will happen to the world if there are not changes in our treatment of trash.

VII. Comments/Suggestions:

The teacher should begin (or follow) this lesson with a short trash pick-up, followed by its classification. Show them a large amount of the trash collected is composed of plastics and other inorganic substances.

You can use this lesson as the impetus for a clean-up campaign, or to initiate trash collection, classification, or a recycling campaign in the school or community. You can also follow it up with letters to authorities who are responsible for trash management.

This theme is apt for dramatization or puppets. You can use "Carlos Conservation Against Contamination" (Ambiente en Acción, p. 73-74), or you could simplify it, or write your own play. I changed "Carlos Conservation ... " so there were only two characters.

Lesson 19 -- Farm for Sale

I. Objective:

The children will learn the use -- good and bad -- of hilly terrain. They will demonstrate this understanding by making a drawing showing the correct land usage of a particular place.

II. Materials:

1. Blackboard and chalk (of different colors, if you have them)

III. Introduction:

Before class draw on the blackboard something like this:

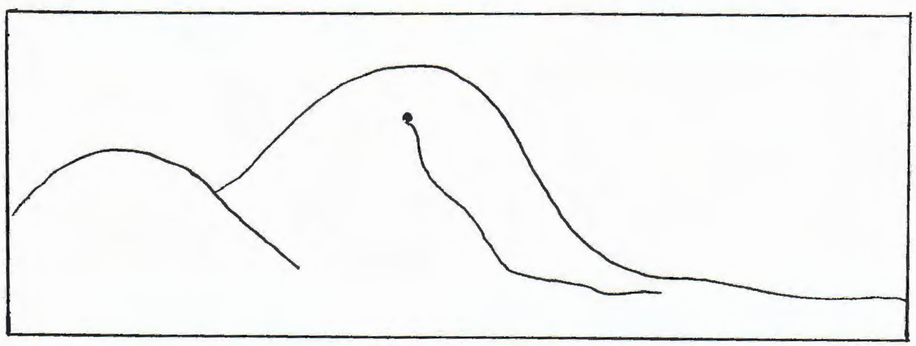


Figure 18. Farm for sale

Form groups of children and tell them that each group needs to decide what types of crops they are going to plant, which types of trees, and if they are going to have animals or not. Then afterward, they are going to make a drawing showing where they would locate their crops, trees, etc.

IV. Activity:

Give each group time to discuss what they are going to do; meanwhile draw other representations of your farm, one for each group.

Then give each group time to draw their own plans for the farm. Be sure that all participate. [It's probable they will want to use chalk of different colors for their drawing.]

V. Discussion:

Afterward discuss their ideas. Be sure they understand the necessity to protect the spring and the brook. [E. g., they should not plant fruit trees on the hillside above it, since they will probably need to use pesticides for the fruit trees and don't want to contaminate their water source.]

VI. Homework:

Revise your plan for this farm to avoid problems of contamination, lessen erosion, etc. and draw your new revised plan in your notebook.

VII. Comments/Suggestions:

You the teacher can modify the farm drawing depending on the type of terrain in your community.

Lesson 20-- A Community Seeking Employment

I. Objective:

The children will learn about the concept of sustainable development and will demonstrate their understanding in an activity that deals with creating employment.

II. Materials:

1. Blackboard and chalk

III. Introduction:

Before class, draw the following on the board:

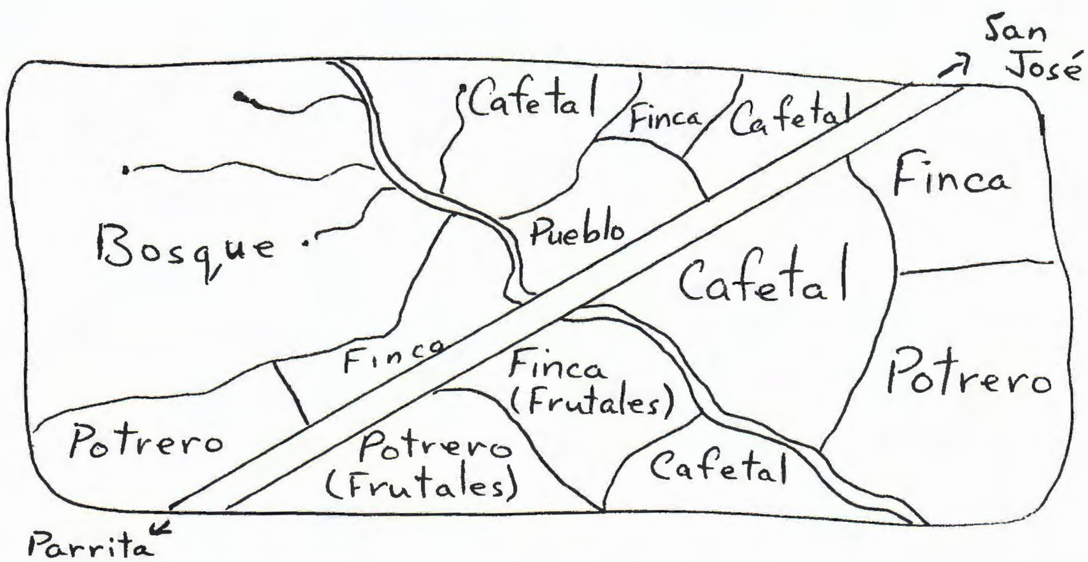


Figure 19. Town seeking employment

Tell your students "This map represents a community similar to one near here. The problem for this community is there is not enough employment for its members. The majority of the community needs to commute to San José to work."

"Your community has a natural forest of medium size. Although it does not contain any rare species, it has a high diversity of animals and plants, including many trees suitable for lumber. The farms of your community have many crops and the farmers use good erosion control techniques and also produce good crops. Your coffee farms send their coffee to a processing plant near San José."

"You are members of a commission which has been established to seek or create new sources of employment for the community."

Begin by asking them if they have any ideas as to how they could increase employment in this community. Some possible responses: (1) A tourism center (taking advantage of the natural forest) (2) A small-scale lumber industry (3) A fruit-processing plant (4) A coffee-processing plant (5) A slaughterhouse

Divide the class into groups and give to each group one of the ideas to investigate. Tell them they need to discuss this option and give a presentation of their ideas to the rest of the class. They need to answer the following questions in their presentation:

1. How are they going to begin/finance this project, and where will they locate it?
2. What are the advantages of this project?
3. What could be the disadvantages of this project?
4. How could you avoid these disadvantages?

Give them time to plan their response.

IV. Activity:

Each group should present their plans for their project, locate their project on the map and respond to any questions from the class.

V. Discussion:

After every project has been discussed, the teacher should begin a general discussion on the concept of sustainable development. Emphasize that each type of project has its advantages and disadvantages. Also emphasize that it's possible for them to use the forest for lumber, but if they want to use it for lumber they need to reforest it at the same time and possibly begin a reforestation program in other areas as well to provide more lumber for a lumber industry.

Finally, emphasize if people do not have another option for employment they are going to use the products of forests in some manner. What is important is that there be controls to prevent the complete destruction of forests.

VI. Homework:

Some people have suggested that the natural resources of the National Parks be used by people (e.g., wood for lumber, gold, etc.). What do you think? Write an essay that explains your opinion on this topic, justifying your position.

VII. Comments/Suggestions:

It is probable your students will need help to think of different employment options.

The book Orientación Pedagógicas en la Educación Ambiental para el Desarollo Sostenible has other ideas on how you can introduce and discuss this topic.

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APPENDIX 2

EDUCACION AMBIENTAL
UN PROGRAMA PARA SEGUNDO CICLO

Elaborado por

Craig Jackson, Voluntario

Cuerpo de Paz

Puriscal, Costa Rica

CONTENIDOS

Programa para Educación Ambiental -- Costa Rica (Segundo Ciclo)

De 1993-1995 implementé un programa de educación ambiental en algunas de las escuelas ubicadas en el Cantón de Puriscal, Costa Rica. El proposito de este programa era de fomentar el deseo y la abilidad de los niños para investigar por su mismo el ambiente de su propia lugar de modo que ellos puedan hacer sus propias decisiones con respecto a su medio ambiente en el futuro como ciudaños.

El basis de este programa es el concepto de la ecología ("el estudio de las relacions entre las especies que habitan la tierra y su ambiente" (Chacón et al., p. 5). Este programa empiece con la biodiversidad de todo de Costa Rica para introducir los conceptos que los estudiantes pueden aplicar a su propia lugar. En 1995 revisé el programa del año previo. Desde que yo estaba en cada clase solamente una vez por semana, podría usar solamente una lección por cada tema. Sin embargo, he incluido otras lecciones, y ideas para o fuentes de lecciones para amplificar cada tema. También, he incluido algunas actividades adicionales que puede usar en su clases.

Espero que este programa y estas lecciones sean útil para los maestros de este país. Aunque en mi segundo año (1995) enseñe principalmente a los niños de 4º o 5º grado, yo creo que este programa es mejor para 6º grado. Se puede servir tanto como un breve reviso de temas ambientales ya aprendido y también como un basis para exploración y investigación del nuevo tejematico "C" en el nuevo programa de Ciencias para 6º grado: "Medio Ambiente, Población Humano, y Desarollo." Es mi esperanza que usar este programa en sexto grado preparará los niños a investigar, estudiar, y analizar sus materias en colegio con un conocimiento ambiental.

La metología de mi programa esta basada en estas suposiciones:

1. Los niños saben muchas cosas de su propia ambiente (la lugar donde ellos viven), aunque es posible que ellos no den cuenta de su conocimiento.
2. Los niños pueden entender solamente las cosas que están relacionado con su anterior conocimiento.
3. Aprendizaje activo es mejor de aprendizaje pasivo.

El maestro puede usar este programa para aumentar otras materias también. Las tareas escritas son buenas para expresión en Español. También, los problemas ambientales son aptos para discusiones acerca de la historia del país, los cambios sociales, y para discusiones de los valores éticos.

Este programa está diseñado para comunidades semi-rurales y rurales alrededor de Santiago de Puriscal. Mi suposición es que estas escuelas no tienen muchos libros de otro tipo a los de textos. Entonces la habilidad de los estudiantes para que investiguen temas por libros, independientemente, es muy limitada. Por otro lado, los estudiantes y sus familias han tenido mucha experiencia directa con la naturaleza, por medio de su trabajo o el lugar donde viven.

Entonces, en vez de pedir a los estudiantes que busquen repuestas de libros, sería mejor que investigaran por medio de encuestas con la gente de su comunidad, o por su propia observación. Por eso, la mayoría de las actividades/lecciones tratan de cosas locales.

El maestro puede ayudarlos a entender cómo observar y hacer entrevistas. Puede empezar con las actividades de observación temprano. También, él puede asignarles algunas actividades en que necesitan entrevistar a la gente de su comunidad. Yo usé el terremoto de 1990 que ocurrió en Puriscal y la Revolución de 1948 como temas para estas investigaciones.

Otra idea es que los estudiantes hagan un informe de la historia de su pueblo. [Es mejor dividir la historia en tres partes -- natural, social, y política.] También, debe dar a diferentes estudiantes, en cada grupo diferentes épocas -- una reciente, una de la época de sus padres, y la otra de la época de sus abuelos.

Para cada lección tenga al menos una tarea. Las tareas son, no solamente, para revisar temas aprendidos en clase, sino también para aumentar el aprendizaje de los estudiantes por su propia investigación. Muchas veces las tareas incluyen actividades para mejorar su entendimiento de la próxima lección. El maestro debe asegurarse que los estudiantes hagan sus tareas, pero lo más importante es que sean estimulados para que hagan sus propias investigaciones.

He puesto las lecciones en orden según mis ideas de cómo enseñar los temas. Sin embargo, el maestro puede ordenar estas lecciones en otro orden, o reponer o aumentar algunas de ellas. Por ejemplo, puede usar las lecciones de observación y de lectura como una introducción a los métodos de investigación, o cuando quiere revisar estos métodos. También, algunas lecciones, por ejemplo, del Arbol, son aptas para días o actividades especiales. [Si el maestro quiere buscar otras lecciones a aumentar éstas, hay muchas en Ambiente en Acción.]

Expreso mi sincero agradecimiento a todos los directores y maestros de las escuelas en que enseñé los últimos dos años; a la gente de MIRENEM, en particular a Róger Delgado; y especialmente a Lucia Acuña Quesada, Enrique López Jiménez, y Harys Regidor Beltrán, quienes me ayudaron a revisar este manuscrito. Sin embargo, cualquier error es mío.

Craig Jackson, voluntario
Cuerpo de Paz (1993-95)
Puriscal, Costa Rica

Esquema del Programa de la Educación Ambiental

I. Como Obtenir Nuestra Conocimiento
    A. Observación -- Usando todos los sentidos
    B. Investigación
        1. Como leer para información
            a. Analizar, evaluar
        2. Experiencias/Conocimiento de la gente
            a. Historia oral
            b. Conocimiento practico
    C. Experimentación
    D. Contemplación

II. Biodiversidad de Costa Rica
    A. ¿Qué significa?
    B. ¿Alta o baja?
    C. Causas
    D. Importancia

III. Clima de Costa Rica
    A. ¿Qué significa?
        1. Elementos
    B. Determinantes
    C. Diferentes climas de Costa Rica
    D. Relación con alta biodiversidad

IV. Cosas Bióticas
    A. Animales en nuestra lugar
        1. Microclimas y microhabitats de los animales
            a. ¿Qué significa?
            b. Investigación
        2. Habitat/nicho
            a. Observaciones diarios
    B. Plantas en nuestra lugar
        1. Fotosíntesis
            a. ¿Qué significa?
            b. Componentes
            c. Importancia
    C. Otros seres vivos
        1. Monera, Protista, Fungi
        2. Importancia

    D. Cadenas Alimenticias
        1. ¿Qué significa?
        2. Diferentes partes y su papel
            a. Productores
            b. Consumidores
                1. Herbívoros
                2. Carnívoros
                3. Omnívoros
            c. Descomponedores

V. Cosas Abióticas
    A. Agua
        1. Ciclo
        2. Importancia
    B. Aire
        1. Componentes
        2. Ciclos
        3. Importancia
    C. Tierra
        1. Componentes
        2. Ciclos
        3. Importancia

VI. Naturaleza y Ecosistemas
    A. ¿Qué significa?
    B. Componentes
    C. Relaciones entre los componentes
        1. Bióticas -- bióticas
        2. Bióticas -- abióticas
    D. Equilibrio Biológico

VII. Desequilibrio de la Naturaleza
    A. Causas "naturales"
        1. Abióticas -- procesos "naturales"
            a. Geotermal/geológica
                1. Volcanos, terremotos
            b. Erosión/sedimentación
        2. Bióticas
            a. Enfermadades
            b. Cambios del ambiente
                1. Ejemplos -- castor, ganado, hombres
            c. Depredaciòn
    B. Causas "abnormales" -- causado por hombres
        1. ¿Qué es la diferencia?
        2. Problemas
            a. Contaminación
                1. Aire
                2. Agua
                3. Suelo
            b. Deforestación
            c. Perdido de recursos naturales
            d. Extinción
            e. Sobrepoblación

VII. Soluciones -- Ventajes/desventajes
    A. Conservación
    B. Reforestación
    C. Leyes
    D. Educación
    E. Desarollo Sostenible

Lección A -- Observación de un ser vivo

I. Objetivo:

Los niños van a mejorar su habilidad de observar la naturaleza con esmero, y recordar sus observaciones.

II. Materiales:

1. parte de una planta -- una rama, flor, etc.
2. pizarra, tiza

III. Introducción:

Escriba en la pizarra las siguientes palabras: observación, suposición, explicación, y conclusión. Enseñe una parte de una planta -- una rama, una fruta, o una hoja seca a la clase. Entonces, pregunte a los niños "¿Cuáles cosas pueden observar en esta?" Escriba las repuestas en la pizarra. Después de sus repuestas enfatice que las únicas observaciones que ellos podrían hacer con su vista son de forma, de color, de tamaño, y posiblemente de qué materia esta hecho. Explique que otras ideas, como lo que es una fruta o una flor son suposiciones basadas en nuestros conocimientos y experiencias previas.

Para explicar esto, dibuje una tela de una araña en la pizarra y en sus propias palabras explique lo siguiente: "Nosotros suponemos que esta cosa es una tela de una araña, pero en verdad no podemos observar qué es. Podemos observar solamente la forma, tamaño y color de este tipo de red. Habiendo visto telas antes, suponemos que es una tela de una araña. Si hay una araña sobre esta cosa, nosotros tendriamos una explicación para la red, pero hasta que nosotros veamos la araña haciendo esta red no podemos sacar la conclusión que esto es en verdad una tela de una araña.

Aunque esta diferencia puede parecer muy fina, en verdad es importante aprender que la ciencia empieza con observaciones, y que entonces las suposiciones y las explicaciones son hechos que deberán ser probados con más observaciones. Nosotros debemos basar nuestras conclusiones en nuestras observaciones, no en nuestras suposiciones, si queremos aprender la verdad."

Enfatice que el fundamento de la ciencia es la observación (el uso de todos los sentidos), y que los niños muchas veces pueden hacer sus propias observaciones. Finalmente, explíqueles que también si una cosa es viva, podemos observar qué hace; pero si queremos observar acciones naturales de los seres vivos necesitamos estar callados e inmóviles.

IV. Actividad:

Después de esta explicación dígales que cada uno de ellos debe ir afuera, buscar un animal y observar este animal por 10 minutos, anotando sus observaciones en su cuaderno. Cuando regresan, discuten algunas de sus observaciones. Asegúrese que ellos hayan entendido cuáles eran observaciones y cuáles eran suposiciones, etc. Entonces, dígales que deben hacer una lista de todas las observaciones que hicieron durante el resto de la clase.

V. Tarea:

Diga a los niños que deben escoger un animal o grupo de animales (como un avispero), y hacer observaciones de este animal cada día, anotando la hora y duración de las observaciones. Enfatice que este animal no puede ser doméstico y debe ser fácil para observar (preferiblemente alrededor de su casa). Ellos deben continuar este diario por algunas semanas.

VI. Comentarios/Sugerencias

Esta tarea podría ser dificil para los niños si ellos no entienden bien el concepto de observación. Entonces es importante que el maestro revise las listas (hechas en clase por los niños). También es recomendable que el maestro examine los diarios frecuentamente para asegurar que ellos entienden el propósito de la tarea.

Después de esta lección, el maestro debe dar la(s) lección(es) de los sentidos para enfatizar que los niños necesitan usar todas los sentidos para hacer observaciones.

El maestro puede usar las ideas de Ambiente en Acción (p. 7) para usar estas lecciones de observación como una introducción al método científico.

Lección B -- Los sentidos

I. Objetivo:

Los niños comprenderán que es importante usar todos sus sentidos para observar la naturaleza.

II. Materiales:

1. dos o más estacas de cada diferente tipo de árbol, aproximademente 30 cm de largo (es mejor si ellos son gruesos -- al menos 5 cm de ancho)
2. vendas (4-5 -- una para cada grupo)
3. pizarra, tiza

III. Introducción:

Pregunte a los niños quines saben los nombres de los diferentes sentidos. Escribea las repuestas en la pizarra, asi:

Table 13. Los sentidos

	olfato	vista	tacto	oído	gusto
1.					
2.					
3.					
4.					

Entonces discutan que diferentes animales usan principalmente diferentes sentidos . Después forme grupos de niños para decidir cuáles animales usan cuáles sentidos, principalmente. Después de 5 minutos, pida a cada grupo que digan cuáles animales deben estar en cada columna y escriba en la pizarra.

Entonces discuten sus repuestas y traten de decidir cuales son correctos. [En algunos casos es posible que no sepan; enfatice que hay muchas cosas que necesitamos investigar más (por observar/ leer)].

IV. Actividad:

Empiece la actividad por decir: "Nosotros vamos a ver como está para un animal que no usa su vista." Entonces, forme grupos para una competencia (aproximademente 4-5 personas por grupo) y una persona de cada grupo se venda.

Entonces escoja algunas estacas -- algunas parejas, otras solas, otras más de dos de un tipo. Ponga estas estacas en frente de cada persona vendada en turno y anote cuánto tiempo tarda antes de separar las estacas por tipo. Déles al máximo 120 segundos para hacerlo.

Escriba los segundos por cada grupo en la pizarra y entonces se vendan los próximos miembros en cada grupo. Cambie el número y algunas de las estacas por cada vendada -- ellos separan las estacas por tipo, y anote cuánto tiempo dura para hacerlo.

Al fínal, sume los segundos y el grupo con el menor tiempo en total será ganador, el próximo, el segundo ganador, etc. Entonces aplauden a cada grupo que ganó. [Es importante que el maestro indique segundo, tercero, etc. De esta manera los niños van a mantener más interés y lo más importante, la mayoría de los niños van a estimarse.

Es probable que los niños usen solamente su tacto en esta competencia. Entonces, después de la competencia recuerde a los niños que habían olvidado sus otros sentidos. Golpee las estacas en el suelo -- algunas tienen sonidos muy distintos. También enséñeles que algunas tienen olores diferentes.

V. Comentarios/Sugerencias

Cuando hice esta actividad los niños tuvieron muchas problemas, cuando hay algunas estacas que no son parte de una pareja. Si hay tiempo sería mejor si cada persona tiene dos oportunidades -- una con solamente parejas de estacas; otra con una mezcla diferente.

También sería bueno si el maestro deja las estacas y las vendas en la clase. Entonces los niños pueden jugar el juego otras veces por si mismo.

La maestra puede hacer competencias/juegos que utilicen otros sentidos también. Esta actividad es una adaptación de actividad C. en pagina 13 de Ambiente en Acción. Ideas para los otros sentidos están en paginas 12-14 del mismo libro.

Lección C -- "Guajipal" (Como leer para información)

I. Objetivo:

Los niños aprenderán como leer un artículo para buscar información, entender, interpretar, analizar, y hacer conclusiones.

II. Materiales:

1. pizarra
2. tiza
3. copias de articulo "Guajipal" de Guia de Campo de las Especies más Comunes del Parque Nacional Tortuguero por Jose A. Solano.

III. Introducción:

Explique a los niños que muchas veces nosotros necesitamos buscar información en libros, que no podemos hacer observaciones nosotros mismos. Entonces dígales que vamos a leer un artículo que trata de Guajipales, animales que no podemos observar en nuestra parte del país. Enfatice que después de leer van a formar grupos y va a darles preguntas. (Vea articulo)

IV. Actividad:

Lean el artículo oralmente en turno (ayudando y explicando algunas palabras). Después forme grupos y escriba en la pizarra las preguntas siguientes y abajo de cada una el número de repuestas: [He incluido las repuestas en paréntesis]

1. Describa un guajipal.
   1.1. (mide entre 1m y 1.5m)
2. ¿De cuáles materias son los nidos de los guajipales?
   2.1. (zacate, hojas, ramas, y tierra)
3. ¿Cómo saben los guajipales cuando deberían liberar sus crías
   3.1. (ellos saben por la voz que emiten las crías)
4. ¿De qué se alimentan los guajipales (crías/adultos)?
   4.1. (crías -- insectos acuáticos)
   4.2. (adultos -- peces, anfibios y otros vertebrados pequeños como armadillos y aves)
5. ¿Cuáles animales comen las crías?
   5.1. (peces como el gaspar)
   5.2. (aves como el pato aguja)
   5.3. (mamíferos como los mapaches y los zorros)
6. ¿Cuáles son las diferencias entre los guajipales y los cocodrilos amarillos? Compare los dos usando sus repuestas arriba.

Table 14. Comparación entre guajipales y cocodrillos amarillos

	guajipal	cocodrilo
largo	1m - 1.5m	más o igual a 5m
nido	zacate, hojas, ramas, tierra	arenales
cabeza		más alargada
mandíbulas		más estrecha

7. ¿Cuál es lo más común?
   7.1. (el guajipal)
8. ¿De qué trata este ensayo? (¿Por qué está escrito?)
   8.1. (El autor quiere dar una breve descripción de la vida natural de estos dos animales y comparar los dos)
9. ¿Sabe usted dónde puede encontrar cocodrilos cerca de aquí?
   9.1. (El Río Tárcoles, cerca del mar)
10. ¿ Cómo los hombres usan guajipales o cocodrilos? (¿Qué importancia tiene la familia cocodrila para los hombres?
   10.1. (Comercio de su piel)
   10.2. (Atraer turistas)
   10.3. (¿Comida?)

Entonces dé a cada grupo tiempo para buscar las repuestas, antes de discutirlas. En su discusión enfatice lo siguiente para cada pregunta:

1. Este artículo no da una buena descripción física de un guajipal ni un cocodrillo. Los dibujos son una parte integral del artículo.

2,4 y 5. Lea por detalles.

3. Necesita leer cuidadosamente.
6. Análisis
7. Necesita inferir esta repuesta del ensayo.
8. De qué trata indica la inclinación del autor y por qué escribió este artículo de esta manera. Enfatice que cada autor tiene su propia inclinación.
9. Algunos niños pueden saber esto; también la repuesta puede dar conocimiento de la posibilidad de gastos del turismo asociada con los cocodrilos
10. Repuestas requiren de los niños inferir, analizar, e interpretar

V. Comentarios/Sugerencias

Esta actividad puede ser hecho con algun tipo de artículo que trata de la naturaleza. Lo más importante es que las preguntas incluyan procesos diferentes: búsqueda de información; análisis; inferencia; interpretación; comprensión; y determinación de la inclinación del autor.

Este artículo y actividad es más fácil de "Tortuga Verde" (Lección IVB). El maestro puede usar los dos en secuencia o escoger uno depende de las habilidades de sus estudiantes.

guajipal *Caimán crocodilus*

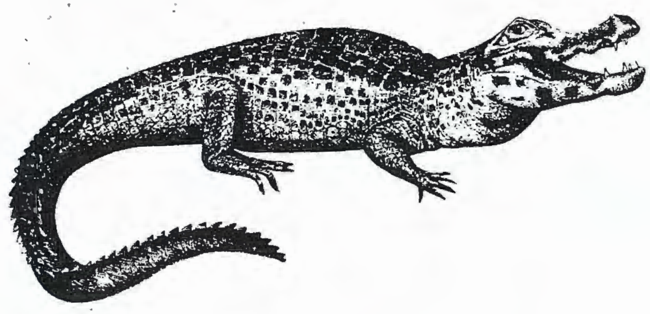
El guajipal es uno de los cocodrilos más pequeños del continente americano y, a la vez, el más abundante. Mide entre 1 m y 1,5 m. Está amenazado por el comercio de su piel, pero es factible criarlo en cautiverio. En esta especie, el cortejo comienza cerca de tres meses antes del período de anidación. Los machos adultos establecen y vigilan territorios acuáticos temporales. Los nidos son hechos de zacate, hojas, ramas y tierra. La descomposición de esta materia orgánica mantiene el interior del nido a unos 60 °C.

El período de incubación es de 73 a 75 días. La voz que emiten las crías que están todavía dentro del huevo atrae a los adultos y los estimula a liberarlas. Los depredadores de las crías son peces como el gaspar, aves como el pato aguja y mamíferos como los mapaches y los zorros. Las crías se alimentan de insectos acuáticos, en tanto que los adultos comen peces, anfibios y otros vertebrados pequeños y medianos, como armadillos y aves. El guajipal se distribuye desde el Pacífico Sur de México hasta el sur de Ecuador, y del occidente de Honduras hacia el este y el sur, hasta la Cuenca del Amazonas y el centro de Brasil.

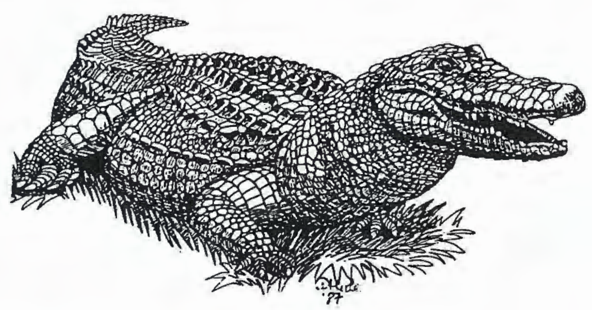
Su similar, el cocodrilo amarillo (*C. acutus*), es mucho mayor, de hasta 5 m. de longitud y habita cerca del mar. Hace sus nidos en arenales, donde el calor solar facilita la incubación de los huevos.

La cabeza del cocodrilo amarillo, en comparación con la del guajipal, es mucho más alargada y las mandíbulas más estrechas. El cocodrilo amarillo se aventura en ocasiones al mar abierto. Puede alimentarse de cualquier animal de hasta 30 o 40 kg de peso y es, aparentemente, el principal predador de las crías de manatí.

Este animal es poco común en la zona, pero cualquier cocodrilo de más de 2,5 m pertenece con seguridad a esa especie.



guajipal



cocodrilo

Figure 20. Guajipal. Reproducido con permiso de PACTo de Guia de Campo de las Especies Mas Comunes del Parque Nacional Tortuguero por Jose A. Solano

Lección D -- "Tortuga Verde" (Como leer para información)

I. Objetivo:

Los niños aprenderán como leer un artículo para buscar información, entender, interpretar, analizar, y hacer conclusiones.

II. Materiales:

1. copias del articulo "Tortuga Verde" de Guia de Campo de las Especies más Comunes del Parque Nacional Tortuguero por José A. Solano.

III. Introducción:

Explique a los niños que muchas veces nosotros necesitamos buscar información en libros, que no podemos hacer observaciones nossotros mismos. Entonces dígales que vamos a leer un artículo que trata de Tortugas Verdes, animales que no podemos observar en nuestra parte del país. Enfatice que después de leer van a formar grupos y va a darles preguntas. (Vea artículo)

IV. Actividad:

Lean el articulo, oralmente, en turno (ayudando y explicando algunas palabras). Después forme grupos y escriba en la pizarra las preguntas siguientes y abajo de cada una el número de repuestas: [He incluído las repuestas en paréntesis]

1. Describa las tortugas verdes.
   - 1.1. (aletas delanteras son muy largas)
   - 1.2. (cabeza es corta y redondeada)
   - 1.3. (mide 150 cm)
   - 1.4. (pesa 250 kg)
2. ¿De qué se alimentan las tortugas verdes?
   - 2.1. (pastos marinos)
   - 2.2. (algunos invertebrados)
3. ¿Dónde se pueden encontrar las tortugas verdes?
   - 3.1. (los mares calídos de todo el mundo)
4. Describa su migración y anidación en Tortuguero.
   - 4.1. (cada individual migra cada 2-3 años)
   - 4.2. (están en Tortuguero 4 meses)
   - 4.3. (cada hembra pone huevos cada 15 días)
   - 4.4. (cada hembra pone un total de 300 huevos por año)
   - 4.5. (las tortugas verdes hacen 20.000 nidos en Tortuguero por año)
5. Aproximademente, ¿cuántos huevos hay en cada nido en Tortuguero?
   - 5.1. (37-38 huevos cada nido)
6. ¿Cuáles son/eran las relaciones entre los humanos y las tortugas verdes?
   - 6.1. (alimentación)
   - 6.2. (protección)
   - 6.3. (turismo)
   - 6.4. (uso cultural)
7. ¿Por qué es Tortuguero importante?
   - 7.1. (Tortuga verde es una especie en peligro de extinción)
   - 7.2. (Una de las dos más grandes colonias de tortugas verdes en el Caribe)
8. ¿De qué trata principalmente este ensayo?
   - 8.1. (anidación de tortugas verdes en Tortuguero)

Entonces dé tiempo a cada grupo para buscar las repuestas antes de discutirlas. En su discusión enfatice lo siguiente para cada pregunta:

1. Este artículo no da una buena descripción fisica de una tortuga verde. Si no era un dibujo, podría ser como a la derecha. Es porque el propósito principal de este ensayo no es dar una descripción física de una tortuga verde.
2 y 3. Necesita leer cuidadosamente
4. Lea por detalles
5. Esta pregunta no es fácil! La repuesta no es 300 huevos!

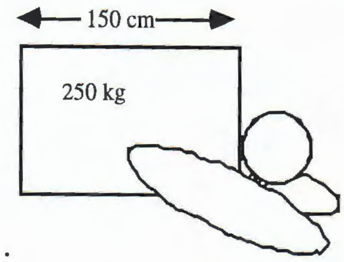


Figure 21. Tortuga Verde (imaginary)

6 y 7. Necesita inferir estas repuestas del ensayo.
8. "De qué trata" indica la inclinación del autor y por qué escribió este artículo de esta manera. Enfatice que cada autor tiene su propia inclinación.

Figure 21. *Tortuga Verde* (imaginación)

Después de discutir estas repuestas, dígales a los estudiantes lo siguiente:

"Pretendan que nosotros somos diputados de la Asemblea Legislativa. Yo soy diputado de Limón y quiero cambiar la ley para permitir el consumo, por hombres, de los huevos de tortugas verdes de Tortuguero.

Mi argumento es: Ahora hay 20.000 nidos en Tortuguero cada año con 37-38 huevos en cada uno -- un total de aproximademente 750.000 huevos cada año --, un grandísimo número de huevos. Ademas, ahora es permitido consumir huevos de otro tipo de tortuga que anida en Ostional (la tortuga carpintera o lora). Entonces, yo siento que la ley actual discrimina a la gente de Limón.

Ahora ustedes necesitan decidir si van a votar a favor o en contra de un cambio en la ley y necesitan decir porqué."

Después voten (Cada persona necesita votar) y escriban las razones de sus votos.

V. Comentarios/Sugerencias

Cuando hice esta lección, en todas mis clases solamente un grupo pudo resolver el problema matemático (pregunta #5). Entonces yo pienso que estaría mejor preguntar primero lo siguiente:

1. ¿Cuántos huevos pone cada hembra en un año en Tortuguero?
2. ¿Cuántos nidos hace cada hembra en un año?
3. ¿Cuántas hembras hay en un año?
4. ¿Cuántas huevos hay en cada nido?

La maestra puede hacer una lección de matemáticas con esta información y otros datos que puede obtener que trate de esta u otras especies de tortugas marinas.

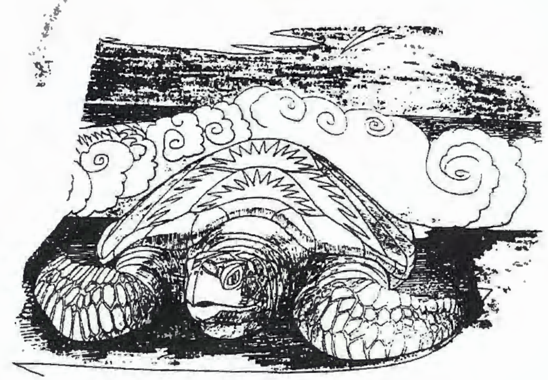
La más importante parte de la votación es que los niños aprenden que podrían haber razones para las dos posiciones -- que muchas veces es necesario que la gente tome decisiones entre opciones. También ellos necesitan entender que cada argumento es prejuiciado por las inclinaciones de la persona que lo hace.

Esta actividad puede ser hecha con algún tipo de artículo que trata de la naturaleza. Lo más importante es que las preguntas incluyn procesos diferentes: búsqueda de información; análisis; inferencia; interpretación; comprensión; y determinación de la inclinación del autor. Este artículo es más dificil que el artículo de Guajipal. Puede usar los dos en secuencia o escoger uno u otro depende de las habilidades de sus estudiantes.

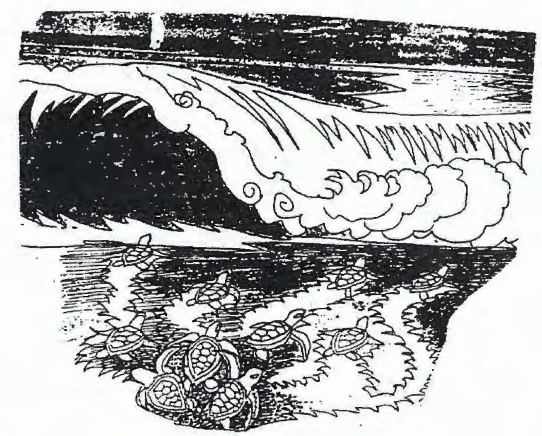
tortuga verde *Chelonia mydas*

El nombre de esta tortuga proviene del color de su grasa, que es verde. Sus aletas delanteras son muy largas y su cabeza es corta y redondeada. Llega a medir 150 cm y a pesar 250 Kg.
La tortuga verde se alimenta fundamentalmente de pastos marinos y, en menor grado, de algunos invertebrados. Se distribuye por los mares cálidos de todo el mundo. En el Caribe tiene dos colonias importantes: la Isla Aves en Venezuela y Tortuguero en Costa Rica.
Esta es una especie migratoria, que recorre grandes distancias desde su sitio de alimentación al de anidación. La migración individual ocurre cada 2 ó 3 años. Esta especie permanece en Tortuguero por 4 meses, de julio a octubre y los apareamientos se producen en aguas del Parque Nacional. Las hembras salen a anidar cada 15 días y ponen 300 huevos o más por año de puesta, luego no vuelven a poner, hasta dos o tres años después. En las playas del Parque Nacional se registran más de 20.000 nidos al año.
La tortuga verde ha sido utilizada como alimento desde hace mucho tiempo. De hecho su presencia en la zona fue el atractivo para los primeros asentamientos humanos en esta costa. En todo el mundo es una especie amenazada, tanto por la pesca de ejemplares adultos como por el saqueo de sus nidos para el consumo humano. Desde el establecimiento del Parque Nacional, en 1975, los nidos son protegidos, por lo que las poblaciones ya podrían estar recuperándose. En señal de respeto a una tradición de muchos años, se permite a los pobladores de Tortuguero capturar dos adultos por semana (para todo el pueblo), pero sólo después del desove y asegurando que se trate de individuos que están heridos o mutilados por tiburones.
La observación de estos gigantes cuando salen del mar a desovar es uno de los espectáculos más emocionantes que ofrece la naturaleza en Tortuguero. Sin embargo, es necesario observar ciertas normas:

*Dentro del Parque, sólo se puede visitar las playas en compañía de un guía autorizado.
*Las lámparas de mano y cualquier otra luz artificial asustan y desorientan a las tortugas, por lo que está prohibido su uso en el Parque; el visitante deberá acostumbrar sus ojos a la penumbra y caminar sin luz.
*Tampoco están permitidos los perros en la playa, ya que son depredadores de nidos.



tortuga verde



crías

Figure 22. Tortuga Verde-- Reproduced with permission of PACTO from Guía de Campo de las Especies más comunes del Parque Nacional Tortuguero by José A. Solano

Lección 1 -- Biodiversidad en Costa Rica

I. Objetivo:

Los niños entenderán el concepto de biodiversidad y tendrán una apreciación para la alta biodiversidad de Costa Rica. También investigarán la importancia de esta alta biodiversidad para su país.

II. Materiales:

1. pizarra, tiza
2. afiches de la flora, la fauna, y las actividades de las diferentes regiones del país
3. libros y articulos de los periodicos que trata de la biodiversidad
4. mapa de Costa Rica y el mundo o globo

III. Introduccion:

Escribe en la pizarra lo siguente, que no está entre paréntesis: (las repuestas están en paréntesis)

Table 15. Competencia de la biodiversidad

	Costa Rica	Mundo
# mamíferos	{201}	4000
# reptiles	{199}	6300
# anfibios	{150}	4200
# aves	{850}	9000
# mariposas	{1200}	12000
# insectos		750000
# orquídeas	{1300}	
# árboles	{1500}	
Total # de especies	{4% total}	10-50,000,000

Para empezar, dígales a los niños -- "Primero, vamos a definir qué es una especie. Quién puede decirme qué es? Después de definirla pregúnteles, "Ustedes saben cuáles son mamíferos?, reptiles?, anfibios, etc.?"

Después de estas preguntas discuta el tamaño relativo de Costa Rica con el resto del mundo, usando un mapa/globo para enfatizar que Costa Rica es muy pequeño en comparación con el resto del mundo.

Cuando los niños entiendan esto, diga: "Pero Costa Rica tiene muchos animales y plantas, ¿Sí? Vamos a ver cuántas especies existen en Costa Rica en comparación con el resto del mundo."

IV. Actividad -- Competencia de biodiversidad:

Entonces dígales que van a tener una competencia y explique que escribió en la pizarra. -- "Estos números son los números de especies de cada cosa que existen en el mundo. Yo quiero que ustedes adivinen cuántas especies de cada cosa existe en Costa

Rica." Entonces, busque cinco repuestas de los niños por cada cosa. Después, indique cuál es lo más cercana y escriba el número correcto en la columna. (Vea los números arriba en paréntesis)

V. Discusión:

Después, pregunte a los niños: "Qué significan estos números?" Aunque con sexto grado es posible de determinar los porcentajes primero, con los otros grados es mejor discutir solamente que aunque Costa Rica es un país muy pequeño, hay muchas especies aquí; entonces, Costa Rica tiene una gran biodiversidad.

Después de esto, pida a los niños que escriban en sus cuadernos una definición de "especie" y de "biodiversidad", y una oración que trate sobre la biodiversidad de Costa Rica.

Entonces, pregúnteles lo siguiente:

1. ¿Qué importancía tiene esta alta biodiversidad para Costa Rica?

Repuestas: (turismo; investigación; medicinas; fuente de trabajo, comida, e ingresos; y calidad de vida). Después de cada repuesta solicite comentarios o ejemplos que amplíen cada repuesta, con ejemplos locales, si existen.

Vl. Tarea:

Los niños deben investigar en grupos cada una de las razones arriba indicadas. Deben hacer un informe que trate de como la biodiversidad de su país es importante para los costarricenses. También deben escribir cómo esta alta biodiversidad ayuda a la gente en relación con esta razón. El maestro debería sugerir que los niños no solamente investiguen en libros, periódicos, etc., sino también que ellos hagan entrevistas con la gente de la comunidad.

Vll. Comentarios/Sugerencias:

Originalmente, enseñé lecciones 1A y 1B juntos, pero observé que era mucho contenido para los niños. Empiece la tarea en la clase o dé a los niños tiempo para hacerla (al menos en parte) usando las materiales antes citados.

Lección 2 -- El Clima de Costa Rica

1. Objetivo:

Los niños entenderán el concepto del clima, sus elementos, y sus determinantes. También ellos se darán cuenta que la gran diversidad de los climas que se pueden encontrar en este país es una de las más importantes razones para la alta diversidad de Costa Rica. Ellos demonstrarán este conocimiento indicando la flora, fauna, y actividades comerciales características de cada tipo del clima de este país.

ll. Materiales:

1. pizarra, tiza
2. afiches de la flora, la fauna, y las actividades de las diferentes regiones del país
3. libros y articulos de los periodicos que trata de la biodiversidad y de las diferentes regiones del país
4. mapa escolar grande de Costa Rica (con alturas de relieve)

lll. Introducción:

Diga a los niños que en nuestra lección pasada examinamos la biodiversidad de Costa Rica, y que hoy continuamos examinando la causa principal de esta alta biodiversidad.

Entonces pregúnteles: ¿Por qué Costa Rica tiene una alta biodiversidad? Escriba las repuestas en la pizarra.

[Algunas repuestas posibles: (país con clima tropical, leyes para proteger especies, parques nacionales, conciencia de la gente) Si los niños no dicen una cosa como "clima," solicite el concepto de ellos].

Después pregúnteles:

1. ¿Cuáles son los elementos del clima?
   (repuesta: temperatura, humedad, viento, presión atmosférica, lluvia o precipitación, y brillo solar)
2. ¿Cuáles son los factores que determinan el clima? (repuesta: latitud, relieve general, disposición de las montañas, altura, proximidad del mar, dirección/velocidad de los vientos)
   [Necesita explicar cómo estos causan las diferencias en el clima. Por ejemplo, porqué la vertiente Atlántica tiene lluvia por todo el año, en cpero la vertiente Pacífica tiene una estación seca en verano, y una estación lluviosa en invierno -- el efecto de las diferentes direcciones del viento en invierno y verano y como las montañas causan lluvia].

Después de esta explicación dígales que en Costa Rica hay cinco diferentes tipos del clima: tropical húmedo, tropical muy húmedo, tropical seco, intermedio (antes "templado"), y frío. Enseñe el mapa abajo que ilustra donde se encuentra cada tipo del clima. [Puede dibujar en la pizarra o usar tiza de diferentes colores; marque los diferentes climas sobre un mapa grande de Costa Rica (el mapa escolar con diferentes alturas es ideal para esto).

Pregúnteles que expliquen por qué las diferentes regiones tienen estos diferentes climas. (Vea repuestas arriba). Use el mapa para ilustrar cómo altura, las montañas, etc. determinan el clima. Enfatice donde está su pueblo y su tipo del clima.

Figure 23. Las climas de Costa Rica

IV. Actividad:

Entonces divida la clase en 5 grupos, un grupo por cada tipo del clima. Cada niño necesita investigar uno de estos tipos del clima para su tarea y reponder a estos dos preguntas:

1. ¿Dónde se encuentra este clima en Costa Rica? (¿Cómo se llaman estas regiones?)
2. ¿Cuáles son la flora y fauna característica de este tipo del clima (de estas regiones)?
3. ¿Cuáles son las principales actividades comerciales de esta región?

V. Tarea:

Los niños deben terminar este proyecto.

VI. Comentarios/Sugerencias:

Los niños pueden hacer esta tarea en grupos; pero si ellos la hacen de esta manera, divida las responsibilidades. (Por ejemplo, alguno(s) puede(n) hacer un mapa de su clima, otro(s) investiga(n) la flora, otro(s) la fauna (puede dividir en aves, mamíferos, etc., si es necessario), y otro(s) actividades comerciales.

Lección 3 -- Microclima y microhábitat

l. Objetivo:

Los niños entenderán los conceptos del microclima y del microhábitat y demostrarán este conocimiento al hacer un cuadro que enseñe los animales que se encuentran en diferentes tipos de microhábitats.

ll. Materiales:

1. pizarra, tiza
2. lupa, si tienen

lll. Introducción:

Revise que Costa Rica tiene cinco diferentes tipos de clima y que el clima es "el conjunto de las condiciones atmosféricas de un lugar. Después pregunte a los niños si alguien sabe qué significa la palabra "microclima." Para ayudarlos divida la palabra asi: "micro/clima" y pídales si ellos conocen algunos palabras que empiecen con "micro."

Entonces ayúdeles a entender que un microclima es "el conjunto de las condiciones atmosféricas de un lugar pequeño," desde que macroclima es "el conjunto de las condiciones atmosféricas de un lugar más grande. [Por ejemplo Costa Rica tiene un macroclima tropical porque está ubicada dentro de los trópicos].

Después pregúnteles dónde, alrededor de la escuela, se puede encontrar diferentes microclimas. Es posible que vaya a necesitar dar pistas o algunos ejemplos (como "abajo de una piedra," "en la copa de un árbol," etc.). Finalmente, dígales que el lugar donde se encuentra un tipo de microclima se llama un "microhábitat."

lV. Actividad:

Entonces dígales que ellos deben ir afuera, buscar diez animales alrededor de la escuela, y anotar en su cuaderno en cuál tipo de microhábitat se encuentra cada uno. Es importante que usted vaya acompañar a los niños y ayude a algunos si ellos tienen problemas. Después de aproximadamente 15 minutos, los niños deben regresar al aula para discutir lo que encontraron.

V. Discusión:

Cuando ellos regresen al aula, pregúnteles cuáles tipos de microhábitat encontraron; escriba su nombre en la pizarra, y abajo escriba cuáles animales se encontraron en este hábitat. Entonces haga lo mismo con los diferentes tipos de microhábitats, dependiendo del tiempo. Al final, en la pizarra tendrá una lista de microhábitats alrededor de la escuela y los animales que se encontraron en cada uno.

Después, el maestro debe explicar que aunque algunos animales se encuentran en más de un tipo de microhábitat (pueden vivir en diferentes tipos de microclimas), otros se encuentran en menos o solamente un tipo de microhábitat.

Vl. Tarea:

Los niños deben hacer una lista de los microhábitats alrededor de su casa y anotar cuales animales se encuentran en cada uno de los microhábitats que se encuentren.

Vll. Comentarios/Sugerencias:

Si quiere puede dar a cada niño la responsibilidad de examinar regularmente una muestra de tierra y anotar cuales animales se encuentran en esta muestra. (Posiblemente dos o tres veces por día durante una semana). [Vea <u>Métodos de Educación Ambiental</u>, p. 72 &114.]

Lección 4 -- Hábitat, nicho y las necesidades de los seres vivos

l. Objetivo:

Los niños entenderán los conceptos de hábitat y nicho y demostrarán este conocimiento por observaciones diarias de un animal.

ll. Materiales:

1. pizarra, tiza
2. cuadernos
3. lupas, si tienen

lll. Introducción:

Empiece con una pequeña discusión de la tarea (microhábitats alrededor de la casa y animales que se encuentran en cada uno). Entonces hable un poco de como puede encontrar algunos animales en diferentes microhábitats e introduzca el concepto de hábitat (que consiste en: "los lugares en que se encuentra un ser vivo").

Ahora es bueno que escriba en la pizarra la siguiente definición:

hábitat -- "el lugar que ocupa una especie en la comunidad." Dentro de su hábitat un ser vivo tiene todas las condiciones que hacen posible su vida. (de Chacón et al , p. 12)

Entonces pregúnteles "¿Cuáles son las necesidades de todos los seres vivos?" y escriba en la pizarra. (Repuesta: alimentación, agua, aire, protegerse, territorio/hogar, y reproducirse). Después puede enfatizar que dentro de su habitat un ser vivo puede satisfacer todas de estas necesidades.

Entonces pregúnteles "¿Cómo es el hábitat de un tigre?" También pregúnteles "¿Por qué necesita un gran habitat?" o "¿Por qué no hay tigres cerca de aquí?" (Repuesta: un tigre necesita un gran territorio para encontrar su comida y esconderse de los hombres que quieren matarlo). Entonces compare el hábitat de un tigre con el de un cienpiés.

lV. Actividad:

Antes de empezar esta actividad escriba en la pizarra el nombre de un animal (como zompopas). Discuta con los niños su alimentación (hongos que cultivan), su manera de protección (muerde y su hormiguero), su hábitat (hormiguero, árboles, y el suelo donde ellos caminan) y su nicho (descomponen las hojas y alimenta el suelo) Después pídales que escojan un animal que viva en Costa Rica (no animales domésticos) y escriban en su cuaderno lo siguiente: 1) ¿de qué se alimenta? 2) ¿cómo se protege? 3) ¿en qué consiste su habitat? y 4) ¿cuál es su nicho? (su rol en la naturaleza).

V. Discusión:

Pídales que digan sus repuestas. Es probable que el maestro tenga que ayudarles, especialmente para comprender lo que significa el nicho de un animal. Discuta algunos ejemplos de los niños, enfatizando como cada animal tiene su propio nicho, en la naturaleza, para mantener el equilibrio (por ejemplo: las ardillas, las ratones, y muchos pájaros propagan semillas; las culebras y los sapos controlan plagas (ratones e insectos, respectivamente); los insectos comen plantas y proveen comida para muchos animales que no pueden alimentarse de las plantas, etc.). De esta manera, dé ejemplos para que los niños puedan entender el concepto de "nicho."

Cuando los niños han comprendido el concepto, escriba en la pizarra la siguiente definición:

nicho -- "función que desempeña una especie en el ecosistema" o "el rol de un ser vivo en la naturaleza" (Chacón et al, p. 11)

VI. Tarea:

Los niños deben hacer observaciones diarias de un animal que vive cerca de su casa, anotando cómo se alimenta, se protege, en qué consiste su hábitat, y si puede; ¿cómo es su nicho?

VII. Comentarios/Sugerencias:

Si el maestro quiere ampliar esta lección, puede tratar la actividad en Ambiente en Acción, p. 54. También es bueno hacer una gira para hablar y enseñarles los nichos de algunos animales.

Lección 5 -- Plantas y su importancia

I. Objetivo:

Los niños aprenderán la importancia de las plantas como la base de cadenas alimenticias. También ellos entenderán el proceso de fotosíntesis, y como las plantas reponen oxígeno en el aire y usan el dióxido de carbono.

II. Materiales:

1. pizarra, tiza
2. 36 fichas -- 6 con letra mayuscula "C"; 18 con letra "O"; y 12 con letra "H"
3. cinta

III. Introducción:

Pregunte a los niños "¿Cuáles cosas en esta aula están hechos de madera?" y escriba las repuestas en la pizarra. (Si es posible, pida a todos los niños al menos una repuesta.) Después, dígales que aunque la madera sea un importante uso de plantas, hay otros usos muy importantes también. Entonces, pregúnteles que digan otros usos de plantas y escriba estos en una lista diferente. (Posibles respuestas: adornar, medicina, sombra, rompevientos, cercas/barreras vivas, manera de evitar erosión, base de alimentación para seres vivos [si los niños olvidaron esta repuesta, solicite por medio de preguntas como: "¿A usted le gusta el maíz?"])

Entonces, enfatice que las plantas casi son los únicos seres vivos que pueden producir su propia alimentación. Preguntéles si alguien sabe el nombre de este proceso y en qúe consiste. Si nadie sabe, puede solicitar parte de la repuesta al preguntar "¿Cuáles son las necesidades de las plantas?"

De esta manera el maestro debe tratar de solicitar lo siguiente: Las plantas necesitan luz solar, agua, y dióxido de carbono para producir su propia alimentación (glucosa). Entonces, el maestro debe introducir los símbolos químicos para estas moléculas (agua = H_2O; dióxido de carbono = CO_2 ; glucosa = $C_6H_{12}O_6$) y después escriba la siguiente fórmula parcial:

agua	+	dióxido de carbon		glucosa
H_2O	+	CO_2	————————>	$C_6H_{12}O_6$

Explique que cada letra significa un átomo de un elemento y como ellos se combinan para formar moléculas. Entonces explique que este fórmula enseña como está formada la glucosa (alimentación sencilla) en las plantas.

IV. Actividad:

Dependiendo de su clase (su tamaño y su comportamiento) puede hacer esta actividad usando a los niños o solamente con las fichas. Explique que ellos van a hacer glucosa, como producen las plantas. Escoja dos niños -- uno va a representarse como el sol y el otro como la clorofila. Después pídales que primero ellos necesitan formar moléculas de agua y de dióxido de carbono, usando las fichas. Probablemente, al principio necesitará enseñarles cómo hacerlo.

Cuando ellos han formado moléculas usando todas las fichas, dígales que ahora nuestra planta va a hacer glucosa. Pídeales que traigan las moléculas de agua y dióxido de carbono al frente del aula. Cada niño puede representar una molécula aguantando las fichas o puede solamente traer las fichas y pegarlas en la pizarra.

Cuando todas las moléculas están adelante, pídales que ellos cuenten cuantos tipos hay de cada una. Escriba estos números en frente de los símbolos en la fórmula arriba ($6H_2O + 6CO_2$).

Entonces pídales a los niños que representen al sol y a la clorofila para crear una molécula de glucosa colocando de otra manera los átomos de agua y dióxido de carbono. (Otra vez, es posible que necesite ayudarlos). Al final, deberá tener una molécula de $C_6H_{12}O_6$ y doce otros átomos de O.

Dígales a los niños "Ahora hemos formado una molécula de glucosa, pero tenemos átomos sobrantes. ¿Qué podemos formar con estos?" Entonces ayúdeles a entender que con doce átomos de oxígeno, podemos formar seis moléculas de oxígeno ($6O_2$).

Escriba el resto de la fórmula:

$$\text{agua} + \text{dióxido de carbono} \qquad\qquad \text{glucosa} + \text{oxígeno}$$

$$6H_2O + 6CO_2 \xrightarrow[\text{clorofila}]{\text{luz solar}} C_6H_{12}O_6 + 6O_2$$

Finalmente, dígales que esta fórmula representa el proceso de fotosíntesis y escriba la siguiente definición que ellos pueden copiar:

"Fotosíntesis es el proceso en el cual las plantas, por medio del sol y la clorofila, convierten agua y dióxido de carbono en su propio alimento (glucosa) y oxígeno."

V. Discusión:

Después de esto, pregúnteles si ellos pueden decir las dos razones por qué la fotosíntesis es muy importante para seres vivos. (La fuente básica de alimentación y las plantas renuevan la cantidad de oxígeno y al mismo tiempo reducen la cantidad de dióxido de carbono).

Enfatice que el proceso de fotosíntesis se complementa con el proceso de respiración en que cada uno usa los productos del otro --

la fotosíntesis usa agua y dióxido de carbono, los productos de la respiración; mientras que la respiración usa glucosa y oxígeno, los productos de la fotosíntesis. Asegúrese que ellos entiendan que sin cualquiera de los dos procesos, la vida en esta planeta sería imposible.

Después hable un poco de cómo las plantas sirven como alimentación básica para todos los seres vivos y explique en términos sencillos en qué consiste una cadena alimenticia.

VI. Tarea:

Los niños deben dibujar una cadena alimenticia y escribir un párrafo donde la expliquen.

VII. Comentarios/Sugerencias:

Aunque el proceso de fotosíntesis puede ser difícil para los niños de entender, el concepto es muy importante, puesto que es fundamental en ecología y sirve como base de muchas de las relaciones en algun ecosistema. Vale la pena asegurar que los niños lo

Lección 5A-- El Arbol

l. Objetivo:
Los niños van a entender las funciones de los diferentes partes de los árboles.

ll. Materiales:
1. pizarra, tiza
2. bolsas para árbolitos
3. semillas
4. suelo (mezcla del suelo bueno y granza de arroz)

lll. Introducción:
Para empezar pregunte a los niños cuáles son las partes de un árbol y escríbalas en la pizarra. Después los niños deben decir para qué sirve cada parte, y se escriban las repuestas también. Es probable necesite ayudarlos para recordar algunas de las funciones.
Entonces debería tener una lista como esta:

raíces -- sostenerse, absorber agua y minerales
hojas -- respirar, producir comida por fotosíntesis, sombra
corteza (cáscara) -- protegerse
flores -- reproducirse (por polinización)
frutas -- distribución y germinación de semillas
tronco -- sostenerse

lV. Actividad:
Después construya un árbol con los niños actuando como partes de un árbol ("El Arbol Conversa," p. 46 , Ambiente en Acción), pero añada las hojas.

V. Discusión:
Después revise cada parte del árbol y pregúnteles para qué funciona.

VI. Tarea:
1. El mismo día u otro, los niños deben llenar las bolsas con una mezcla del suelo y granza de arroz y sembrar una semilla en cada bolsa. Puede usar estas bolsas para hacer un vivero o los niños pueden llevarlas a su casa para cuidarlas.
2. Hay diferentes tipos de árboles -- frutales, maderables, leguminosas, ornamentales. Divida la clase en grupos. Cada grupo debeinvestigar un tipo de árboles y haga una lista de lo más común de su región.

VII. Commentarios/Sugerencias
Puede hacer esta actividad con niños más pequeños, también. Para ellos es bueno hacer un dibujo en su cuaderno también.
Esta actividad es recomendable para el Día del Arbol o antes de empezar un vivero. Si su escuela tiene o va a tener un vivero, puede dar a cada niño la responsibilidad de anotar regularmente la altura de "su" arbolito, cuantas hojas tiene, el tamaño de las hojas, etc. Los niños pueden hacer un cuadro que demuestra el crecimiento de su árbol.

Lección 6 -- Cadenas/Tramas Alimenticias

I. Objetivo:

Los niños aprenderán cómo la transferencia de energía, en verdad, es una trama o red y no es una cadena sencilla. También ellos entenderán los diferentes papeles de los productores, consumidores (herbívoros, carnívoros, y omnívoros), y de los descomponedores. Ellos demostrarán su comprensión al clasificar el papel de diferentes seres vivos dentro de una trama alimenticia.

II. Materiales:

1. pizarra, tiza

III. Introducción:

Empiece con una discusión de la tarea de la última lección. Pídales que expliquen sus repuestas y escriba en la pizarra algunas de sus cadenas. Explique que una cadena alimenticia es, en verdad, una explicación de cómo la energía es transferida -- que cada ser vivo recibe su energía de su alimento, y en turno, es fuente de energía para otro ser vivo. Enfatice que el origen de energía en todas las cadenas es el sol; que las plantas transfieren este energía solar a la glucosa; que los animales usan esta energía directa o indirectamente, y que, finalmente, los hongos y las bacterias devuelven este energía otra vez al suelo, para el uso de las plantas como nutrientes.

Usando los ejemplos de los niños anote cada parte como productor (las plantas principalmente), consumidor (los animales principalmente), o descomponedor (los hongos y bacterias). Distinga los diferentes tipos de consumidores (herbívoros, carnívoros, y omnívoros), también usando los mismos ejemplos.

Explique, también, que a cada nivel de una cadena alimenticia hay menos energía (el ser vivo ha usado una parte de esta). Entonces hay menos predadores, a cada nivel más alto, desde que cada uno necesita comer más para sobrevivir. Entonces la biomasa representada por los productores es lo más grande, de los herbívoros lo proximo más grande, etc., hasta que los predadores, en la cima, son muy pocos. (Hay muy pocos tigres en comparación con el número de plantas en un bosque).

Finalmente, dígales que, desgraciadamente, en realidad la tranferencia de energía generalmente no ocurre en una cadena sencilla; mejor dicho, la transferencia de energía forma una trama o red.

IV. Actividad:

Para enseñar este punto final, escoja una de las cadenas escritas en la pizarra. Pida a diferentes niños que vayan adelante y que representen las diferentes partes de la cadena. Para representar la transferencia de energía (alimentación), los niños deben cogerle la mano al otro(s) niño(s).

Ahora, pregunte a los otros niños cuáles otros animales pueden alimentarse de las partes de esta cadena. Si un niño responde, añada este niño a la cadena como representante de este animal. De esta manera, pronto, en vez de una cadena sencilla, una red o trama se desarollará, mucho más complicada que la cadena original. Enfatice que esto -- la formación de tramas -- es lo que ocurre en la naturaleza.

Después, dígales que tendrán una competencia. Escriba los nombres de 20 seres vivos en la pizarra (Aunque la mayoria sea común, incluya algunos que los niños no conocen bien). Dígales que ellos necesiten clasificar cada ser vivo, por su papel en la naturaleza, como un productor (P), herbívoro (H), carnívoro (C), omnívoro (O), o descomponedor (D).

Despúes de 15 minutos, ellos deben cambiar sus papeles. Pídales sus repuestas y dígales si son correctas o no y porqué. Los niños anotarán cuales son correctas, y al final, determine los ganadores (busque más de un solo ganador -- "el segundo ganador, tercer, etc.")

V. Discusión:

Revise las partes de tramas alimenticias, enfatizando otra vez que el más alto el nivel en una trama, lo más presa se require cada ser vivo para obtener su energía. Escriba definiciones de cada parte que los niños pueden copiar o mejor solicite definiciones de ellos y escribalas, modificándolas si es necesario.

VI. Tarea:

Los niños deben hacer una trama alimenticia de una finca o un potrero. Esta debe incluir, al menos, 5 productores, 3 herbívoros, 3 carnívoros, 3 omnívoros, y 2 descomponedores. Pueden dibujar si quiren. También los niños deben explicar su red en un párrafo y anotar en cuál papel cada cosa sirve.

VII. Comentarios/Sugerencias:

El maestro puede dividir esta lección en dos partes, si quiere -- una parte que trata del concepto de trama o red, y después la otra parte que trata de los diferentes papeles dentro de una trama alimenticia.

El maestro debería revisar antes de la competencia los papeles de los diferentes seres vivos. ¡Algunos no son obvios!

Biología Integrada - Los Seres Vivos y Su Ambiente explica estos conceptos bién.

Lección 7 -- Cosas Abióticas - Agua

I. Objetivo:

Los niños aprenderán la importancia del agua en nuestra vida y entenderán qué significa el ciclo de agua. También van a apreciar la necesidad de conservar nuestras aguas.

II. Materiales:

1. pizarra, tiza

III. Introducción:

Empiece por decir que antes estudiamos las cosas bióticas y revise cuáles son. Entonces dígales que ahora vamos a estudiar las cosas abióticas y solicite de ellos una definición de cosas abióticas y cuáles son estas: [cosas inorgánicas; factores de clima; y algunos cosas orgánicas producidas por seres vivos] Hagan una lista que debe incluir aire, agua, rocas, etc. Dígales que hoy nosotros vamos a estudiar el agua.

Entonces pídales que digan todos los diferentes usos del agua. Escríbalos en la pizarra. (Es posible que ellos vayan a necesitar ayuda con algunos) [posibles respuestas: fotosíntesis; regar plantas; tomar; lavar ropa, etc.; bañarse; disolver; cocinar; para servicios; en industria (como beneficios); hábitat para animales; navegar/transportar].

Ahora pregúnteles "¿Cuáles tipos de agua puede encontrar en el mundo y dónde pueden encontrarlos?" [Respuestas: agua salada - -mar, estuarios; agua dulce - - quebradas, ríos, lagos, subterráneo, lluvia, nieve, tanques, tubería; agua de casquetes polares -- polo norte y sur]. Entonces anoten en su lista de usos, cuáles tipos de agua pueden servir para estos.

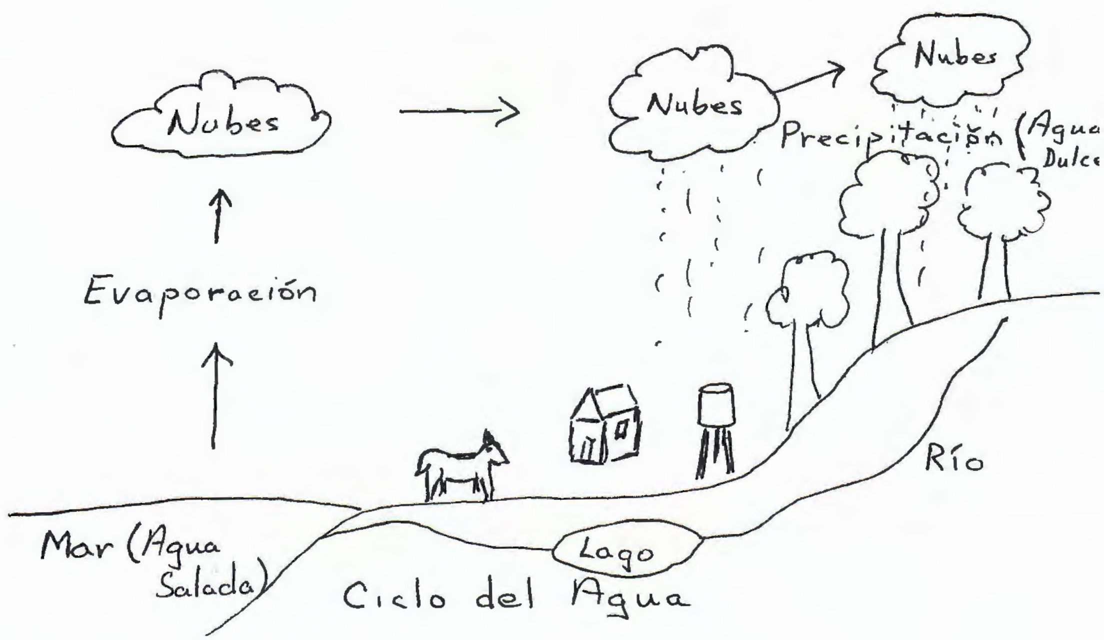


Figure 24. El ciclo del agua

Ahora pregúnteles "¿De dónde viene nuestra agua dulce y que pasa con ella?" Solicite de los niños la repuesta que viene de la lluvia. Otra vez pregúnteles "¿Y de dónde viene la lluvia?" [Respuesta: los nubes] Siga preguntando hasta que los niños hayan definido el ciclo del agua invertido. [Es más fácil de solicitar respuestas con un dibujo en la pizarra].

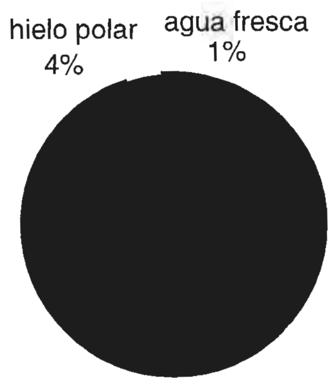
Después revise el ciclo de agua y como el agua cambia. [El agua salada en el mar es evaporada por el sol y forma nubes. El viento sopla los nubes sobre la tierra. Los nubes suben y como resultado el agua cae en forma de lluvia. Alguna lluvia es usada por seres vivos, pero parte va directamente a los ríos. Eventualmente todo del agua que cayó va al ríos y finalmente regresa al mar.]

IV. Actividad:

Ahora pídales que hagan un buen dibujo del ciclo de agua. Deben incluir en su dibujo algunos de los usos de agua también. Déles aproximademente 20 minutos para hacerlo, pero dígales que ellos pueden terminar su dibujo en casa.

V. Discusión:

Después dibuje en la pizarra y divida como a la derecha:



Díga a los niños que este círculo representa toda el agua que existe en el mundo, con las tres partes representando los tres tipos de agua. Pregúnteles que ellos adivinen cuál parte representa cual tipo de agua. Entonces enséñeles que casi 95% representa agua salada, 4% representa el agua en casquetes polares , y sólo 1% representa agua dulce. Discuta con los niños las implicaciones de estos hechos, en relación con nuestros usos del agua (principalmente el uso de agua dulce para muchas cosas). Enfatice con ellos el gran efecto de contaminación de agua dulce y la necesidad de mantener nuestra agua dulce limpia.

VI. Tarea:

1. Los niños deben terminar su dibujo y escribir una explicación del ciclo de agua.
2. Ellos deben escribir un cuento que trate de la historia de una gota de agua.
3. Ellos deben responder a la siguiente pregunta: "¿Si el clima de la tierra esta calentándose, como algunos científicos piensan, cuáles podrían ser los efectos para el mundo y para los seres vivos, y específicamente, cuáles podrían ser los efectos para Costa Rica?"

VII. Comentarios/Sugerencias:

Si el maestro quiere hacer otras actividades en relación con el tema de agua, hay otras lecciones en Ambiente en Accion, pps. 17-25.

Lección 8 -- Cosas Abióticas -- Aire (CO_2 - O_2)

I. Objetivo:

Los niños aprenderán la importancia del oxígeno y dióxido de carbono en el aire. También ellos empezarán a entender el problema del aumento de dióxido de carbono en el aire -- "El Efecto Invernadero." Finalmente discutirán la posibilidad que Costa Rica y otros países tropicales pueden recibir apoyo monetario de los países más desarollados como paga para un "intercambio" del dióxido de carbono por oxígeno.

II. Materiales:

1. pizarra, tiza

III. Introducción:

Pregúnteles "¿Para qué sirve el aire?" y escriba las repuestas en la pizarra. [Posible respuestas: respiración, fotosíntesis, molinos, producir energía, barcos de vela, soplar bombas/inflar otras cosas, volar (cometas, aviones, etc. , o seres vivos), y combustión. (Si los niños no dan las respuestas "respiración," "fotosíntesis," y "combustión," solicite estas repuestas con preguntas)].

Después pregúnteles si alguien sabe de que está compuesto el aire. [Respuesta: nitrógeno, oxígeno, y dióxido de carbono principalmente] Entonces pídeles que adivinen cuál porcentaje del aire está hecho por cada gas. Después de sus conjeturas, escriba lo siguiente: ">78%" y ">21%" y explique qué significa ">." Entonces dígales que estos porcentajes son los de dos de estos tres gases y pregúnteles cuáles son esos gases. Finalmente escriba lo siguiente para nitrógeno y oxígeno:

Table 16. Porcentage de los gases en el aire

nitrógen	(N)	--	>78%
oxígeno	(O_2)	--	>21%
dióxido de carbono	(CO_2)	--	[<0,03%]

Antes de escribir los datos para dióxido de carbono, pregúnteles si pueden calcular la cantidad.

Entonces pregúnteles cuál parte del aire se usa para cada cosa en la lista arriba, y escriba el símbolo al lado de esta cosa. Discutan la importancia de oxígeno y dióxido de carbono para respiración, fotosíntesis, y combustión.

IV. Actividad:

Haga un dibujo rápido que enseña el ciclo de O_2 - CO_2. (Vea abajo). Después dígales que ellos deban hacer su propio dibujo (pero mejor) en su cuaderno, pero también debería incluir algunos de los otros usos del aire. Déles aproximademente 20 minutos para hacerlo, diciendo que pueden terminarlo en casa.

V. Discusión:

Revise con ellos la manera en que la fotosíntesis y la respiración son complementarios, usando las fórmulas. Explique que también combustión es como respiración en este sentido -- usa oxígeno y produce dióxido de carbono. Discutan la importancia de los bosques que utilizan dióxido de carbono y producen oxígeno, y como de esta manera ellos mantienen los mismos proporciones de estes gases en el aire.

También discutan que el nivel de dióxido de carbono ha estado aumentando a causa del aumento de combustión causada principalmente por industria y carros. Explique que una idea para prevenir el empeoramiento de esta situación es que más árboles deben estar plantados. Dado que los árboles crecen mucho más rápido en los tropicos, la idea es que los países desarollados paguen a los países tropicales para sembrar y mantener árboles, los cuales pueden mantener el equilibrio de estos gases en el mundo.

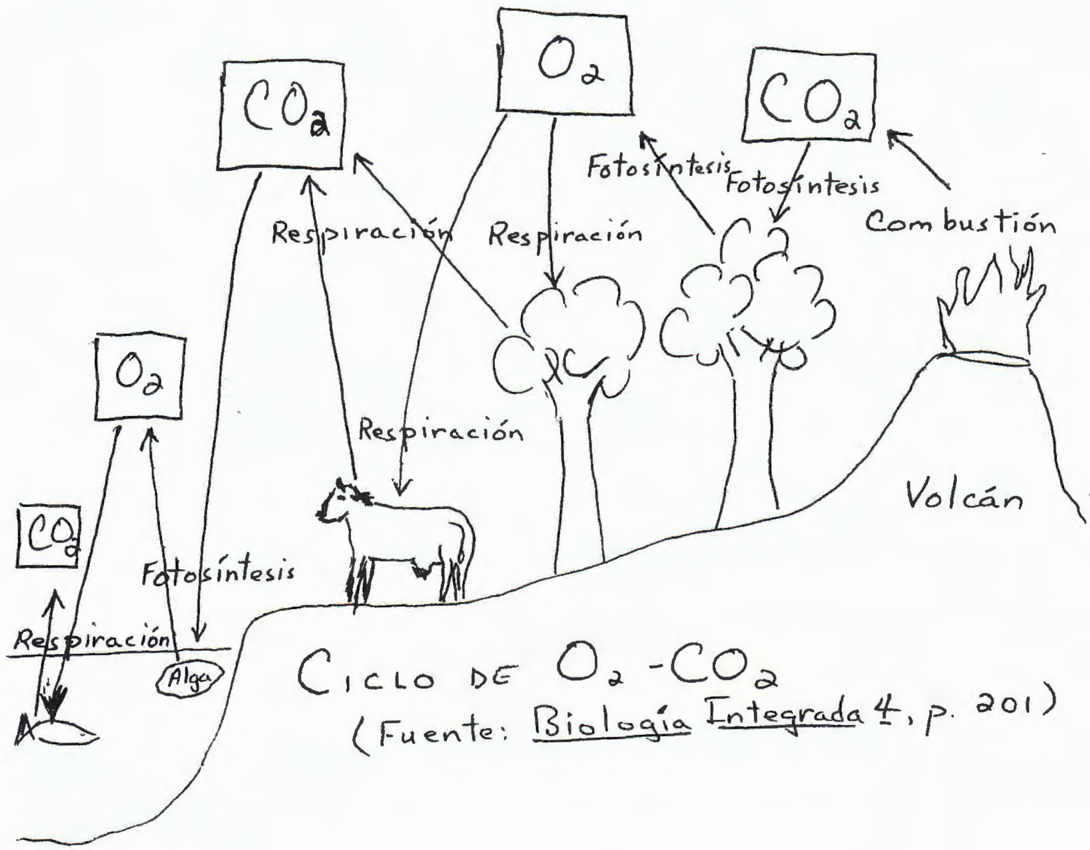


Figure 25. El ciclo del oxígeno-dióxido carbono

VI. Tarea:

1. Los niños deben terminar su dibujo y escribir una explicación del ciclo de oxígeno - dióxido de carbono.
2. Ellos deben responder a la siguiente pregunta: "¿Si nosotros quemamos demasiados bosques, cuáles podrían ser los efectos para los seres vivos?" [Este es "El Efecto Invernedero"]
3. Explique que todavía no hablamos de nitrógeno. Para la próxima clase, ellos deben preguntar a sus padres o otros agricultores cuál(es) tipo(s) de abono usan y para cuál(es) cultivos.

VII. Comentarios/Sugerencias:

El maestro puede demostrar la habilidad de las plantas para purificar el aire. Coloca una bolsa plastica completamnte alrededor de una planta. En algunos días los niños pueden ver esta planta y anotar que ha pasado. [La planta puede sobrevivir porque ella respira oxígeno; bota dióxido de carbono; y usa dióxido de carbono para producir oxígeno].

También el maestro puede hacer un terrario que tenga animales pequeños asi como plantas. Aunque el terrario esté cubierto completamente, los seres vivos pueden sobrevir porque hay un intercambio continuo de O_2 y CO_2.

Lección 9 -- Cosas Abióticas -- Aire (Nitrógeno)

I. Objetivo:

Los niños aprenderán la importancia del nitrógeno en el aire y como es usado por las plantas leguminosas como abono. También ellos aprenderán cómo es posible usar fertilizantes naturales como abono, en vez de abonos químicos (artificiales).

II. Materiales:

1. pizarra, tiza
2. Libros -- Rocap - Ciencias 5

III. Introducción:

Revise con los niños las porcentajes de varios gases en el aire:

Table 17. Porcentage de los gases en el aire

nitrógeno	(N)	--	>78%
oxígeno	(O_2)	--	>21%
dióxido de carbono	(CO_2)	--	[<0,03%]

Entonces explique que antes no hablamos de la importancia del nitrógeno, aunque de este consta la mayor parte del aire. Pregúnteles si alguien, en su investigación, aprendió la importancia de nitrógeno. Si no, pregúnteles cuáles tipos de abono artificiales usan los agricultores de su comunidad . Escriba los números de los abonos en la pizarra (5-10-5, 10-15-10, etc.). Otra vez, pregúnte si ellos saben qué significan estos números. Si nadie sabe, explique que representan las cantidades respectivas de nitrógeno, potasio, y fosfatos en cada abono.

Explique que las plantas necesitan usar nitrógeno para crecer, pero que no pueden usar nitrógeno directamente del aire. Ellas pueden usar nitrógeno, solamente cuando está dentro de compuestos que se llaman "nitratos." Muchas veces el suelo no tiene demasiados nitratos; los cultivos u otras plantas los han agotado. Entonces los agricultores usan abonos artificiales en donde están estos compuestos.

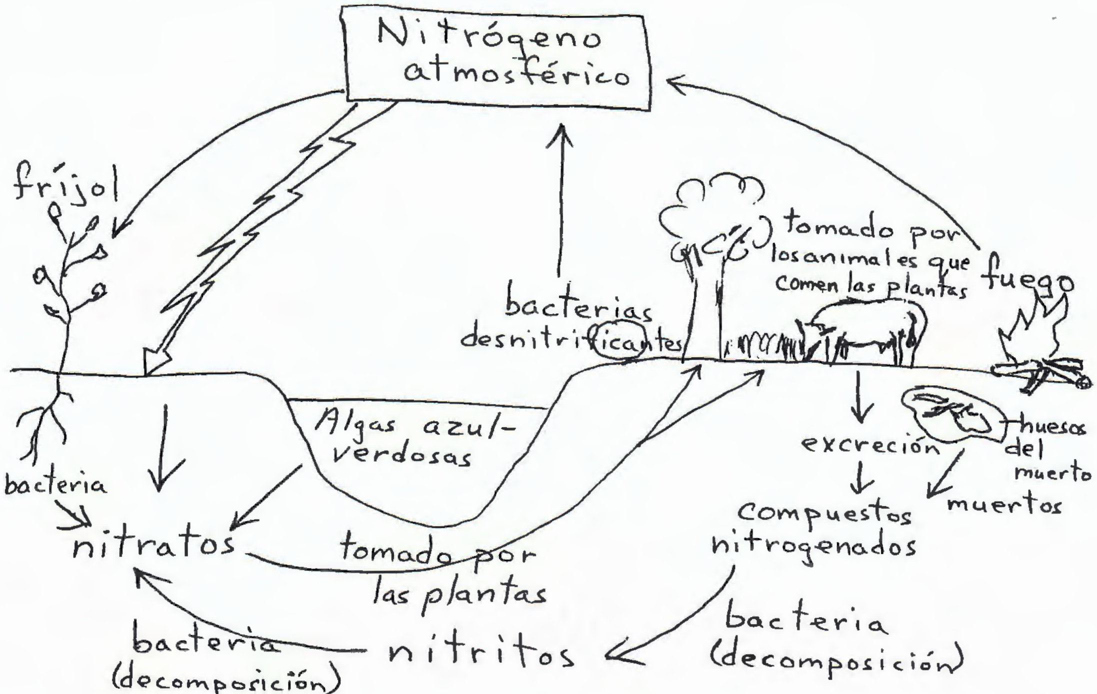
Pregúnteles que digan para cuáles cultivos usan los diferentes abonos y haga un cuadro en la pizarra con cultivo y abono usado. Deje espacio para otra columna. Cuando haya terminado el cuadro, pregúnteles si algunos de sus agricultores usan abonos naturales y para cuáles cultivos. Anótelos a lado de los cultivos, en su cuadro, en la última columna.

Explique que en la naturaleza existen abonos naturales. Los principales abonos naturales son las plantas leguminosas. En conjunción con las bacteria en sus raíces, este tipo de planta puede "fijar" el nitrógeno en el suelo (lo convierte en nitratos), para que la planta pueda usarlo como nutriente. [También, las descargas eléctricas y la acción de algunas bacterias y algas azul-verdosas pueden convertir nitógeno en nitratos].

Enséñeles que, aunque muchas veces en tiempos modernos, la gente usa muchos fertilizantes químicos como abono, por miles de años la gente indígena ha usado esta habilidad de las plantas leguminosas para fertilizar sus cultivos. [En América Central y México los fríjoles eran cultivados y usados como abono en combinación con maíz].

IV. Actividad:

Haga un dibujo que enseñe el ciclo de N. (Vea abajo). Después dígales que deban hacer su propio dibujo (pero mejor) en su cuaderno. Déles aproximadamente 20 minutos de hacerlo, diciéndoles que pueden terminarlo en casa.



CICLO DEL NITRÓGENO
(Fuente: Biología Integrada 4, p. 200)

Figure 26. El ciclo del nitrógeno

V. Discusión:

Revise con ellos la manera en que las plantas leguminosas pueden fijar el nitrógeno en el suelo; entonces las otras plantas y animales pueden usarlo. Discutan también cómo el nitrógeno regresa al suelo. Finalmente, discutan los diferentes papeles que las bacterias desempeñan en este ciclo.

Discutan las maneras en que los agricultores pueden plantar plantas leguminosas para abonar sus cultivos. Tenga una discusión de las ventajas/desventajas de cada tipo de abono -- artificial o natural.

VI. Tarea:

1. Los niños deben terminar su dibujo y escriba una explicación del ciclo de N.
2. Los niños deben investigar más el uso de abonos naturales y hacer una lista de las plantas leguminosas en su región.
3. Para la próxima clase, los niños deben traer de 5 a10 rocas de tipos diferentes.
4. Si la escuela tiene el libro, los niños deben leer en Rocap - Ciencias 5 pps.176-197 y responder por escrito a preguntas #4-13 en p.198.

VII. Comentarios/Sugerencias:

El maestro puede invitar a un agricultor o un representante del MAG para dar una charla sobre el uso de abonos naturales. También, la clase puede visitar un cafetal o finca para observar el uso de poró, madero negro, y otros árboles leguminosas.

Lección 10 - Cosas Abióticas -- Rocas

I. Objetivo:

Los niños aprenderán el origen y los diferentes tipos de rocas. También tendrán un conocimiento de su importancia y usos en su país.

II. Materiales:

1. pizarra, tiza
2. las rocas que los niños han traido
3. rocas de diferents tipos, como ejemplos
4. jugo de limón

III. Introducción:

Dígales que, como ellos se dieron cuenta cuando buscaban sus rocas, hay muchos diferentes tipos de rocas. Enséñeles una colección de diferentes rocas que usted haya recogido antes.

Forme grupos de 2 ó 3 niños en cada grupo. Pregúnteles de cuántas diferentes maneras pueden clasificar sus rocas. Discutan algunas de estas (e.j., tamaño, dureza, color, etc.). Déles 10 minutos para hacer una lista de las diferentes clasificaciones de rocas que cada grupo tiene.

Después, escriba las repuestas en la pizarra y los diferentes tipos de cada clasificación. [Forma, color, tamaño, dureza, textura, estratatificación, brillo, densidad]

IV. Actividad:

Ahora, pregúnteles "¿Por qué?" o "¿Cuáles son las razones para estas diferencias en las rocas?" Ayúdeles a entender que las diferencias son el resultado de tres cosas: 1) composición 2) origen y 3) experiencia (cuáles cosas ocurrían a estas rocas -- erosión, presión, temperatura, etc.).

Revise la lista de clasificaciones y discutan cuáles son las razones principales para cada clasificación. [por ejemplo, el color es causada principalmente por su composición].

Ahora dibuje el ciclo de rocas (Vea abajo) y expliquéles. Déles 10 minutos para copiarlo rapidamente.

V. Discusión:

Revisen los diferentes orígenes de las rocas. Después haga una lista de los diferentes usos que se les dan a las rocas en su país. Asegurese que los niños incluyen la formación del suelo en su lista.

Enseñeles cómo se puede determinar la dureza relativa de los minerales que se encuentran en las rocas. También si tiene caliza o un pedazo de marmól, puede enseñarles la reacción de cosas ácidas (jugo de limón) con este tipo de mineral/roca.

VI. Tarea:

1. Los niños deben hacer un buen dibujo del ciclo de rocas con una explicación.
2. Los niños deben investigar los usos de minerales en su región o hacer un mapa que enseñe cuáles minerales se encuentran en las diferentes regiones de su país.
3. Si ellos quieren, pueden buscar otros tipos de rocas y experimentar con ellas.
4. Para la próxima clase, los niños deben traer unas muestras de suelo de diferentes tipos en tarros (2 ó 3 muestras).

VII. Comentarios/Sugerencias:

El maestro puede dividir esta actividad, si no hay demasiado tiempo. También, puede hacer un viaje a una cantera o a un lugar donde las rocas están expuestas al aire (y preferiblemente de diferentes tipos).

El maestro puede buscar más información o ideas para actividades acerca de las rocas y minerales en ROCAP Ciencias 5° p.176-197; Ciencias Naturales 5°, p. 58-71; y Ciencias de la Naturaleza 6°, p. 202-212.

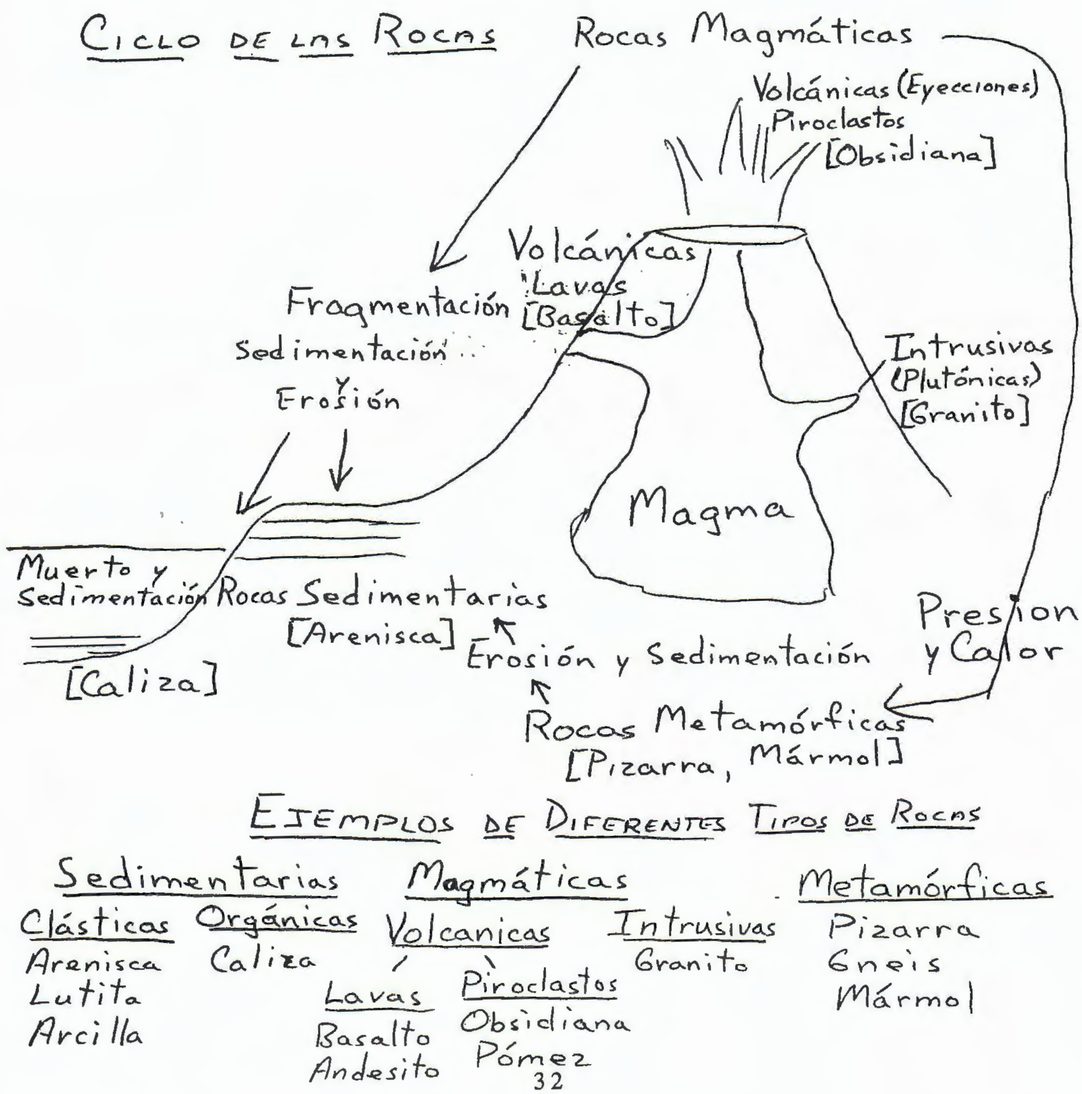


Figure 27. Ciclo de las rocas

Lección 10A -- Geología de Costa Rica

I. Objetivo:

Los niños aprenderán las diferencias entre los conceptos del Vulcanismo y Orogénesis. También ellos entenderán basicamente que los dos son productos del movimiento de las placas. Finalmente, aprenderán cómo se formó Costa Rica.

II. Materiales:

1. pizarra, tiza
2. mapa escolar grande de Costa Rica
3. mapa escolar para los estudiantes

III. Introducción:

Pregunte a los niños si algunos saben la teoría de "La tectónica de placas." Discutan con ellos los conceptos básicos de esta teoría: (fuente: La Diversidad Biología de Costa Rica)

1. La capa rocosa más externa del planeta se halla dividida en pedazos o placas, algunos gigantescos, otros medianos, otros pequeños.
2. Estos pedazos, las placas tectónicas, se mueve activamente, chocan, se deslizan o se alejan unos de otros, según las circunstancias.
3. Las placas forman la litósfera, (su profundidad varía, hasta 200 km dependiendo de región).
4. Las placas litosféricas descansan sobre una capa de roca fundida, la astenosfera, (a unos 100 km de profundidad o más), cuya energía y fluidez permite los movimientos.
5. La forma y posición de los actuales continentes no siempre ha sido como la conocemos en el presente.
6. Las principales actividades de interacción entre placas vecinas son:
    a) Subducción -- cuando dos placas se mueven en forma convergente (uno contra la otra), la placa más pesada se desliza debajo de la más liviana. Este proceso produce gran calor y presión que pueden tener dos resultados:
        1) Vulcanismo -- este calor puede fundir la roca y permite que el magma suba en proyecciones digitiformes a través de la placa suprayacente. Si estas proyecciones llegan hasta la superficie se forman volcanes; si no pueden enfriarse en el interior y constituir rocas intrusivas.
        2) Orogénesis -- La presión de subducción causa que la placa superior se comprima cerca de la linea de interacción y se levanta formando montañas.
    b) Accreción -- durante el proceso de subducción, algunas porciones de la placa subducente quedan adheridos a la placa superior.
    c) Expansión del suelo oceánico -- dentro del océano, donde las placas se separan una de la otra (por moverse en sentidos opuestos) brota el magma o roca fundida desde grandes profundidades, se solidifica y ocupa el espacio dejado por las placas al desplazarse. De esta manera, las rocas "nacen" o se originan en las zonas de expansión y se desplazan (movimientos tectónicas) hacia las zonas de subducción.

d) Fallas -- ocurre cuando una placa se desliza al lado de otra creando una zona de fricción. Esta fricción puede causar temblores o algunas veces terremotos.

7. Los efectos tectónicas en Costa Rica son principalmente el resultado del choque entre las Placas Coco y Caribe, y la subducción de la Placa Coco debajo de la Placa Caribe. [Enseñe a los niños en el mapa las posiciones aproximadas de las dos placas].

[El maestro puede demostrar fácilmente como los niños pueden asimilar el proceso de subducción y orogénesis y la acción de fallas. Para subducción: Dígales que ellos pongan sus puños juntos y se presionen. Eventualmente, uno u otro puño se va a deslizar debajo, al mismo tiempo que la muñeca opuesta va a subir (formando "montañas" por orogénesis). Puede explicar también que esta presión puede producir magma por alta temperatura, formando volcanes. Para fallas: Dígales que pongan las manos juntos y se presionen. Eventualmente, uno u otra o los dos van a deslizarse causando un "temblor" o "terremoto."

IV. Actividad:

Dígales que ahora vamos a aplicar estos conocimientos a la formación de Costa Rica. Use el mapa grande para enseñar, pero es mejor que también dibuje esto en la pizarra y coloree cuando habla de las diferentes regiones geológicas. [Vea dibujo a fines de esta lección.]

Empiece por decir que hasta aproximademente 30-40 millones de años existía un estrecho entre Norte y Sur América. (La parte de Centroamérica, que incluye Costa Rica, la parte sur de Nicaragua, y la región oeste de Panamá, no existía antes). Antes, en vez de este istmo, existían una serie de las islas volcánicas, que nacieron por vulcanismo y desaparecieron por causas de la erosión, para dar paso a otras nuevas. Algunas de las rocas formadas durante esta época se sedimentaron formando rocas sedimentarias, y posteriormente se integraron con el nuevo istmo por proceso de acrección. Hoy, pueden encontrar estas rocas en Santa Elena, Nicoya, Osa, y las zonas de Herradura y Burica. [Dibuje con una tiza de color algunas islas entre Nicaragua y Panamá en su mapa en la pizarra. Después bórrelas para significar su erosión. Dibuje otras. Bórrelas otra vez, pero deje algunas en las regiones de Santa Elena, las peninsulas Nicoya y Osa, y las zonas de Herradura y Burica. Escriba la información en el mismo color.]

Entonces, (hace 30-40 millones de años) la presión de subducción de la Placa Caribe causa el surgimiento de la Cordillera de Talamanca por orogénesis. Cuando se levantó, también se fracturó permitiendo la salida de magma. Sin embargo, no llegó hasta la superficie (no formó volcanes), pero enfrió abajo formando rocas intrusivas. [Usando un color diferente dibuje la Cordillera de Talamanca y escriba la información en el mismo color].

Después, siga con la formación de la Cordillera de Tilarán y los Cerros de Aguacate. [Este yo creo incluye la región alrededor de Puriscal; al menos incluye el Cerro Turrabares]. Esta región estaba formada hace 10 millones de años por la intensificación de actividad volcánica al noreste de la Cordillera de Talamanca, aunque hoy no hay volcanes activos en esta región. Al mismo tiempo se levantó parte de la región Pacífica norte. El resultado es que, al final, existía una angosta faja de tierra que conectaba a Norteamérica con Suramérica. [Usando un color diferente dibuje la Cordillera de Tilarán, los Cerros del Aguacate, y el puente formado durante este tiempo. Escriba la información al lado del mapa en el mismo color].

Ahora siga con vulcanismo reciente -- la formación de la Sierra (Cordillera) Volcánica Central y la Sierra (Cordillera) Volcánica de Guanacaste. Estas montañas están formado por extensa actividad volcánica que empezó hace 2 millones de años y perdura

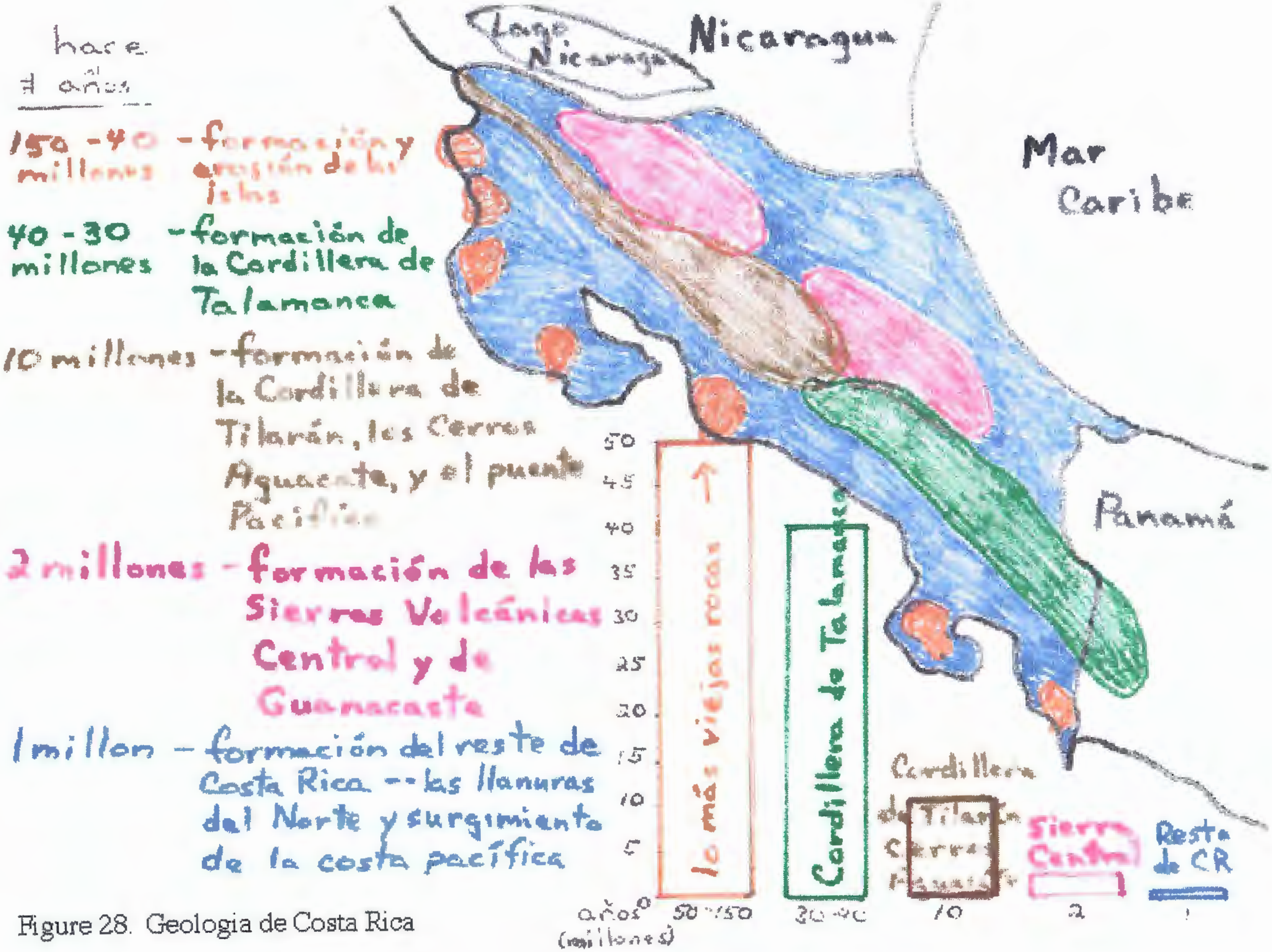


Figure 28. Geologia de Costa Rica

hasta hoy. [Aunque los libros que tengo, usan la palabra "cordillera," algunos maestros me dijeron que se debe usar en lugar de esta la palabra "sierra" porque son volcánicas]. [Usando un color diferente, dibuje estas sierras y escriba la información al lado del mapa].

Finalmente, siga con la formación de las llanuras y el surgimiento del costa Pacífica. Estas empezaron hace 2 millones de años y se concluyeron hace 1 millón. [Dibuje con un color diferente y escriba la información al lado del mapa].

Ahora, haga el diagrama que enseña la edad relativa de cada etapa del proceso.

Déles tiempo para copiar el mapa, la información, y el diagrama. [Vea a fines de esta lección.]

V. Discusión:

Pregúnteles ¿qué importancia tiene la formación geológica de Costa Rica para su biología? Discutan con ellos. Algunas ideas:

1. No hubo dinosaurios en Costa Rica. Los dinosaurios desaparecieron hace 65 millones.
2. Hasta 150 millones de años la mayoría de la biofauna de Norteamérica y Suramérica se evolucionó separada una de otra. Cuando las islas aparecieron hubo alguna posibilidad de intercambio. Pero, solamente hace 10 millones de años, con la formación del puente ístmico, era posible un intercambio verdadero y colonización de nuevas especies en Costa Rica.
3. Con la formación de las montañas la biofauna del Pacífico y del Atlántico estaba separada y empezó a evolucionar separada una de otra. También, las montañas sirven como una barrera biológica para muchas especies de la vertiente Pacifio y de la vertiente Atlántico.
4. Como un resultado de lo expuesto arriba, hay gran biodiversidad en Costa Rica. (Vea lección 1: La Biodiversidad de Costa Rica).

VI. Tarea:

1. Escriba con sus propias palabras una descripción de la formación geológica de Costa Rica y cómo afecta la biodiversidad de Costa Rica.
2. Para la próxima clase los niños deben traer unas muestras del suelo de diferentes tipos, en tarros (2 ó 3 muestras).

VII. Comentarios/Sugerencias:

He incluído mucha información técnica en esta lección (la mayoría es de La Diversidad Biológica de Costa Rica, p.53-73). El maestro puede usar cualquier parte que quiera y debe explicar con sus propias palabras (depende de sus estudiantes).

Esta lección es opcional. Si da esta lección, deje la tarea #4 de la lección 10 para esta lección,10A para preparar para la próxima clase del suelo.

Puede usar esta clase como la base de discusión para "Equilibrio Ecológico" (Lección 15).

Lección 11 -- Cosas Abióticas -- El Suelo

I. Objetivo:

Los niños aprenderán el origen del suelo, de qué elementos consiste y su importancia. También, ellos entenderán los diferentes tipos del suelo y su relativa importancia para los cultivos de su región.

II. Materiales:

1. pizarra, tiza
2. muestras del suelo (recogidos por los niños)
3. Folleto #4 -- "El Suelo" (por PRODAF/GTZ)

III. Introducción:

Revise con los niños que la última vez dijimos que uno de los más importantes usos de las rocas era la producción del suelo. Dígales también que hay muchos tipos del suelos, depende de que está formado.

IV. Actividad:

Dígales que van a investigar sus muestras del suelo. Forme grupos para asegurarse que cada grupo tiene aproximademente el mismo número de muestras. [Es mejor formar grupos de pocos miembros (2-3)]. Indique que cada grupo debe construir un cuadro con sus muestras, como lo siguiente:

Table 18. Analisis de muestras del suelo

Muestra	Color	Compacto	Humedad	Composición
#1				
#2				
#3				
#4				

Dígales que primero cada grupo deba decidir de cada muestra el color, cuán compacta es, y cuán húmeda es la misma según los siguientes criterios:

Compacto: Muy compacto, Compacto, Medio, Suelto, Muy Suelto
Humedad: Muy húmedo, Húmedo, Medio, Seco, Muy Seco

Después de clasificar las diferentes muestras con estas características , ellos pueden separar cada muestra para determinar las diferentes componentes.

V. Discusión:

Pregúnteles si hay diferencias en sus muestras. Discutan que cada tipo del suelo tiene sus propias características, pero en general los suelos son caracterizados como arcillosos, limosos y arenosos dependiendo de cuán compactos son. [arcilloso: partículas de rocas sumamente unidos; arenoso: partículas de rocas totalmente sueltos; y limoso: una mezcla de arenoso y arcilloso]. Enfatice también que las partes orgánicas (ramitas, hojas, etc.) que ellos encontraron en sus muestras se van a descomponer para formar el humus, que es la parte orgánica del suelo, y que ayuda el crecimiento de las plantas.

VI. Tarea:

1. Los niños deben entrevistar a sus padres u otras agricultores acerca de los diferentes tipos del suelos en su lugar, y cuáles son mejores/peores para cuáles cultivos en la comunidad.
2. Escriba un informe de su entrevista.
3. Para la próxima clase, escriba un párrafo o más que describa su concepto de "la naturaleza"

VII. Comentarios/Sugerencias:

El maestro puede hacer una breve visita, con la clase, a un lugar donde algunos metros del suelo están expuestos y discutir cómo el suelo está formado.

Los niños pueden actuar la formación del suelo como en Ambiente en Acción , p. 28 o el maestro puede usar otras de las actividades en este libro, pps. 28-37.

Puede experimentar con diferentes suelos. Por ejemplo, la habilidad de cada tipo de absorber agua; o un experimento para comparar cuánto tiempo cada uno puede retener agua (¿Cuánto tiempo para secar?). Discuten los beneficios/perjuicios de cada tipo para los agricultores y la vida en general.

Lección 12 -- Ecología: Poblaciones y sus relaciones

I. Objetivo:

Los niños aprenderán el concepto de ecología y demonstrarán su conocimiento de los diferentes tipos de relaciones que existen entre las poblaciones.

II. Materiales:

1. pizarra, tiza

III. Introducción

Primero discutan con los niños sus conceptos de la naturaleza y escriba algunas de sus ideas, en la pizarra. [Aunque en estas lecciones, no hemos discutido los otros reinos (científicos): monera, protista, y fungi, asegure que los niños entienden que estos también son una parte de la naturaleza]. Si nadie dice que el hombre también es parte de la naturaleza, pregúnteles ¿por qué? y discútanlo.

Entonces, dígales que, en general, hemos estado estudiando cada una de estas cosas (bióticas y abióticas) y que ellos mismos son individuos, pero en realidad, ellos existen en relación con cada uno. Dígales que el estudio científico de estas relaciones se llama ecología. Define ecología como "el estudio de las relaciones entre las especies que habitan la tierra y su ambiente." (Chacón, p. 5)

Antes de continuar, revise ésto con ellos. Pregúnteles qué es un individuo, discutan y escriba la palabra con su definición. Siga con "especie". Es bueno que escriba esta definiciòn de una especie después: "Seres vivos que pueden reproducirse y sus crías pueden reproducirse también." Explique si es necesario.

Entonces, discuten la idea de "población." Es más fácil empezar con la definición popular (número de habitantes de una lugar (pueblo, ciudad, cantón, país, tierra) antes de extender la definición. Por ejemplo, siga con ¿qué es la población de sexto grado?, de esta escuela?, de su casa? Ahora, puede continuar con la población de perros/ de gatos en su comunidad, antes de introducir la población de tigres, etc. en un bosque, etc.

Asegúrese que ellos entienden que una población (científico) está compuesto de un solo un tipo de especie. [No es posible tener una población de gatos y perros por ejemplo]. Ahora, puede escribir la definición de población: "el número de individuos de una misma especie que viven en el mismo lugar."

Entonces, pregúnteles cuáles tipos de relaciones existen dentro de una población. Discutan ejemplos y escriba en la pizarra. Clasifiquen juntos después. Eventualmente, enseñe a clasificar que son cuatro tipos de relaciones dentro de las poblaciones: cooperación, competencia, neutralismo, y depredación.

Escriba este cuadro en la pizarra y explique:

Table 19.-- Relaciones dentro poblaciones

Beneficio	¿A?	¿B?	Nombre de relación	Ejemplos
	+	+	Cooperación	
	o	o	Neutralismo	
	-	-	Competencia	
	+	-	Depredación	

Con su ayuda llenen este cuadro con sus ejemplos ya escritos.

IV. Actividad:

Dígales que ahora deben ir fuera de la escuela y anotar en sus cuadernos los diferentes relaciones entre poblaciones que ellos pueden observar. Ellos deben ser tán específicos como sea posible. Déles 10-15 minutos, y ayúdeles si necesario.

V. Discusión:

Después discutan los ejemplos y clasifiquen cada uno según los cuatro tipos. Hagan esta clasificación juntos y escriba en la pizarra.

VI. Tarea [Probablemente es mejor hacerla en grupos]:

1. Los niños deben buscar un pequeño lugar en su pueblo (un potrero, una finca, un río, etc.). Ellos deben demarcar parte de este (al menos aproximadamente 3 metros cuadrados).
2. Ellos necesitan hacer una lista de los diferentes poblaciones que encontraron dentro este lugar (Si es posible traten de distinguir un poco -- en vez de "mariposa," anoten "mariposa verde" o "mariposa negro y rojo," etc., si no saben los nombres exactas).
3. Anoten las relaciones dentro de las poblaciones que observen, y clasifíquenlas.

VI. Comentarios/Sugerencias:

Aunque puede enseñar esta y la próxima lección juntas, creo que es mejor separarlas. De esta manera es más fácil de "construir" el concepto de ecosistema poco a poco.

Lección 13 -- Ecología: Comunidades y sus relaciones

I. Objetivo:

Los niños aprenderán el concepto de la "comunidad," como está usado por los científicos. También, entenderán las diferentes relaciones que existen entre diferentes poblaciones. Finalmente, empezarán a entender el concepto del ecosistema.

II. Materiales:

1. pizarra, tiza

III. Introducción:

Revise con los niños su tarea. Escriba en la pizarra los diferentes poblaciones que encontró cada grupo abajo de una palabra que caracteriza su lugar (por ejemplo, potrero, finca, bosque, etc.) Entonces, dígales que todos los seres vivos (todos las poblaciones) juntos en un lugar se llama una comunidad. [Si necesario, usa la palabra "comunidad" por su pueblo para explicar mejor que incluye no solamente los hombres, mujeres, y niños, pero también los perros, gatos, pollos, etc. y también los árboles, las plantas las flores, etc.] Entonces, escriba en la pizarra la siguiente definición de una comunidad: comunidad -- "el conjunto de seres vivos que viven en un lugar"

Ahora, explíqueles que también existen relaciones entre las diferentes poblaciones , algunas de estas similar a ellas dentro poblaciones, otras diferentes. Escriba otra vez la cuadra de la última lección.

Table 20. Relaciones dentro poblaciones

Beneficio	¿A?	¿B?	Nombre de relación	Ejemplos
	+	+	Cooperación	
	o	o	Neutralismo	
	-	-	Competencia	
	+	-	Depredación	

Ayúdeles a los niños a llenar este cuadro con ejemplos de relaciones entre diferentes poblaciones (diferentes especies). Después siga con la siguiente:

1. Primero: Dígales que los científicos usan una palabra en vez de "cooperación" cuando hay poblaciones de diferentes especies. Esta palabra es "mutualismo." Cambie la palabra en el cuadro.
2. Empiece con depredación y pregúnteles ¿Cómo se llama si la cosa que obtiene beneficio es más pequeño? (parasitismo). Escriba la palabra y busque ejemplos para llenar el cuadro.
3. Después, dígales que usamos la palabra "depredación" cuando un animal más grande come otra animal, y "parasitismo" cuando el animal que beneficia es más pequeño, pero si un animal come una planta, tenemos otras palabras: "pastoreo" si come pastos, y "ramoneo" si come ramas. Escriba estas palabras en el cuadro.

4. Finalmente, enseñeles que nuestra esquema falta solamente dos combinaciones (°,+) y (°,-). Escriba estas en el cuadro. Después, pregúnteles si ellos saben algunos ejemplos en que una especie recibe beneficio, pero la otra no recibe beneficio ni daño. [Unos de los más comunes ejemplos son las epífitas. Los nidos de algunos aves son también, pero cuidado!]. Dígales que cuando una especie recibe beneficio, pero la relación es neutral para la otra, este tipo de relación se llama "comensalismo." Escriba en su cuadro. Entonces, dígales que también hay algunos ejemplos donde una especie recibe daño, pero otra no recibe beneficio ni daño. Esta relación se llama amensalismo, pero es menos común; escriba en la pizarra también.

Ahora debería tener un cuadr llenado como esta con sus ejemplos:

Table 21. Relaciones entre poblaciones

Beneficio	¿A?	¿B?	Nombre de relación	Ejemplos
	+	+	Mutualismo	
	°	°	Neutralismo	
	-	-	Competencia	
	+	-	Depredación	
	-	+	Parasitismo	
	+	-	Pastoreo	
	+	-	Ramaneo	
	+	°	Comensalismo	
	-	°	Amensalismo	

Ahora pregúnteles a los niños que ellos clasifiquen estas relaciones en dos grupos: 1) hay beneficio a al menos una especie, pero no hay daño a ninguna 2) hay daño a una o a las dos especies. Déles tiempo para hacerlo. Cuando ellos han terminado, vayan a tener dos grupos, con "neutralismo" afuera de la clasificación.

Table 22. Clasificación de relaciones entre poblaciones según de daño o beneficio

Simbióticas	Antagónicas	Neutras
Mutualismo	Competencia	Neutralismo
Comensalismo	Depredación	
	Parasitismo	
	Pastoreo	
	Ramaneo	
	Amensalismo	

Dígales que nosotros usamos estas palabras para distinguir estos grupos: 1) relaciones "simbioticas" si hay beneficio sin daño; estas relaciones incluye mutualismo y comensalismo 2) relaciones antagónicas en que hay daño a al menos una especie y 3) relaciones neutral. Enfatice que aunque hay menos tipos de relaciones, estas relaciones simbióticas son muy comunes en la naturaleza, porque la evolución las favorece.

Revise todo antes de continuar con la actividad: una competencia.

IV. Actividad: Una competencia

Dígales a los niños que ahora van a tener una competencia para ver si ustedes pueden decir cuál tipo de relación existe entre diferentes poblaciones. Puede dividir en grupos si quiere o no. [Yo creo es mejor]. Escriba un frase de una relación por cada pregunta. Empiece con alguna cosa más fácil. Despúes de cada uno, déles tiempo de responder y discuten las respuestas y explique si necesario, antes de continuar. Las preguntas deben ser más y más dificil.

Este es un ejemplo de una serie de preguntas:

1. Culebra come ratón
   [Depredación -- la culebra beneficia; el ratón pierde su vida]
2. Abeja come polen
   [Mutualismo -- la abeja se alimenta; la flor está polinizada]
3. Ratón come maíz
   [Mutualismo -- el ratón se alimenta; las semillas de maíz son dispersados por el ratón, y como un resultado tienen una mejor oportunidad de crecer]
4. Gavilán tiene su nido en el árbol de Guanacaste
   [Comensalismo: El gavilán recibe protección y un hogar para sus crías; no hay beneficio ni daño para el árbol]
5. Yigüirro tiene nido en el árbol de Higuita
   [Mutualismo: El Yigüirro tiene hogar y protección para sus crías, y también se alimenta de las frutas; el árbol se beneficia porque las semillas del árbol son dispersados por el Yigüirro]
6. Oruga (gusano) come las hojas de una planta
   [Depende: Mutualismo, si las mariposas de este tipo de gusano polinizan este tipo de planta; si no, es una forma de pastoreo]
7. Carpintero hace nido en un árbol
   [Depende: Hay daño al árbol, pero si el carpintero coma larvas, gusanos, y otras insectos dañinos que causan más daño, es posible el resultado neto de esta relación sea positivo para el árbol].

V. Discusión:

Revise otra vez para clarificar preguntas. Enfatice que muchas veces no es fácil para decidir si hay beneficio o daño. Por ejemplo, algunos aves destruyen las semillas cuando ellos comen las frutas. Entonces, no son dispersadores de las semillas; en verdad son deprededores!

Entonces, dígales que en cada ecosistema hay muchos ejemplos de cada tipo de relación. Pregúnteles que digan cuáles son algunos diferentes ecosistemas y escriba en la pizarra (bosque, playa, potrero, finca, ciudad, mar, río, etc.).

VI. Tarea:

Divida los niños en grupos y déles a cada grupo un tipo de ecosistema para investigar.

1. Para cada ecosistema los niños necesitan escribir:
   a) 10 cosas bióticas (nombres especificos) que viven en este ecosistema
   b) 5 relaciones antagónicas (especificas) dentro de este ecosistema
   c) 3 relaciones simbióticas (especificas) dentro este ecosistema
   [Enfatice que los niños necesiten usar nombres especificas y que no pueden usar más de dos ejemplos de alguna de las nueves diferentes relaciones.]
2. Haga un dibujo de su ecosistema. Escriba los nombres de las cosas en su dibujo.

VII. Comentarios/Sugerencias:

Si quiere puede introducir la palabra "inquilismo." Este es el tipo de comensalismo en que el hogar de un ser vivo es dentro de otro. No he incluido porque no estoy seguro que significa "dentro" -- ¿dentro del cuerpo fisicamente (¿en las celulas?) o es un nido dentro del árbol en este sentido?

Para una breve explicación de las más importantes relaciones, vea Santanilla.

Lección 14 -- El Ecosistema

I. Objetivo:

Los niños entenderán el concepto del ecosistema y las relaciones que existen dentro del él, entre cosas bióticas, pero también entre cosas bióticas y cosas abióticas.

II. Materiales:

1. pizarra, tiza
2. hilo
3. tarjetas con nombres de cosas bióticas y abióticas de un particular tipo de ecosistema (preferiblemente uno que puede encontrar cerca de la escuela).

III. Introducción:

Pídales que digan algunas de sus respuestas para los diferentes ecosistemas y escriba en la pizarra. Cuando haya escrito algunas listas, pregúnteles ¿qué falta en estas listas? Si es necesario, déles pistas hasta que ellos recuerden que también hay cosas abióticas en cada ecosistema.

Entonces, déles las tres características que definan un ecosistema. [Puede pedir las respuestas.]

Ecosistema

1. Un lugar definido
2. Incluye todas las cosas bióticas y abióticas dentro este lugar
3. Incluye todas las relaciones que existen entre todas las cosas en este lugar

Asegúrese que los niños entiendan que podemos definir el lugar casi arbitrariamente -- grande o pequeño. Nuestra regla convencional es definir un punto medio. Entonces, podemos tener microecosistemas y macroecosistemas. Sin embargo, el definir nuestro lugar puede determinar la utilidad del concepto. [Por ejemplo, no tiene mucho sentido de hablar del ecosistema de Puriscal, pero tiene sentido hablar del ecosistema de la cuenca del Río Picagres].

Dígales que asi como hay relaciones entre cosas bióticas, también hay relaciones entre cosas bióticas y cosas abióticas, algunas que hayan estudiado antes. Pídales que digan algunas de estas y escriba en la pizarra. [Probablemente, ellos dirán alimentación, respiración, y posiblemente fotosíntesis]. Ayúdeles a pensar también de protección, cambio de temperatura (asolearse, sombrearse, etc.), transporte (volar, nadar), propagación de las semillas, etc. Asegúrese que los niños entiendan muchos de estas relaciones antes de empezar la actividad.

IV. Actividad:

Vayan afuera. Dé a cada niño una (o más) tarjetas y péguelas a su tórax con cinta. Formen un círculo. Dígales que nosotros representamos algunas de las cosas bióticas y abióticas que se encuentran dentro el ecosistema del ____________ (depende de sus tarjetas).

Entonces dígales que vamos a representar algunas de las relaciones que existen en este ecosistema, para unir con este hilo las diferentes cosas. Cada persona, cuando es su turno, necesita tirar el hilo a otra persona después de decir cuál es su relación con esta persona. Pero ellos necesitan sostener el hilo en la mano cuando tiran el resto. [Aunque es difícil de explicar con palabras, será más fácil en la práctica].

Cuando los niños entienden el juego, puede hacer más difícil si limita el tipo de relación (por ejemplo, una relación de comensalismo, de pastoreo, de competencia, etc.). [Es posible que necesite ayudarlos algunas veces].

Cuando todos han tenido al menos una oportunidad, dígales que ahora nosotros hemos construido una red que enseña muchas de las relaciones que existen dentro de este ecosistema. Esta red incluye la red alimenticia que ya han estudiado, pero es más grande y mucho más complicada; como podemos ver. Antes de desenredor el hilo sugiérales que estudien la red y respondan a estas preguntas -- ¿Cuáles cosas en este ecosistema parecen ser las más importantes? / ¿Cuáles los menos? Puede preguntar también, ¿Qué pasa si una parte de este ecosistema es dañada o contaminada?

Después de discutir, desenreden el hilo poco a poco repitiendo cuáles eran las relaciones en cada parte de la red, pero en orden inverso hasta que hayan llegado al principio.

V. Discusión:

Después de regresar al aula, revise las preguntas de arriba. ¿Cuáles parecen ser las más importantes partes de este ecosistema? ¿Por qué? ¿Qué puede ocurrir si hay daño /contaminación /una reducción grave (o un aumento grande) en los números de alguna cosa?

Enfatice que en la realidad es mucho más complicado, porque en vez de individuos, como en nuestro juego, hay poblaciones de individuos. Finalmente, dígales que "normalmente" las poblaciones de un ecosistema se quedan relativamente estables si no hay cambios rápidos en el ecosistema. Nosotros llamamos este concepto de estabilidad en la naturaleza "Equilibrio Biológico."

VI. Tarea:

1. Los niños deben observar sus lugares marcados (los mismos de Lección 12) y anotar todos las relaciones, pueden observar y clasificar las relaciones por tipo.
2. Desde que todo el mundo está cambiando, incluyendo la naturaleza, ¿Qué piensa usted: en verdad existe equilibrio biológico o no? Escriba un párrafo o más en que examine este tema.

VII. Comentarios/Sugerencias:

Es posible que sea mejor de jugar el juego dentro de la escuela. Cuando hay mucho sol o mucho calor, es difícil mantener la participación de los niños por demasiado tiempo con esta actividad, y podría perderse la parte de preguntasy el desenredar de la red, que es muy valiosa.

También, es probable que necesite explicar la segunda tarea con algunas preguntas antes que tratan de erupciones volcánicas, erosión, terremotos, sedimentación, etc. La segunda tarea es para estimular la discusión en la próxima lección.

Lección 15 -- Equilibrio Ecológico (2 clases)

I. Objetivo:

Los niños aprenderán mejor el concepto de equilibrio ecológico, y cómo está roto en la naturaleza. También, ellos entenderán que los cambios causados por los hombres son naturales, aunque sus efectos puedan ser muy graves. Finalmente, ellos tendrán un mejor concepto de los problemas al mantener el equilibrio ecológico.

II. Materiales:

1. pizarra, tiza

III. Introducción:

[Si antes ha usado la lección opcional (Lección 10A -- Geología de Costa Rica), puede referirse a esta; si no, puede usar su conocimiento general de geología]

Pídales que digan sus ideas de qué es equilibrio ecológico y si existe. Escríbalas en la pizarra y discutan sus ideas. En la discusión enfatice si ellos no hayan que:

1. La naturaleza siempre está cambiando, sean cambios de procesos naturales por cosas abióticas: geológicos, climáticos, geotermal, erosión, sedimentación, etc., o sean cambios naturales causados por cosas bióticas: evolución natural, enfermedades, cambios al ambiente por seres vivos (castor, ganado, hombre).
2. Todos estos causan cambios en el ambiente -- algunos grandes y rápidos, otros pequeños y lentos.
3. Puede decir que en vez de equilibrio en la naturaleza en verdad es "desequilibrio." -- es una cosa relativa con el tiempo.

Asegúrese que los niños entenderán que los cambios causados por los hombres son naturales también. El problema es que nuestra tecnología causa cambios rápidos -- tan rápidos para adaptaciones de muchas especies.

IV. Actividad:

Dígales que van a tener un juicio la próxima clase. Los acusados son los hombres; los demandantes son el resto de la naturaleza. La acusación en general es que "los hombres han destruido la naturaleza." La unica pena, por este crimen, es extinción de la especie de los acusados.

Divida la clase -- algunos van a ser acusados, otros demandantes, y otros jueces (al menos 3), quienes tienen el derecho en este juicio de preguntar como los abogados de los dos lados.

Cada grupo puede planear su estrategía, quienes son sus testigos, su(s) abogado(s), etc.

Déles a los niños el resto de la clase para prepararse.

Próxima clase: Juicio

Los niños conducen el juicio.

V. Discusión:

Después de los testigos, argumentos, y conclusiones, déles a los jueces tiempo para consultar y hacer su decisión. Después de su decisión, discutan que pasó: qué piensan de la decisión, del proceso, etc.

Ahora, el maestro puede participar, preguntando si ellos pensaban era justo ¿la acusación?/¿la pena? Ayúdeles si todavía no han hablado de enumerar los problemas causados por los hombres en la naturaleza y escríbalos en la pizarra. Pregúnteles por qué tenemos estos problemas, o en otras palabras, ¿cuáles son los beneficios a los hombres de sus acciones que han causado estos problemas?

Ayúdeles a entender que los problemas son las resultados de las acciones que los hombres hicieron para mejorar su vida. Por ejemplo, deforestación, originalmente ocurre porque el hombre desarolla agricultura -- una mejor manera de garantizar su alimentación. Ahora, todavía está cortando bosques porque el hombre usa madera para construir y muchas otras cosas, además también usa la tierra para su agroganadería.

Discutan qué significa esta [Muchas acciones por hombres dan beneficios, pero también crean problemas. El problema en verdad es cómo podemos recibir los beneficios sin los daños].

VI. Tarea:

1. Divida esta lista entre los niños: sobrepoblación; urbanismo; contaminación del aire y agua; cacería de los animales; deforestación. Cada individuo, en cada grupo, tiene que escribir un informe sobre este problema, incluyendo al menos respuestas a estas preguntas. [Es posible que ellos pueden dar un informe oral después de esta tarea].
    a. ¿Piensa usted que este es un problema en Costa Rica?/ en su pueblo? ¿Si o No? ¿Por qué?
    b. ¿Cómo está este "problema" en Costa Rica? /en su pueblo? (si es un problema)
    c. ¿Cuáles son las razones principales para este "problema?"
    d. ¿Cómo podemos evitar los efectos de este "problema?"

VII. Comentarios/Sugerencias:

Puede usar un juicio menos extremo, pero creo que no sea tan efectivo. Es importante que los niños tengan tiempo para preparar este juicio y para discutir sus implicaciones después.

Después de esta lección, es recomendable ensenarles luego, si puede, la serie de videos por PRODAF/GTZ -- "Sembrando Para El Futuro," "Sembrando en las Escuelas," y "De Bosque a la Finca." Esta serie empieza con destrucción de los bosques en Costa Rica. El segundo video sigue con el problema de deforestación en Puriscal y como los niños pueden actuar para aliviar el problema.

Pero para mí el más importante video; es el tercero. Empiece con las relaciones que pueden encontrar en un bosque natural, "La Cangreja," y siga con una explicación de cómo podemos usar estas ideas para reproducir condiciones más "naturales" dentro de nuestro sistema agropecuario. El video es claro; que aunque no puedan recrear el bosque (o mejor dicho, queremos tener cultivos, ganado, etc.), hay maneras de evitar algunos de los problemas creañdo condiciones "naturales" (Sistemas agroforestales y silvopastoriles).

Estos videos también pueden ser una buena introducción al desarollo sostenible.

Aunque no he incluído tiempo en mis lecciones, es bueno que los niños hagan, en grupos, un informe para el resto de la clase, de la investigación de su problema (de tarea #1).

Lección 16 -- Conservación del Suelo

I. Objetivo:

Los niños aprenderán la importancia que tienen los árboles y cómo ellos pueden prevenir la erosión del suelo. También ellos aprenderán otros métodos de conservar el suelo.

II. Materiales:

1. pizarra, tiza
2. pala, suelo, agua

Antes de la clase, prepare fuera de ella; cuatro montones de suelo. El primero déjelo así, con sólamente suelo. Encima del segundo ponga mucha zacate y otras plantas. En el tercer, haga zanjas o drenajes. Y en el cuatro, haga niveles de contorno alrededor del montón. [Vea: Ambiente en Acción , p. 37.]

III. Introducción:

Pregunte a los niños si ellos saben las cuatro maneras en que las árboles evitan erosión del suelo. Ayúdeles a entender estos cuatro maneras:

1. Los raíces sostienen el suelo.
2. Las hojas protegen el suelo del impacto fuerte y directo de la lluvia.
3. Las hojas también proveen sombra que mantiene la humedad del suelo.
4. Las hojas caídas actuan como un esponja para absorber el agua.

IV. Actividad:

Dígales que hay otras maneras de evitar la erosión. Llévelos afuera, con sus cuadernos, y enséñeles los diferentes montones.

Dígales que cada montón representa un método diferente de cultivar en lugares pendientes. Explique las diferentes métodos: (1) después de cosechar deje limpia (2) mantener una cubierta vegetiva (3) haga una zanja por drenaje (4) siembre en niveles de contornos.

Dígales que ellos deben observar qué pasa cuando hay una fuerte lluvia. Eche agua de un vaso encima de cada montón en sucesión. Pídales que anoten en sus cuadernos que pasó con cada montón.

V. Discusión:

Discutan que ocurre con cada montón y las implicaciones de esta actividad. Discutan sobre los cultivos en su comunidad y cuáles métodos de conservación son mejores para estos cultivos.

VI. Tarea:

1. Haga entrevistas con agricultores para determinar cuáles métodos ellos usan para evitar erosión y para cuáles cultivos
2. Para la próxima clase: Costa Rica usa una alta cantidad de plaguicidas. ¿Qué piensa del uso de los plaguicidas? Escriba su respuesta. También haga entrevistas con agricultores en su comunidad para determinar los tipos de plaguicidas que ellos usan para cuáles cultivos y cómo los aplican.

VII. Comentarios / Sugerencias:

Es bueno si puede invitar un agricultor o un miembro de MAG, quien puede explicar métodos de evitar erosión. También es bueno, si pueden, visitar algunos ejemplos de estos métodos de cultivar y evitar erosión.

Lección 17 -- Plaguicidas

I. Objetivo:

Los niños aprenderán el peligro de usar los plaguicidas. Pero, también ellos entenderán cómo minimizar este peligro y la importancia de leer, entender, y seguir las instrucciones en las etiquetas. Ellos demostrarán su aprendizaje por una competencia.

II. Materiales:

1. pizarra, tiza
2. una mezcla de etiquetas para diferentes plaguicidas químicos. Es bueno si puede tener una etiqueta de cada color (aunque es dificil obtener etiquetas rojas).
3. otra mezcla de etiquetas y publicidades para diferentes plaguicidas (necesita entre 3-5 o más de cada una dependiendo del número de sus estudiantes).
4. copias de hoja de preguntas

III. Introducción:

Sugiérales que digan los resultados de sus encuestas. Escriba en la pizarra. Después, pregúnteles que piensan del uso de plaguicidas. Haga un cuadro con las desventajas y ventajas del uso de plaguicidas químicos. Discutan.

Ahora, pregúnteles si saben ¿qué son etiquetas y para que sirven? Enseñeles etiquetas de diferentes colores y pregúnteles que significan los colores diferentes (rojo, azul, verde, amarillo). Discutan. [Enfatice que aunque algunas plaguicidas sean más tóxicos que otros, todos son tóxicos!]

Después explíqueles que además del nivel de toxicidad, la etiqueta tiene otra información. Esta información incluye:

1. Marca conocida y nombre genérico
2. Composición químico
3. Precauciones del uso
4. Sintomas de intoxicación, primeros auxilios, y antídoto
5. Instrucciones para uso efectivo y seguro

IV. Actividad:

Divida la clase en grupos según del número de etiquetas y anuncios duplicadas que tiene. [Cada grupo debería tener uno de cada de las etiquetas y anuncios.]

Entonces déle a cada grupo una hoja de preguntas y dígales que en esta competencia ellos necesitan usar todas las hojas para buscar las respuestas como un grupo. Déles tiempo para buscar las respuestas y escribirlas. Después determine los ganadores, segundos ganadores, etc.

V. Discusión:

Discutan las respuestas y por qué son correctas si hay preguntas. También discutan porqué mucha gente no lee las etiquetas (dificil de leer -- tamaño de letras y muchas palabras son difíciles, alguna gente no sabe cómo leer, etc.).

Después empiece una discusión sobre el uso seguro de plaguicidas. Pregúnteles cuáles precauciones sus padres toman y si ellos piensan son adecuadas. Discutan también razones de por qué la gente, generalmente, no usa toda la ropa protectora. ¿Hay alternativas más cómodas?

Al final, escriba sus ideas para el uso seguro de plaguicidas. Asegúrese que esta lista incluye al menos lo siguiente:

1. Busque ayuda y lea la etiqueta.
2. Use ropa protectora.
3. Lávese bien después de usar plaguicidas.
4. Guarde los plaguicidas fuera del alcance de los niños.
5. Use plaguicidas como último recurso.

VI. Tarea:

La próxima clase tratará del problema de la basura. Para preparar para esta clase, los niños deben escribir una redacción del tema de la basura que incluye, al menos, lo siguiente:

1. ¿Cómo es el problema de la basura en su pueblo? en Costa Rica?
2. ¿Cómo podemos solucionarlo?
3. ¿Cuáles cosas puede hacer usted para mejorar la situación?

VII. Comentarios/ Sugerencias:

He incluido copias de algunas etiquetas y anuncios que usé en mis clases y también la hoja de preguntas. Aunque las respuestas, son relativemente fáciles, es importante que enfatice: nosotros no podemos saber cuáles son los más tóxicos porque los anuncios no son etiquetas. Su propósito es fomentar su deseo de usarlo, y entonces es posible y probable que ellos omitan -- no incluyan -- toda la información de las etiquetas.

Puede preguntar a un almacén que vende plaguicidas, si ellos tienen algunas etiquetas y anuncios. Haga sus propias preguntas dependiendo de la información que pueda obtener. (Es mejor usar etiquetas verdaderas en vez de copias -- si necesita usar copias indique los colores de alguna manera.

Este tema se presta para dramatizaciónes, títeres, etc. Un ejemplo de una dramatización está en Ambiente en Acción p. 84-5, pero puede hacer su propia idea.

Etiquetas

1. ¿Cuál es el nombre genérico de Graminex 20%?

2. ¿Cuáles de estas plaguicidas son herbicidas?

3. ¿Cuál plaguicida es lo más tóxico?

4. ¿Cuáles de estas plaguicidas son tóxicos?

5. ¿Cuáles de estas pueden usar para cafe?

6. ¿Cuáles son los primeros auxilios en caso de ingestión de Tordon 101?

7. ¿Cuándo no debería provocar el vómito en caso de ingestión de Graminex 20%?

8. ¿Para cuál plaguicida no hay restricción en cuanto al periodo de reingreso al area tratada?

Figura 29. Etiqueta de la herbicida Tordon 101

¡ALTO! LEA ESTA ETIQUETA ANTES DE USAR EL PRODUCTO

PRECAUCIONES Y ADVERTENCIAS DE USO:
Siempre que maneje agroquímicos, utilice el equipo de protección completo, sombrero, mascarilla, guantes, anteojos, delantal y botas de hule. No coma, beba ni fume durante estas labores. Bañese bien una vez terminada la labor y cámbiese de ropas. No lave las ropas que use en la aplicación junto con las ropas de uso normal. Entierre los envases vacios después de usados a 50 cm del suelo, no contaminar lagos, ríos, fuentes de agua, abrevaderos, depósitos de alimentos, etc.

PRIMEROS AUXILIOS:
Ingestión: Si el paciente está conciente, provoque el vómito mediante una correcta dosis de jarabe de ipecacuana (15 cc para niños ó 30 cc para adultos) repitiendo hasta que el vómito fluya claro.
Inhalación: Retire el paciente a un lugar fresco, seco y aireado, manténgalo en reposo y vigile la respiración.
Contacto: Si entra en contacto con la piel o los ojos, lave bien las partes afectadas con suficiente agua por lo menos durante 15 minutos.

SINTOMATOLOGIA DE INTOXICACION:
El contacto prolongado con la piel causa ampollas y quemaduras. En las uñas, puede causar quemaduras y caída, irritación de la piel intacta. Por inhalación causa estomatitis, dolor de cabeza, sangrado por la nariz, tos, irritación de la garganta. En los ojos causa lesiones de la conjuntiva y córnea. Por ingestión hay sensación quemante en la boca y faringe seguido de un intenso dolor abdominal, vómitos que pueden ser sanguinolentos y diarrea.

ANTIDOTO Y TRATAMIENTO MEDICO:
El Paraquat no tiene antídoto específico. Hacer lavado gástrico cuidadoso. Administrar suspensión de bentonita al 5 7%, seguida de un catártico salino como sulfato de sodio. Forzar la diuresis.

EN CASO DE INTOXICACION, LLEVE EL PACIENTE AL MEDICO Y DELE UNA COPIA DE ESTA ETIQUETA.

MEDIDAS DE PROTECCION AL AMBIENTE:
Una vez terminada la aplicación, lave bien el equipo utilizado, manteniendo sumo cuidado de no contaminar fuentes de agua, caños, ríos, lagunas, etc. así como cultivos vecinos con sobrantes de producto, caldo o aguas de lavado.

ALMACENAMIENTO Y MANEJO DEL PRODUCTO:
Transporte y almacene este herbicida en su envase original, bien cerrado y con su respectiva etiqueta debidamente adherida, aparte de alimentos, medicinas, utensilios de uso doméstico, insecticidas, fungicidas y fertilizantes. Almacénese bajo llave en un lugar fresco, seco y aireado, lejos del alcance de los niños, personas mentalmente incapaces y de los animales.

AVISO DE GARANTIA:
La compañía garantiza el contenido original de materia activa del producto, pero no responde en forma alguna por el uso que de él se haga.

AVISO AL COMPRADOR: Debido a que está fuera de nuestro alcance el control sobre almacenamiento, manipuleo y uso de este herbicida, nos es imposible asumir responsabilidades por posibles daños que puedan ocasionarse debido a estos factores. Nuestra responsabilidad alcanza únicamente a la composición química del producto tal y como se indica en esta etiqueta siempre y cuando el envase se encuentre sellado.

agrocosta

GRAMINEX 20% SA

HERBICIDA BIPIRIDILO

NOMBRE GENERICO: PARAQUAT

Composición química:
Ingrediente activo:

1,1-dimetil-4,4-bipiridilo	18,4% p/p
Solventes, emulsificantes, inertes	81,6% p/p
Total	100,00%

EL GRAMINEX 20% SA contiene el equivalente de 200 gramos de ion Paraquat por litro
a 20 °C la densidad del GRAMINEX 20% SA es de 1 15 g/cc

CUIDADO VENENO

ESTE PRODUCTO PUEDE SER MORTAL SI SE INGIERE, VENENOSO SI SE INHALA. PUEDE OCASIONAR DAÑO A LOS OJOS.

NO ALMACENAR EN CASAS DE HABITACION. MANTENGASE ALEJADO DE LOS NIÑOS, ANIMALES DOMESTICOS Y ALIMENTOS. DESTRUYA ESTE ENVASE DESPUESDE USAR EL PRODUCTO.

Contenido neto: ☐ 1 litro

Formulado por
FORMULACIONES QUIMICAS S.A.,
Chomes, Puntarenas, Costa Rica
Distribuido por
AGROQUIMICAS DAF DE COSTA RICA
Tel 31-7744
San José, Costa Rica

NO USE EL PRODUCTO EN FORMA DIFERENTE A LA RECOMENDADA

INSTRUCCIONES DE USO:
Durante la preparación del caldo y carga del equipo de aplicación, utilice el equipo de protección. No coma, beba ni fume durante estas labores. Evite todo contacto directo del producto o caldo con su cuerpo. Antes de cargar el equipo de aplicación cerciorarse de que está en perfecto estado de funcionamiento. Para preparar el caldo de aplicación, llene el tanque hasta la mitad con agua limpia, ponga el sistema de agitación a trabajar y vierta la cantidad requerida de GRAMINEX 20% SA terminando de llenar el tanque con agua limpia.

USO RECOMENDADO:
El GRAMINEX 20 es un herbicida con acción de toxicidad aguda (efecto quemante) sobre los tejidos no leñosos, no presentando ninguna acción pre-emergente a la maleza. El espectro de malezas que controla es muy amplio, y siendo su efecto de control por acción de contacto ha de tenerse en cuenta la posibilidad de la rebrotación en plantas perennes. Se recomienda para usar en cultivos tales como Banano y Plátano (*Musa spp*), Café (*Coffea arabica*), Cítricos (*Citrus spp*), Chile (*Capsicum frutenscens*), para lo cual se utiliza una dosis de 1.5-3,0 lts de GRAMINEX 20% SA por hectárea. Si se desea limpiar áreas determinadas (bandas de fertilización, etc.) se usan dosis de 500-700 cc (excepcionalmente 1000 cc) por estañón. En casos de pre-emergencia temprana con poco desarrollo, para ser mezclado con pre-emergentes con dosis de 350 cc por 200 litros de caldo. En todos los casos agregar un adyuvante. Puede mezclarse con otros pre-emergentes o post-emergentes, se utiliza una dosis de 2-0-3,0 litros de GRAMINEX 20% SA/ hectárea en pre-emergencia o 3 días antes de sembrar. Como post-emergente en aplicaciones dirigidas. En post-emergencia temprana con bomba de mochila se aplica un 570 litros de caldo/hectárea 2,3 lts/ha. Para desecar caña se utiliza la misma dosis en tratamiento general.
En otros cultivos, tales como Algodón (*Gossypium hirsutum*), Papa (*Solanum Tuberosum*), Lechuga (*Lactucca sativa*), Arroz (*Oryza sativa*), Sorgo (*Sorghum vulgare*), Maíz (*Zea mays*), Repollo (*Brassica oleracea*), Cebolla (*Allium cepa*) Apio (*Apium graveolens*), Piña (*Ananas cumosus*), Soya (*Glycine max*), se utiliza una dosis de 1,5-3,0 litros de GRAMINEX 20% SA/ha aplicado en presiembra y pre-emergencia del cultivo. En suelos arenosos se debe dejar un período de 3 días entre la aplicación y la emergencia o siembra. Este producto no se recomienda para desecación en ningún cultivo. En maíz la aplicación debe hacerse cuando esté encañado. Para áreas no cultivadas usar 3,5-5 5 lts/ha aplicado con post o pre-emergentes necesarios.

COMPATIBILIDAD Y FITOTOXICIDAD:
Este herbicida es compatible con los plaguicidas de uso normal. Su efecto quemante lo hace fitotóxico a los tejidos no leñosos. En caso de gramíneas y plantas leñosas, se debe usar para su erradicación herbicidas específicos. Evite el uso de coadyuvantes iónicos ya que pueden disminuir su actividad. No hay restricción en cuanto al período de reingreso al área tratada.

País Costa Rica **Nº de Registro:** 2324 **Fecha:** 07 03 80

Lote Nº **Fecha:** **Permiso M.A.G. Nº** 63

Importado y envasado por:
AGROQUIMICOS DAF DE COSTA RICA S.A.

ALTAMENTE TOXICO

Figure 30. Etiquetta de la herbicida Graminex 20%

Figure 31. Etiquetta de la fungicida Ridomil

NUEVO

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TERBUTILAZINA 50 P.L.

La **TERBUTILAZINA 50 P.L.** es un herbicida de acción pre emergente a la maleza, y de post-emergencia temprana.

Se utiliza en cultivos como café, cítricos, caña india y otras ornamentales.

Para malezas de más de 3 cm de altura, es recomendable mezclarlo con **GRAMINEX** (paraquat) o con **RIVAL** (glifosato).

Presenta un prolongado efecto residual (90-120 días) y actúa sobre malezas tanto de hoja ancha como gramíneas provenientes de semilla

VENTAJAS DE USAR TERBUTILAZINA 50 P.L.

- Con **solamente dos aplicaciones al año** se puede controlar la maleza en los cultivos en que se recomienda su uso
- Su eficiente control reduce los costos porque requiere de **menor número de aplicaciones**, lo cual implica un menor movimiento de agua, menos daños mecánicos al cultivo y en general, menores costos de aplicación.
- El excelente control de malezas se traduce en una **mayor producción** porque el cultivo crece sin competencia con las malezas, además se facilitan las demás prácticas agronómicas y la cosecha.
- Presenta una **alta selectividad** para los cultivos en la frecuencia y dosis en que se ha recomendado.

RECOMENDACIONES DE USO

La **TERBUTILAZINA** 50 P.L. se recomienda aplicar cuando las malezas inician su desarrollo en el cultivo de café. También se utiliza en cítricos, Caña india y otros.

DOSIS:

En **post-emergencia** temprana la dosis general recomendada en alto volumen es de 3 L/ha en 540 L de agua, con la boquilla 8002. Sin embargo, esta dosis podría aumentarse a 4 L si la presión de malezas es muy alta. También se puede aplicar en bajo volumen utilizando 60 a 80 L/ha de agua en la mezcla, y con una boquilla como la 80050

En **post-emergencia** tardía se puede usar la dosis anterior de 4 L/ha en mezcla de 2 a 4 L/ha de **GRAMINEX**; o bien, con 1 a 1,50 Kg/ha de **RIVAL**.

MALEZAS QUE CONTROLA:

La **TERBUTILAZINA 50 P.L.** es recomendada para el control de Chiquizacillo (*Borroeria* spp). Verdolaga (*Portulaca oleracea*), Mozote (*Bidens pilosa*), Tomate silvestre (*Solanun nigrum*), Mielcilla (*Galinzoga* sp), Malva (*Malva* spp), Bledo (*Amaranthus* sp) y Pata de gallina (*Eleusine indica*).

agrocosta

TEL.: 31-7744 • FAX: 31-5954 • APDO.: 310-1150 LA URUCA

Soluciones modernas a los tradicionales problemas del agro.

ADVERTENCIA. Los agroquímicos en general, siempre deben usarse con el adecuado equipo de protección.

Figure 32. Ad para Terbutilazina 50 PL.

Lección 18 -- Basura

I. Objetivo:

Los niños aprenderán la importancia de clasificar la basura, como un método para aliviar el problema. También, aprenderán los diferentes tiempos que duran diversos tipos de basura antes de descomponerse.

II. Materiales:

1. pizarra, tiza
2. cartel -- ¿Cuánto tiempo dura la basura? (si quiere hacerlo o puede escribir solamente en la pizarra) [Vea Ambiente en Acción, p. 68.]

III. Introducción:

Pida a los niños que digan qué piensan ellos de lo que la gente puede hacer con la basura?, y escriba en la pizarra todas sus respuestas, sin ningún comentario. [Vea tarea de lección previa.]

Después pregúnteles cuáles son los diferentes tipos de basura, y escriba sus respuestas en otra parte de la pizarra. [Incluya al menos cáscara de banano, papel, estaca de madera, zapato de cuera, estaca pintada, lata, envase de aluminio, plástico, llantas, y vidrio]. Es probable que ellos vayan a decir estas respuestas, pero si no búsquelas.] Anuncie a ellos que ahora van a tener una competencia.

IV. Actividad:

Dígales que ahora necesitan adivinar cuánto tiempo dura cada tipo de basura. Ellos necesitan escribir los nombres de los diferentes tipos y al lado su adivinación en lápiz. Explíqueles que el tiempo de duración es cuánto tiempo tarda la basura en descomponese totalmente. Déles 10-15 minutos para hacerlo.

Pídales sus respuestas y escríbalas al lado de cada tipo de basura [Busque muchas respuestas para cada uno e incluya a todos los niños]. Después de escribir todas, sugiérales que ellos comenten las diferentes respuestas para cada tipo. (E.j., ¿cuáles duran más?; ¿cuáles menos?; ¿podemos clasificar en dos grupos?)

En esta discusión debe incluir que algunas cosas son orgánicas y otras son inorgánicas, y que en general las cosas orgánicas duran mucho menos (Explique que en verdad plástico es orgánico pero dura mucho tiempo como si fuera inorgánico). Enfatice el daño al ambiente si ellos queman plásticos.

Ahora enséñeles la cartulina con respuestas o escríbalas en la pizarra. Vea abajo:

Table 23. ¿Cuanto tiempo dura la basura?

¿Cuánto Tiempo Dura La Basura?

Cáscara de banano	3 semanas
Papel	3 semanas - 4 meses
Estaca de Madera	1-2 años
Zapato de cuero	3-5 años
Estaca pintada	10-12 años
Lata	50-100 años
Envaso de aluminio	350-400 años
Plástico	500 años
Llanta	500 años
Vidrio	indefinido (eternamente)

V. Discusión:

Pídales a los niños cuál es la mejor manera de disponer en su lista de cada tipo de basura. Discutan porqué. Enfatice que para ellos y su comunidad lo mejor, para muchas cosas inorgánicas, es reutilizarlas, y si no, deben enterrarlas. Explíqueles la importancia de los 4 R's -- rechazar, reducir, reutilizar, y reciclar, y que ellos deben tratar de seguir éstas en orden. [Reciclar debe ser la última opción]. Finalmente discutan que la fuente del problema es el uso de muchas cosas inorgánicas en nuestra sociedad -- plásticos, especialmente, y que la solución de este problema son leyes que prohiban su uso o al menos lo reduzcan.

VI. Tarea:

1. Los niños deben escribir uno o otra:
    a. un cuento en que la gente no trata en una buena manera de su basura y necesitan confrontar la consecuencias de su negligencia.
    b. una descripción de una sociedad que trata en una buena manera con su basura.

VII. Comentarios/Sugerencias:

El maestro puede iniciar (o seguir) esta lección con una breve recoleción de basura, antes de clasificarla. Enseñe la gran cantidad de plásticos y otros cosas inorgánicas que ellos tenían.

Puede usar esta lección como impetu de una campaña de limpieza, recolección, clasificación, o reciclar de basura en la escuela o en la comunidad. También puede empezar un proyecto de hacer abono orgánico.

Puede seguir esta lección con cartas a las autoridades que tratan del problema.

Una obra de títeres es muy buena para esta tema. Puede usar "Carlos Conservación Contra la Contaminación" o puede simplificarla (Yo cambié esta obra de manera que son solamente dos títeres), o escribir su propia obra.

Lección 19 -- Finca Para Vender

I. Objetivo:

Los niños aprenderán el uso -- bueno y malo -- de las tierras con pendientes. Ellos demostrarán su aprendizaje al dibujar el uso correcto de un lugar determinado.

II. Materiales:

1. pizara, tiza (de diferentes colores)

III. Introducción:

Antes de clase dibuje en la pizarra una cosa asi:

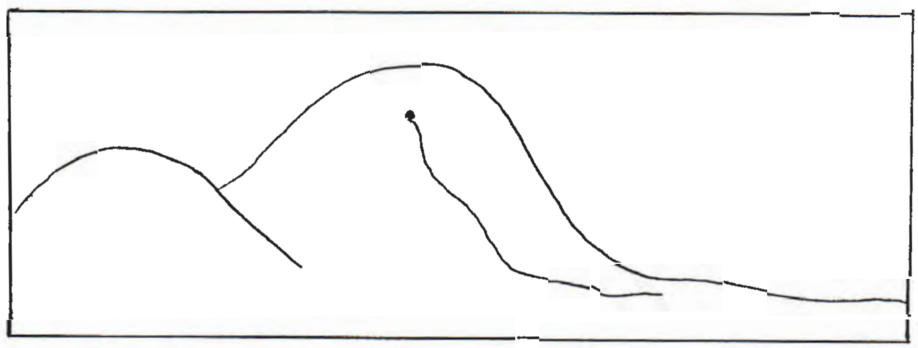

Figure 33. Finca para vender

Diga a los niños. "Esta es mi finca. Tenía muchas vacas, pero ya vendí todas. Mi finca tiene una naciente y una pequeña quebrada. Mi suelo esta demasiado agotado y soy viejo. Quiero vender mi finca a ustedes."

Forme grupos de niños y dígales que cada grupo necesita decidir cuáles tipos de cultivos va a sembrar, cuáles tipos de árboles, y si van a tener animales o no. Después, ellos necesitan dibujar en su finca dónde van a ubicar estas cosas.

IV. Actividad:

Dé a cada grupo tiempo para discutir, mientras que dibuje otras representaciones de la finca, una para cada grupo.

Después déles tiempo para dibujar su plan de cultivos para la finca. Asegúrese que todas participan. [Es probable que ellos quieran usar tizas de diferentes colores para su dibujo.]

V. Discusion:

Después, discutan sus ideas. Asegúrese que ellos entiendan la necesidad de proteger la naciente. [No deben sembrar árboles frutales arriba, si ellos necesitan el uso de plaguicidas, por ejemplo.]

VI. Tarea:

Revise su plan para esta finca para evitar problemas de contaminación, alta erosión del suelo, etc. y dibuje un nuevo plan en su cuaderno.

VII. Comentarios/Sugerencias:

Por supuesto, el maestro puede modificar el dibujo de "su finca," dependiendo de cómo está el terreno en su comunidad.

Lección 20 -- Una comunidad en busca del empleo

I. Objetivo:

Los niños aprenderán el concepto de desarollo sostenible y demostrarán su conocimiento con una actividad que trata del empleo.

II. Materiales:

1. pizarra, tiza

III. Introducción:

Antes de clase, haga un dibujo asi en la pizarra:

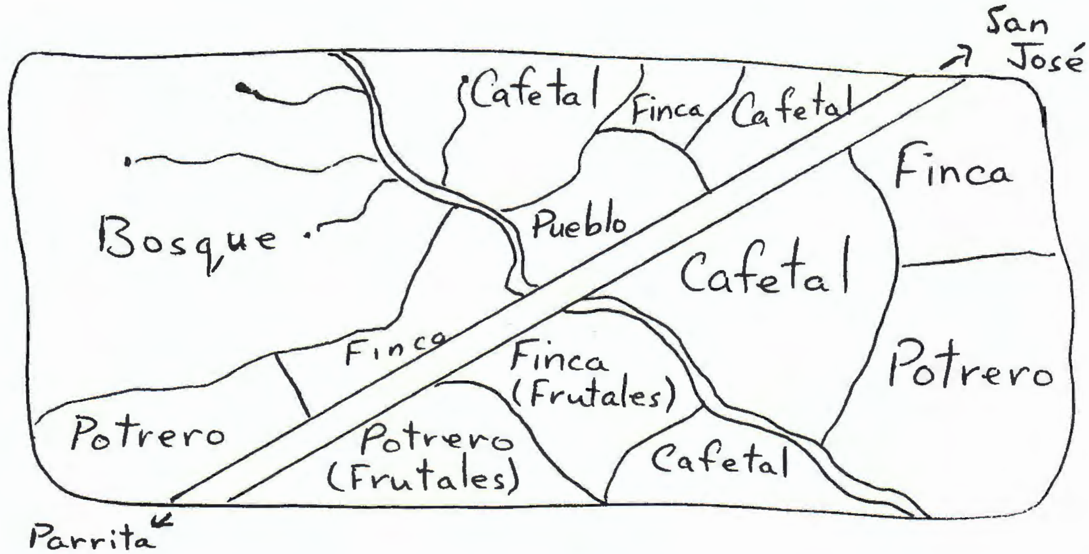

Figure 34. Una comunidad buscando empleo

Diga a los niños. "Este mapa representa una comunidad similar a la de aquí. El problema para esta comunidad es que no hay demasiado trabajo para la gente. La mayoría de la gente necesita ir a San José para trabajar."

"Su comunidad tiene un bosque natural que es medianamente grande. Aunque no tiene algunas especies raras, tiene una alta diversidad de animales y plantas, incluyendo muchos árboles maderables. Sus fincas tienen muchos cultivos y los agricultores usan buenos métodos para controlar la erosión y también producen buenos cultivos. Sus cafetales mandan su café a un beneficio cerca de San José."

"Ustedes son miembros de una comisión que está orientada a buscar o crear nuevas fuentes del empleo para esta comunidad"

Empiece por preguntarles cuáles son algunas ideas para aumentar el empleo en esta comunidad. Algunas respuestas: (1) Centro turístico (2) Industria maderera (3) Fábrica de frutales (4) Beneficio (5) Carnicería

Divida la clase en grupos y dé a cada grupo uno de las ideas para investigar. Dígales que ellos necesitan discutir esta opción e informar, al resto de la clase, sus ideas. Ellos necesitan decir lo siguiente:

1. ¿Cómo van a empezar/financiar este proyecto, y dónde va a ubicarse?
2. ¿Cuáles son las ventajas de este proyecto?
3. ¿Cuáles podrían ser las desventajas de este proyecto?
4. ¿Cómo podrían evitar este desventajas?

Déles tiempo para planear.

IV. Actividad:

Cada grupo debe presentar sus planes para su proyecto, ubicar su proyecto en el mapa y responder a algunas preguntas del resto de la clase.

V. Discusión:

Después de la discusión de cada proyecto, el maestro puede empezar una discusión general del desarollo sostenible. Enfatice que cada tipo del proyecto tiene ventajas y desventajas. También, enfatice que es posible que ellos usen el bosque para madera. pero si ellos lo usan para madera, necesitan reforestar al mismo tiempo y posiblemente empezar un programa de reforestación en otros lugares también para proveer más madera.

Finalmente, enfatice, si la gente no tiene otra opción de empleo, ellos van a usar los productos del bosque, de alguna manera. Lo importante es que hay controles para prevenir la destrucción total del bosque.

VI. Tarea:

1. Algunas personas han sugerido que los recursos de los Parques Nacionales deban ser usados por los hombres (por ejemplo, madera, oro, etc.). ¿Qué piensa usted? Escriba un informe que trata de su opinión en esto aspecto.

VII. Comentarios / Sugerencias

Es probable que los niños vayan a necesitar ayuda para pensar en las opciones. Orientación Pedagógicas en la Educación Ambiental para el Desarollo Sostenible tiene otras ideas de cómo puede introducir y discutir esta tema.

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APPENDIX 3

SCIENCE CURRICULUM GUIDELINES (ENGLISH)

Fourth Grade

C. Theme: Learning about the biological richness of Costa Rica

1. Diversity of living things (biodiversity) in Costa Rica

a. Contents

1. Concepts of biodiversity, environment, species, niche, and habitat
2. Diversity of plant and animal species in Costa Rica. Examples.
3. Reasons that favor the diversity of species of Costa Rica: natural climate zones, variety of habitats.
4. Importance of this biodiversity for Costa Rica and the world.

b. Procedures

1. Construction of concepts related to living things, biodiversity, species, niche, habitat, and environment.
2. Comparison in nature of different species, a description of their habitat, and of their niche.
3. Establishment of the relationship between the variety of habitats and niches and the diversity of species that a particular region presents.
4. Execution of field activities that are directed toward the verification of the diversity of plant and animal species.
5. Determination of the reasons that favor the grand variety of living things that our country possesses.
6. Explanation of the importance of biodiversity of living things for Costa Rica and the world.

c. Values and attitudes. The student:

1. Appreciates, defends, respects, and conserves life in all of its forms.
2. Becomes aware of the value of the ecological richness and biodiversity of our country's natural heritage, in order to protect it.
3. Values the potential of our country's natural heritage as a source of scientific knowledge.

d. Criteria for evaluation. The student:

1. Identifies in diverse contexts the niche and habitat of various species.
2. Explains the concepts of biodiversity and environment.
3. Enumerates the reasons that explain the diversity of species in Costa Rica.
4. Explains the importance of the biodiversity of species for Costa Rica and the rest of the world.

2. Vital functions that permit the survival and reproduction of living things in their environment: nutrition, respiration, reproduction, and response to stimuli.

a. Contents.

1. Characteristics of living things which enable them to fulfill vital functions: nutrition (autotrophic and heterotrophic), respiration (by means of gills, pulmonary, and cutaneous), reproduction (sexual and asexual), responses

to stimuli (tropisms and migration), others (adaptations, hibernation, protected coloration, type of food, and others).

b. Procedures.

1. Construction of concepts related to vital functions.
2. Identification of vital functions common to all living things.
3. Determination of various actions that living things must do to carry out these vital functions.
4. Observation of various characteristics of living things that permit them to fulfill these vital functions.
5. Investigation of various adaptations that living things present.

c. Values and attitudes. The student:

1. Shows interest, perseverance, and discipline in the construction and application of new understandings related to nature and its conservation.
2. Appreciates the importance of the existence of different forms of life, respects, protects, and conserves them.

d. Criteria for evaluation. The student:

1. Explains and gives examples of the different vital functions of organisms and the actions which they must take to fulfill them.
2. Identifies the differences in the characteristics of different living things.

3. Protection against predators

a. Contents.

1. Examples: camouflage, horns, carapace, thorns, odors.

b. Procedures.

1. Investigation and analysis of the protective adaptations against natural enemies that some plants and animals possess; confirmation of some of these by means of observation.
2. Analysis and discussion of the importance of possessing protective adaptations.

c. Values and attitudes. The student:

1. Appreciates the adaptations of living things as mechanisms that assure their survival.

d. Criteria for evaluation. The student:

1. Explains the importance of various mechanisms which animals and plants use to protect themselves and shows in a clear and ordered presentation the results of her observations and conclusions.

D. Theme: Humans investigate the planet and space.

1. Global structure of the Earth

a. Contents.

1. External structure:
2. The hydrosphere: concept and its importance.
3. The atmosphere: concept and its importance, some proofs of its existence, its structure and composition, the importance for life's existence of certain gases in the atmosphere, the importance of the ozone layer, the concept of atmospheric pressure.
4. Climate and atmospheric conditions (weather).
5. The difference between weather and climate.
6. Factors which determine the climactic conditions of a region. Examples.

7. The influence of climate on human activities, and determination of geographic zones of the country.
8. Atmospheric storms and hurricanes that affect the national territory.
9. Security measures for floods, land slides, avalanches, tornadoes, hurricanes, and other natural disasters.
10. Internal structure: nucleus, mantle (asthenosphere), crust (lithosphere). Principal characteristics of each.

b. Procedures.

1. Construction of understanding about the external and internal structure of the earth.
2. Construction of the concept of the hydrosphere and establishment of the importance which it has in our life.
3. Communication of the knowledge which has been gained about the structure and composition of the atmosphere.
4. Investigation of the importance of the ozone layer for living things.
5. Development of the concept of atmospheric pressure.
6. Differentiation between weather and climate and recognition of the influence of these in human activities.
7. Demonstration of the mastery of security measures for natural disasters.
8. Identification of the principal internal layers of the Earth (using diagrams) and specification of some of their characteristics.

c. Values and attitudes. The student:

1. Assumes the responsibility of caring and protecting the planet in which she lives and promotion of actions toward that end.
2. Values the importance of the hydrosphere for life and make decisions for its protection.
3. Appreciates the benefits which the atmosphere brings us.
4. Accepts the responsibility of caring about the ozone layer.
5. Understands the effect of atmospheric pressure on natural phenomena.
6. Identifies the positive effects which atmospheric conditions offer to living things.
7. Applies preventive safety measures against floods, hurricanes, land slides, and other natural disasters.
8. Analyzes and follows instructions on the subject of prevention and security in the face of natural disasters.
9. Demonstrates interest in understanding the internal structure of the Earth.

d. Criteria for evaluation. The student:

1. Justifies with reasons the importance of the hydrosphere and explain the concept.
2. Enumerates some benefits of water for life on the planet.
3. Justifies with reasons the importance of the atmosphere.
4. Explains the importance of the ozone layer.
5. Learns the meaning of the concept of atmospheric pressure.
6. Develops an understanding of the concepts of weather and climate; and recognize the difference.
7. Promotes positive actions to avoid contamination of the atmosphere.
8. Mentions some preventive measures of security that every child should know in case of storms.
9. Names and recognizes in diagrams the different internal layers of the Earth.

Fifth Grade

C. Theme: life, its levels of complexity, and relationships

1. Levels of organization of living things.

a. Contents.

1. Concepts of individual, population, community, ecosystem, biosphere, and their relationships.

b. Procedures.

1. Investigation of the levels of organization of living things down to the basic level.

c. Values and attitudes. The student:

1. Shows scientific curiosity concerning the organization of living things and respects different forms of life.

d. Criteria for evaluation. The student:

1. Produces a summary of the basic concepts of organizational levels of living things, explains them, and offers examples.

2. Life, its levels of complexity, and their interrelationships.

a. Contents.

1. The grand variety of living things.
2. Ways in which one can group living things. Popular criteria and scientific ones: unicellular and multicellular; autotrophs and heterotrophs; biological kingdoms.
3. General characteristics of the five biological kingdoms: Monera, Protista, Fungi, Plants, and Animals.
4. Relationships of microscopic living things with humans: sickness, medicine, and industry.
5. Importance of fungi.
6. The Vegetal Kingdom (plants): photosynthesis -- a vital function of plants and the substances involved in the process.
7. Importance of photosynthesis for life.
8. Asexual reproduction: grafting twigs, *acodos*, runners, tubers, bulbs, and leaves.
9. Sexual reproduction: pollinization and reproduction by seeds. Examples of inferior plants: algae, mosses, and liverworts; and of superior plants: ferns, conifers, and flowering plants.
10. Animal Kingdom: classification -- vertebrates and invertebrates.
11. Principal characteristics of the vertebrates (amphibians, reptiles, fish, birds, and mammals).
12. Features that characterize humans as members of the Animal Kingdom.

b. Procedures.

1. Recognition of the variety of living things that comprise the surroundings.
2. Classification of the large diversity of organisms using popular and scientific criteria.
3. Analysis of the features and examples of the five biological kingdoms.
4. Establishment of the relation between microscopic living things and human beings.
5. Identification of the importance which members of the Fungi Kingdom have for other living things.

6. Identification of the vital function (photosynthesis) and indication of its importance.
7. Experimentation with respect to sexual and asexual reproduction of plants.
8. Production of a classification scheme with examples of plants.
9. Establishment of the difference between vertebrates and invertebrates.
10. Description of the principal characteristics of vertebrates.
11. Specification of the reasons which are used to classify human beings as members of the Animal Kingdom.

c. Values and attitudes. The student:

1. Shows scientific curiosity discovering and learning about the variety of living things.
2. Respects and partakes of the biological richness and acts for its defense and conservation.
3. Shows sensibility and preoccupation for rigor and objectivity in the search and interpretation of information.
4. Appreciates the beauty which superior and inferior plants possess and their importance for life.
5. Accepts that she forms part of nature and that all that affects it affects her in some sense.

d. Criteria for evaluation. The student:

1. Proposes criteria with which one can group living things.
2. Explains the characteristics of each biological kingdom with examples.
3. Explains the relationships between microscopic organisms and human beings.
4. Judges the importance of fungi.
5. Explains in scientific vocabulary the importance of photosynthesis and the mechanisms of reproduction in plants.
6. Describes some examples of inferior and superior plants.
7. Clarifies the difference between invertebrates and vertebrates.
8. Justifies the classification of human beings within the Animal Kingdom.

3. Relationships between living things: for sustenance, reproduction and protection of territory.

a. Contents.

1. Symbiosis (mutualism, commensalism) and antagonistic relationships (parasitism, and predation).

b. Procedures.

1. Description of some of the relationships that are found between members of the same species.
2. Analysis and discussion of the importance of intraspecific relationships for the survival of the individual, the well-being of a population, and the continuity of the species over time.
3. Description of some of the relationships that are found between individuals of different species.
4. Analysis and discussion of the importance of interspecific relationships for the survival of the individual and the species.

c. Values and attitudes. The student:

1. Recognizes the value of each organism and the role that it plays in the web of life.
2. Shows appreciation for life in all its forms and manifestations.

d. Criteria for evaluation. The student:

1. Cites examples of specific relationships and explains them.

D. Theme: The Planet Earth Is In Constant Change.

1. The changing planet

a. Contents.

1. External agents that modify the crust of the Earth.
2. External forces that modify the crust of the Earth: wind, water, temperature, masses of ice, actions of human beings.
3. The concept of erosion.
4. Actions of living things that modify, erode, and contaminate the soil, and analysis of measures which humans can employ to avoid and counteract their effects.
5. The process of sedimentation.

b. Procedures.

1. Investigate external forces that modify the crust of the Earth.
2. Construction of the concept of erosion.
3. Identification of the principal actions of living things that modify, erode, and contaminate the soil, and analysis of measures which humans can employ to avoid and counteract their effects.
4. Description of the process of sedimentation.

c. Values and attitudes. The student:

1. Displays interest learning about the external forces that modify the crust of the Earth.
2. Helps to avoid the erosion of soil.
3. Cooperates in counteracting the negative effects of living things that modify, erode, and contaminate the soil.
4. Shows understanding of the changes that occur in the surface of the Earth which are caused by internal forces.
5. Shows understanding of the positive and negative effects of volcanoes.

d. Criteria for evaluation. The student:

1. Names the different external forces that affect the crust of the Earth.
2. Describes erosion as an external agent which modifies the surface of the Earth.
3. Clarifies the actions of living things that modify, erode, and contaminate the soil, and the measures which humans can employ to avoid and counteract their effects.
4. Explains what is the process of sedimentation, by giving examples.

2. Internal processes that construct the crust of the Earth.

a. Contents.

1. Volcanism: the structure of volcanoes, volcanic action in the atmosphere and on the surface of the Earth (effects of volcanism) examples: acid rain, catastrophes, contribution to the formation and enrichment of the soil.
2. Effects of volcanism in Costa Rica. Examples: Poás, Irazu, and Arenal Volcanoes.
3. Diatropism: the movements of tectonic plates , the effects of plate movements on the terrestrial surface: seismic activities, upheavals and

ruptures (folds and faults), plate movements that affect the surface relief of Costa Rica (Plates: Caribbean and Cocos).

4. The relationship of volcanism to the formation of igneous rocks.
5. The formation of metamorphic rocks from igneous and sedimentary rocks, due to factors such as pressure, temperature, and chemical changes in the soil.
6. The importance of observing and recording systematically volcanic and seismic activity to prevent disasters. The application of scientific and technological advances in this field.
7. Safety measures before, during, and after a natural disaster.

b. Procedures.

1. Analysis of the effects of internal forces (volcanic and diatropic) that construct the Earth's crust.
2. Production of a model of a volcano, highlighting its principle parts.
3. Determination of the effects of volcanism in the atmosphere and on the terrestrial surface.
4. Construction of notions related to volcanism in Costa Rica and some things that have happened in our country which were caused by volcanoes.
5. Enumerate the effects of tectonic plate movements on the Earth's surface.
6. Identify the tectonic plates that modify the surface relief of Costa Rica.
7. Interpretation of the function of volcanism in the formation of igneous rocks.
8. Determination of the factors that intervene in the formation of metamorphic rocks.
9. Analysis of the importance of the study and interpretation of volcanic and seismic activity.
10. The practice of safety measures before, during, and after a natural disaster.

c. Values and attitudes. The student:

1. Recognizes the benefits that the volcanoes of our country bring through ecotourism.
2. Shows scientific curiosity in understanding the effects of the movements of the Earth's plates and the factors that come into play in the formation of rocks.
3. Appreciates the work that has been accomplished on the observation and control of volcanic and seismic activity in the country.
4. Practices safety measures to be used in case of natural disasters.

d. Criteria for evaluation. The student:

1. Constructs a model of a volcano.
2. Relates the parts of a volcano and describes some of their effects.
3. Enumerates the active volcanoes of Costa Rica.
4. Names some of the effects of tectonic plate movements.
5. Distinguishes the tectonic plates that affect the surface relief of Costa Rica.
6. Describes the relationship between internal forces and the formation of rocks.
7. Names the instruments used and the institutions responsible for the observation and recording of seismic and volcanic activity.
8. Recommends safety measures for her own protection and that of others and practices them during fake events.

Sixth Grade

C. Theme: The Environment, Human Population, and Development.

1. The ecosystem

a. Contents.

1. Components of an ecosystem: biotic and abiotic; examples.
2. Classification of biotic components by their type of nutrition: producers, consumers, and decomposers. Examples.
3. The importance of biotic components in food chains and webs.
4. The importance of some abiotic components. Examples: air, water, and temperature.
5. Examples of life zones and ecosystems typical of Costa Rica: dry tropical forest (coastal zones), humid tropical forest (Atlantic zone), cloud forest.
6. Human actions with negative effects on ecosystems. Examples: water and air contamination, increased sound levels, deforestation.
7. Positive and negative effects of large-scale tourism on ecosystems.

b. Procedures.

1. Description of the characteristics and components of different ecosystems.
2. Interpretation of pertinent information, including components, facts about, and phenomena of different ecosystems.
3. Determination of the importance of biotic and abiotic components in food chains and webs.
4. Deduction of the different classification criteria of ecosystem components.
5. Confirmation by experiment of the influence of biotic and abiotic factors on the survival of living things.
6. Comparison of different ecosystems and life zones of our country.
7. Investigation and analysis of negative actions by humans on ecosystems, which produce environmental contamination and deforestation.
8. Determination of the consequences of large-scale tourism on ecosystems and the effects it could have in both the short and long term.

c. Values and attitudes. The student:

1. Values, respects, and enjoys the diversity of ecosystems, land forms, and the biological richness of Costa Rica and acts to defend and conserve it.
2. Understands the value of human beings as one more link in the food chain.
3. Acts with responsibility to avoid actions which may harm ecosystems.
4. Participates in the conservation and care of nature's riches.
5. Displays consciousness and concern to counteract the negative effects of large-scale tourism on ecosystems.

d. Criteria for evaluation. The student:

1. Describes the characteristics and components of different ecosystems.
2. Explains the importance of producing, consuming, and decomposing organisms.
3. Explains the concept of a food chain.
4. Represents the different links of a food chain.
5. Confirms and judges the importance of biotic and abiotic factors in ecosystems.
6. Shows by way of illustration different life zones and ecosystems of our country.

7. Enumerates personal and collective actions which can be taken to avoid contamination and deforestation.
8. Explain negative attitudes of tourists which affect ecosystems and how to avoid their effects.

2. Ecological equilibrium (the concept).

a. Contents.

1. Factors that affect ecological equilibrium: natural ones: examples (storms, hurricanes, floods, volcanic eruptions, others)
2. Factors that affect ecological equilibrium: produced by human beings (uncontrolled urban growth, poor use of the land, others).
3. Acceleration of population growth.

b. Procedures.

1. Analysis of and conclusions concerning different natural and human variables which affect ecological equilibrium.
2. Description of hypothetical situations that might occur as repercussions of ecological disequilibrium in the human population and in the environment.
3. Investigate the relationship of the accelerated increase of human population with its influence on the natural equilibrium of the planet, the demand for resources, and on living space.
4. Construction of the concept of ecological equilibrium.

c. Values and attitudes. The student:

1. Becomes aware that human actions need to be in accord with the laws of nature.
2. Becomes aware of the factors which contribute to social, environmental, economic, and productive sustainability.

d. Criteria for evaluation. The student:

1. Explains the concept of ecological equilibrium.
2. Cites causes and effects of ecological disequilibrium.
3. Explains how human actions should respect the laws of nature.

3. Human activities and natural phenomena and their impact on the environment.

a. Contents.

1. Examples: urbanization, deforestation, plantations, tourism, uncontrolled hunting and fishing, acid rain, pesticide contamination, trash and garbage, hurricanes, floods, landslides, forest fires, others.
2. Consequences for local and migratory plants and animals of the modification and destruction of habitats.
3. Actions to protect the environment. Examples: respect and protect national parks, biological reserves, and other protected zones; prevent the extinction of species; prevent environmental contamination; participate in campaigns to prevent deforestation; others.
4. Importance of national parks and protected zones.

b. Procedures.

1. Investigation and creative presentation of some human activities and natural phenomena that change habitats.
2. Description of the consequences for living things of the destruction of habitats.

3. Mention of some personal and governmental actions which protect the environment.
4. Determination of some actions that could and should be taken both on a personal and collective level to further ensure protection of the environment.
5. Investigation of the importance of national parks, protected zones, and the institutions dedicated to keep watch over them to protect species and their habitats.

c. Values and attitudes. The student:

1. Shares information obtained through investigation.
2. Becomes aware of human activities and natural phenomena that alter and destroy habitats and of the consequence for her own existence and that of all living things.
3. Values, conserves, and defends the environment and the natural heritage of our country.
4. Displays creativity and a favorable disposition in her participation in campaigns that promote respect for and protection of protected areas, as well as in actions she takes to diminish the human impact on habitats.
5. Appreciates the role that protected zones play in the conservation of the country's natural heritage for future generations.

d. Criteria for evaluation. The student:

1. Indicates the principal natural causes and human activities that alter and destroy habitats.
2. Determines the risks and problems that human activities and natural phenomena produce.
3. Judges principal actions for environmental protection.
4. Enumerates the ways in which she can contribute to environmental protection.
5. Explains the importance of national parks.

4. Relationship between the increase in population, sustainable development and the quality of life.

a. Contents.

1. Effects of accelerated human population growth on Costa Rica and in other places in the world.
2. The increase in the destruction of habitats and in the demand for physical space for agriculture and urbanization; energy resources, food sources, of *esparcimiento* and recreation.
3. Repercussions on the human species, local and migratory forest species.
4. Importance of sustainable development for the quality of life and the maintenance of equilibrium in the biosphere.
5. The relationship between sustainable development and the preservation of biological richness.
6. The development and importance of Ecology and its contributions.
7. The importance of the relationship between human beings and nature.
8. Negative effects of consumerism and possible solutions.

b. Procedures.

1. Analysis of information with reference to population increase, sustainable development, and quality of life.
2. Establishment of the relationships of cause and effect, with respect to population increase, demand for resources, physical space and the

destruction of habitats, in the quality of life and the maintenance of ecological equilibrium.
3. Investigation of the importance of sustainable development in the quality of life of humanity and the continuity of life on the planet.
4. Critical analysis of the importance of biological richness and sustainable development.
5. The search for, selection, and recording of relative information and the importance of ecology as a science and its contributions.
6. Critical analysis of human attitudes which justify its dominion over and irrational exploitation of nature.
7. Description of the negative effects and some solutions regarding the relationship between humans and nature.

c. Values and attitudes. The student:

1. Values the natural environment as an indispensable resource and important element for the quality of life and promises to better and conserve it.
2. Becomes aware of individual and collective responsibility in achieving a betterment in the quality of life through sustainable development and has a favorable disposition to act to assure its achievement.

d. Criteria for evaluation. The student:

1. Enumerates positive and negative effects of the accelerated growth of human population on Costa Rica and other places in the world.
2. Interprets the importance of sustainable development on the quality of life and on equilibrium of the biosphere.
3. Explains the importance of Ecology for life on the planet.
4. Communicates possible solutions for the negative effects of humans on nature.

D. Theme: Investigating the Universe. (Partial)

1. Origin and evolution of the planet. The most evident changes of the land, as seen from the geologic record.

a. Contents.

1. The concept of geological record.
2. Fossils and their importance.
3. The formation and changes which the atmosphere has undergone up to the present.
4. Characteristics of the Age of the Dinosaurs.
5. Probable causes for the extinction of the dinosaurs.
6. The presence and domination of humans on Earth and their effects of the total environment of the planet.
7. Expected changes on Earth and for the beings who presently live there.
8. The uses of science and technology, its effects of the population and equilibrium of the planet.
9. Conditions of the Earth necessary for life.
10. Similarities and differences of the Earth and other planets of the Solar System.
11. The form, size, position, and movements of the atmosphere.
12. Possibilities of the existence of life on other celestial bodies of the Solar System.

b. Procedures.

1. Investigation of the changes that the earth has undergone over time.

2. Construction of the concept of a geologic record and establishment of the relation between sedimentary rocks and the fossil record and evidence of past life.
3. Investigation concerning fossils, their formation, and importance in the record of life.
4. Determination of the importance of the geologic record, as an archive and reservoir of facts, phenomena, and processes related to the dynamism, transformation, and evolution of the planet, including life (the history of the Earth).
5. Comprehension of the hypothesis for the evolution of the planet, as well as the formation and changes that the atmosphere has undergone up to the present.
6. Description of the characteristics of the Age of the Dinosaurs.
7. Investigation of the possible causes for the extinction of the dinosaurs and hypotheses advanced to explain it.
8. Determination of the reasons why human beings have achieved their present development, the actions, and the effects of their actions on the global environment of the planet.
9. Determination of the conditions necessary for life on the planet.
10. Establishment of the similarities and differences of the Earth with other planets of the Solar System.

c. Values and attitudes. The student:

1. Displays curiosity about the evolution of the Earth and its betterment both for the natural and social order.
2. Appreciates fossils for their value as reservoirs of the history of life on the Earth.
3. Shows creativity, spontaneity, and interest in the work she does.
4. Values the presence of humans and their actions on the planet.

d. Criteria for evaluation. The student:

1. Names the principal changes occurring on the planet Earth and explains the importance of the fossil record.
2. Display in creative form work on the evolution of the planet.
3. Name the principal characteristics of the Age of Dinosaurs and possible causes for their extinction.
4. Enumerate the reasons for the presence and domination by humans and their effects on the planet.

APPENDIX 4

PROGRAMA DE ESTUDIAS CIENCIAS (PARTE)

CUARTO GRADO

C *EJE TEMATICO: CONOZCAMOS LA RIQUEZA BIOLOGICA DE COSTA RICA*

1. Contenidos. Diversidad de seres vivos (biodiversidad) en Costa Rica.

Concepto de biodiversidad, medio ambiente, especie, nicho y hábitat.
Diversidad de especies de plantas y animales en Costa Rica. Ejemplos.
Razones que favorecen la diversidad de especies de Costa Rica: zonas climaticas naturales,variedad de hábitats.
Importancia de la biodiversidad para Costa Rica y el mundo.

Procedimíentos.

Construcción de conceptos relacionados con los seres vivos, la biodiversidad, especie, nicho, hábitat y medio ambiente.
Comparacion en la naturaleza de las diferentes especies, descripción de su hábitat y su nicho.
Establecimiento de la relación de la variedad de hábitats y nichos con la diversidad de especies, que presenta una región en particular.
Realización de actividades de campo que permitan verificar la diversidad de especies de plantas y animales.
Determinación de las razones que favorecen la gran variedad de seres vivos que posee nuestro pais.
Explicación de la importancia de la l biodiversidad de seres vivos para Costa Rica y el mundo.

Valores y actitudes. El estudiante:

Aprecia, defiende, respeta y conserva la vida en todas sus formas.
Toma conciencia del valor de la riqueza ecológica y de la biodiversidad de nuestro patrimonio natural para su protección.
Valora el potencial del patrimonio natural como fuente de conocimientos científicos.

Criterios de evaluación. El estudiante:

Identifica en diversos contextos el nicho y el hábitat de algunas especies.
Explica los conceptos de biodiversidad y medio ambiente.
Enumera razones que justifiquen la biodversidad de especies de Costa Rica.
Explica la importancia de la biodiversidad de especies para Costa Rica y el resto del mundo.

2. Contenidos. Funciones vitales que permiten la supervivencia y reproducción de los seres vivos en su medio: nutrición, respiración, reproducción, respuesta a estimulos.

Características de los seres vivos para cumplir las funciones vitales: nutrición (autotrofa y heterótrofa), respiración (branquial, pulmonar, cutánea), reproducción (sexual y asexual), respuestas a estimulos (tropismos y migración) otras (adaptaciones, invernación, coloración protectora, tipo de alimentación, otras).

Procedimientos.

Construcción de conceptos relacionados con las funciones vitales.

Identificación de las funciones vitales comunes a todos los seres vivos.
Determinación de algunas acciones que deben ejecutar los seres vivos para realizar las funciones vitales.
Observación de algunas características de los seres vivos que les permiten realizar las funciones vitales.
Investigación de algunas adaptaciones que presentan los seres vivos.

Valores y actitudes. El estudiante:
Muestra interés, perseverancia y disciplina en la construcción y aplicación de nuevos conocimientos relacionados con la naturaleza y su conservación.
Estima la importancia de la existencia de las diferentes formas de vida, las respeta, las protege y las conserva.

Criterios de evaluación. El estudiante:
Explica y ejemplifica las funciones vitales y las acciones que se deben ejecutar para realizarlos.
Reconoce las diferencias en las características de los seres vivos.

3. **Contenidos. Proteccion contra depredadores.**
Ejemplos: mimetismo (camuflaje), cornamentas, caparazón, espinas, olores.

Procedimientos.
Investigación y análisis de las adaptaciones protectores contra enemigos naturales que presentan algunas plantas y animales, comprobación de algunas de ellas a través de la observación.
Análisis y discusión de la importancia de poseer adaptaciones protectoras .

Valores y actitudes. El estudiante:
Valora las adaptaciones de los seres vivos como mecanismos que asegura su supeivivencia.

Criterios de evaluación. El estudiante :
Explica la importancia de algunos mecanismos que utilizan los animales y plantas para protegerse de los depredadores y expone en forma clara y ordenada los resultados de sus observaciones y conclusiones.

EJE TEMATICO: EL HOMBRE INVESTIGA EL PLANETA Y EL ESPACIO.

1. **Contenidos. Estructura global de la Tierra.**
Estructura externa:
La Hidrosfera: concepto e importancia.
La atmósfera: concepto e importancia, algunas manifestaciones de la existencia de la atmsfera, estructura y composición, importancia de ciertos gases de la atmósfera para la existencia de vida, importancia de la capa de ozono, la presión atmosférica: concepto.
El clima y el tiempo atmosférico:
Diferencia entre tiempo atmosférico y clima.
Factores que determinan las condicioncs climáticas de una región. Ejemplos.
Influencia del clima en las actividades del hombre y la determinación de las zonas geograficás del país.
Tormentas atmosféricas y huracanes que afectan el territorio nacional.
Medidas de seguridad ante inundaciones, deslizamientos, avalanches, tornados, huracanes y otros desastres naturales.
Estructura interna núcleo, manto (astenosfera), corteza (litosfera). Principales características.

Procedimientos.

Construcción de conocimientos acerca de la estructura externa e interna de la tierra.
Construcción del concepto de hidrosfera y establecimiento de la importancia que tiene en nuestra vida.
Comunicación de los conocimientos adquiridos acerca de la estructura y composición de la atmósfera.
Investigación de la importancia de la capa de ozono para los seres vivos.
Desarrollo del concepto de presión atmosférica.
Diferenciación del tiempo atmosférico y del clima y reconocimiento de la influencia de ellos en las actividades humanas.
Demostración de dominio de las medidas de seguridad ante desastres naturales.
Identificación de las principales capas internas de la tierra (mediante la utilización de esquemas) y determinación de algunas de sus características.

Valores y actitudes. El estudiante:
Asume la responsabilidad de cuidar y proteger el planeta en que vive y promueve acciones tendientes a su logro.
Valora la importancia de la hidrosfera para la vida y tome decisiones para su protección.
Aprecia los beneficios que brinda la atmósfera.
Acepta la responsabilidad de cuidar la capa de ozono.
Conoce el efecto de la presión atmosférica en los fenomenos naturales.
Identifica los efectos positivos que ofrecen las condiciones atmosféricas a los seres vivos.
Aplica medidas preventivas y de seguridad ante inundaciones, huracanes, deslizamientos, y otros desastres naturales.
Analiza y sigue las instrucciones en materia de prevención y seguridad ante los desastres naturales.
Demuestra interés por conocer la estructura interna de la tierra.

Criterios de evaluación. El estudiante:
Justifica con razones la importancia de la hidrosfera y expresa el concepto.
Enumera algunas ventajas del agua en la vida del planeta.
Justifica con razones la importancia de la atmósfera.
Explica la importancia de la capa de ozono.
Aprende el concepto de presión atmosférica.
Desarrolla los conceptos de tiempos atmosférico y clima, reconoce la diferencia.
Promueve acciones positivas para evitar la contaminación de la atmósfera.
Comenta algunas medidas preventivas y de seguridad que debe conocer todo niño.
Nombra y reconoce en esquemas las diferentes capas internas de la Tierra.

QUINTO GRADO

C. EJE TEMATICO: LA VIDA, SUS NIYELES DE COMPLEJIDAD YSUS RELACIONES.

1. **Contenidos. Niveles de organizacion de los seres vivos.**
Concepto de individuo, población, comunidad, ecosistema, biosfera, y sus relaciones.
Procedimientos.
Investigación de los niveles de organización de los seres vivos a nivel básico.
Valoresy actitudes. El estudiante:
Muestra curiosidad científica por la organización de los seres vivos y respeta sus formas de vida.
Criterios de evaluación. El estudiante:
Elabora un resumen con los conceptos básicos de los nivelcs de organizaciones de los seres vivos, los explica y brinda ejemplos.

2. **Contenidos. La vida, sus niveles de complejidad y sus interrelaciones.**
La gran variedad de seres vivos.
Forrnas en las que se pueden agrupar los seres vivos. Criterios propios y criterios científicos: unicelulares y pluricelulares; antótrofos y heterótrofos; reinos biológicos.
Generalidades de los cinco reinos biológicos: Monera, Protista, Fungi, Plantas y Animales.
Relación de los seres microscópicos con el ser humano: enfermedades medicamentos e industria.
Importaneia de los hongos.
Reino Vegetal (plantas): función vital de las plantas, fotosíntesis, elementos que intervienen en la fotosíntesis.
Importancia de la fotosíntesis para la vida.
Reproducción asexual: estacas, acodos, estolones, tubereulos, bulbos, y hojas.
Reproducción sexual: polinización y reproducción por semillas. Ejemplos de plantas inferiores: algas, musgos, y hepáticas; y de plantas superiores: helechos coníferas y plantas con flor.
Reino Animal: clasificación del Reino Animal: invertebrados y vertebrados.
Principales características de los vertebrados (anfibios, reptiles, peces, aves, y mamíferos).
Rasgos que caracterizan a los seres humanos como miembros del Reino Animal.
Procedimientos.
Reconocimiento de la variedad de seres vivos que conforman el ambiente.
Clasificación de la gran diversidad de organismos utilizando criterios propios y científicos.
Análisis de las generalidades y ejemplificación de los cinco reinos biológicos.
Establecimiento de la relación de los seres microscópicos con el ser humano.
Identificación de la importancia que tienen para otros seres vivos los integrantes del Reino Fungi.
Identificación de la función vital de las plantas (fotosíntesis) y señalamiento de su importancia.
Experimentación en relación con la reproducción sexual y asexual de las plantas.

Elaboración de un esquema con ejemplos de plantas.
Establecimiento de la difereneia entre invertebrados y vertebrados.
Descripción de las principales characterísticas de los vertebrados.
Determinación de las razones que characterizan a los seres humanos como miembros del Reino Animal.

Valores y actitudes. El estudiante:

Manifiesta curiosidad científica por descubrir y conocer la variedad de seres vivos.
Respeta y disfruta la riqueza biológica y actúa en su defense y conservación.
Muestra sensibilidad y preocupación por el rigor y la objetividad en la búsqueda e interpretación de información.
Aprecia la belleza que poseen las plantas superiores e inferiores y su importancia para la vida.
Acepta que forma parte de la naturaleza y que todo lo que a ella le ocurra lo afecta en algún sentido.

Criterios de evaluacion. El estudiante:

Propone algunos criterios con los que se pueden agrupar los seres vivos.
Explica las características de cada reino biológico y da ejemplos de cada uno.
Explica la relación de los seres microscópicos con los seres humanos.
Juzga la importancia de los hongos.
Explica con vocabulario científico la importancia de la fotosíntesis y los mecanismos de reproducción de las plantas.
Describe algunos ejemplos de plantas inferiores y superiores.
Distingue la diferencia entre los invertebrados y los vertebrados.
Justifíca la clasificación del ser humano dentro del Reino Animal.

3. **Contenidos. Relaciones entre los seres vivos: para alimentación, reproducción y protección del territorio.**

Específicas: simbióticas (mutualismo, comensalismo) y antagónicas (parasitismo, depredación).

Procedimientos.

Descripcion de algunas relaciones que se dan entre los miembros de una misma especie.
Análisis y discusión de la importancia de las relaciones intraespecíficas en la supervivencia del individuo, la existencia de la población y la continuidad de la especie en el tiempo.
Descripción de algunas relaciones que se dan entre los individuos de diferentes especies.
Análisis y discusión de la importancia de las relaciones interespecíficas en la supervivencia del individuo y la especie.

Valores y actitudes. El estudiante:

Reconoce el valor de cada organismo y el papel que juega en la trama de la vida.
Aprecia la vida en sus diferentes formas y manifestaciones.

Criterios de evaluación. El estudiante:

Cita ejemplos de las relaciones específicas y los explica.

D. EJE TEMATICO: EL PLANETA TIERRA ESTA EN CONSTANTE CAMBIO.

1. **Contenidos. El Cambiante Planeta.**

Agentes externos que modifican la corteza terrestre.
Fuerzas externas que modifican la corteza terrestre: el viento, el agua, la temperatura, masas de hielo, la acción del hombre.

Concepto de erosion.
Acciones de los seres vivos que modifican, erosionan o contaminan el suelo y los medios que el hombre emplea para evitarlos o contrarrestarlos.
Proceso de sedimentación.

Procedimientos.

Investigación de las fuerzas externas que modifican la corteza terrestre.
Construcción del concepto de erosión.
Identificación de las principales acciones de los seres vivos que modifican, erosionan y contaminan el suelo y análisis de los medios que el hombre emplea para evitarlos y contrarrestarlos.
Descripcion del proceso de sedimentación.

Valores y actitudes. El estudiante:

Manifiesta interés por conocer las fuerzas externas que modifican la corteza terrestre.
Contribuye a evitar la erosión del suelo.
Coopera para contrarrestar los efectos negativos de las acciones de los seres vivos que modifican, erosionan y contaminan el suelo.
Aprecia los cambios que suceden en el relieve por causa de las fuerzas internas.
Estima los efectos positivos y negativos de los volcanes.

Criterios de evaluacion. El estudiante:

Nombra las diferentes fuerzas externas que afectan la corteza terrestre
Describe la erosión como un agente externo modificador de relieve terrestre.
Enuncia las acciones de los seres vivos que modifican, erosionan y contaminan el suelo y los medios que el hombre emplea para evitarlos o contrarreslarlos.
Explica en que consiste el proceso dc sedimentación y lo ejemplifica.

2. **Contenidos. Procesos internos que construyen la corteza terrestre.**

Vulcanismo: estructura de los volcanes, acción volcánica en la atmósfera y en el relieve terrestre (efectos del vulcanismo) ejemplos: lluvia ácida, catástrofes, contribución en la formación y enriquecimiento del suelo.
Efectos del vulcanismo en Costa Rica. Ejemplos: Volcanes Poás, Irazú, Arenal.
Diatropismo: movimientos de placas tectónicas, efecto del movimiento de las placas tectónicas en el relieve terrestre: sismicidad, levantamiento y rupturas (pliegues, fallas), placas tectónicas que modifícan el relieve en Costa Rica (Placas: Cocos y Caribe).
Relación del vulcanismo en la formación de rocas ígneas.
Formación de rocas metamórficas a partir de las rocas ígneas y sedimentarias, debido a factores como presión, temperatura y cambios químicos del suelo.
Importancia de observer y registrar sistemáticamente la actividad volcánica y sísmica pare prevenir desastres. Aplicación de avances científicos y tecnológicos en este campo.
Medios de seguridad antes, durante y después de un desastre natural.

Procedimientos.

Análisis de los efectos de las fuerzas internas (vulcanismo y diatropismo) que construyen la corteza terrestre.
Elaboración del modelo de un volcán destacando sus partes principales.
Determinación de los efectos del vulcanismo en la atmósfera y en el relieve terrestre.
Construcción de nociones en relación con el vulcanismo en Costa Rica y algunos hechos que suceden en el país causados por los volcanes.

Enumerar los efectos del movimiento de las placas tectónicas en el relieve terrestre.
Identificación de las placas tectónicas que modifícan el relieve costarricense.
Interpretación de la función del vulcanismo en la formación de rocas ígneas.
Determinación de los factores que intervienen en la formación de rocas metamórficas.
Análisis de la importancia del estudio e interpretación de la actividad volcánica y sísmica.
Practica medidas de seguridad antes, durante y despues de un desastre natural.

Valores y actitudes. El estudiante:

Valora los beneficios que brindan los volcanes de nuestro país al ecoturismo.
Manifiesta curiosidad científica por los efectos del movimiento que producen las placas tectónicas y por los factores que intervienen en la formación de rocas.
Aprecia el trabajo que se desarrolla sobre la observación y control de la actividad volcánica y sísmica en el país.
Practica medidas de seguridad ante los desastres naturales.

Criterios de evaluacion. El estudiante:

Construye el modelo de un volcán.
Reconoce las partes de un volcán y describe algunos de sus efectos.
Enumera los volcanes activos de Costa Rica.
Nombra algunos efectos del resultado del movimiento de las placas tectónicas.
Distingue las placas tectónicas que afectan el relieve costarricense.
Describe la relación de las fuerzas internas en la formación de rocas.
Nombra instrumentos e instituciones encargados de la observación y registros de la actividad sísmica y volcánica.
Recomienda medidas de seguridad para su protección y la de los demás y realiza prácticas de simulacro.

SEXTO GRADO

C.EJE TEMATICO: MEDIO AMBIENTE, POBLACION HUMANA Y DESARAOLLO.

1. Contenidos. Ecosistema.

Componentes de un ecosistema: bióticos y abióticos; ejemplos.
Clasificación de los componentes bióticos por su nutrición: productores: consumidores, descomponedores, ejemplos.
Importancia de los componentes bióticos en las cadenas y tramas alimentarias.
Importancia de algunos de los componentes abióticos. Ejemplos: agua, aire y temperatura.
Ejemplos de zonas de vida y ecosistemas típicos de Costa Rica: bosque tropical seco (zonas costeras), bosque tropical húmedo (zona atlántica), bosque nuboso.
Acciones negativas del hombre en los ecosistemas. Ejemplos: contaminación del agua, contaminación del aire, contaminación sónica, deforestación.
Efectos positivos y negativos del turismo masivo en los ecosistemas.

Procedimientos.

Descripción de las características y componentes de los diferentes ecosistemas.
Interpretación de la información pertinente, incluyendo componentes, hechos y fenómenos de diferentes ecosistemas.
Determinación de la importancia de los componentes bióticos y abióticos en las cadenas y tramas alimentarias.
Deducción de los diferentes criterios de clasificación de los componentes del ecosistema.
Comprobación en forma experimental de la influencia de los factores bióticos y abióticos en la supervivencia de los seres vivos.
Comparación de los diferentes ecosistemas y zonas de vida del país.
Investigación y análisis de las acciones negativas del hombre en los ecosistemas; que producen la contaminación ambiental y la deforestación.
Determinación de las consecuencias del turismo masivo en los ecosistemas y los efectos que podrá tener a corto y largo plazo.

Valores y actitudes. El estudiante:
Valora, respeta y disfruta la diversidad de ecosistemas, paisajes y riqueza biológica de Costa Rica y actua en su defensa y conservación.
Aprecia el valor del ser humano como un eslabón más en la cadena alimentaria.
Actúa con responsabilidad para evitar acciones que perjudican los ecosistemas.
Participa en la conservación y cuidado de la riqueza natural.
Manifiesta sensibilidad y preocupación por contrarrestar los efectos negativos del turismo masivo en los ecosistemas.

Criterios de evaluación. El estudiante:
Describe las características y componentes de los diferentes ecosistemas.
Explica la importancia de los organismos productores, consumidores y descomponedores.
Explica el concepto de cadena alimentaria.
Representa los diferentes eslabones de una cadena alimentaria.
Comprueba y juzga la importancia de los factores bióticos y abióticos en los ecosistemas.
Expone e ilustra las diferentes zonas de vida y ecosistemas del país.
Enumera acciones personales y colectivas que realiza para evitar la contaminación y la deforestación.
Juzga las actitudes negativas de los turistas que afectan los ecosistemas y las divulga para evitarlas.

2. **Contenidos. Equilibro ecológico (concepto).**
Factores que afectan el equilibrio ecológico: naturales: ejemplos, tormentas, huracanes, inundaciones, erupciones volcánicas, otros.
Producidos por el hombre: urbanismo descontrolado, mal uso de la tierra, otros.
Crecimiento acelerado de la poblacion.

Procedimientos.
Análisis y obtención de conclusiones de las diferentes variables naturales y humanas que afectan el equilibrio ecológico.
Descripción de situaciones hipotéticas acerca de las repercusiones del desequilibrio ecológico en la población humana y en el ambiente.
Investigación de la relación del crecimiento acelerado de la población humana con su influencia en el equilibrio natural del planeta, la demanda de recursos y de espacio vital.
Construcción del concepto de equilibrio ecológico.

Valores y actitudes. El estudiante:

Toma conciencia de que las actuaciones del hombre deben estar acorde con las leyes de la naturaleza.

Toma conciencia de los factores que contribuyen a la sustentabilidad social, ambiental, económica y productiva.

Criterios de evaluacion. El estudiante:

Explica el concepto de equilibrio ecológico.

Cita causas y efectos del desequilibrio ecológico.

Explica cómo las.acciones del hombre deben respetar las leyes de la naturaleza.

3. Contenidos. Actividades humanas fenomenos naturales y su impacto sobre el ambiente.

Ejemplos: urbanización, deforestación, plantaciones, turismo, caza y pesca no controlada, lluvia ácida, contaminación por plaguicidas, basura, huracanes, inundaciones, deslizamientos de tierra, incendios forestales, otros.

Consecuencias para las plantas y los animales locales y migratorios de la modificación y destrucción de los hábitats.

Acciones de protección al ambiente. Ejemplos: respeto y protección de los parques nacionales, reservas biológicas y otras zonas protectoras, evitar la extinción de especies, evitar la contaminación ambiental, participación en campañas para evitar la deforestación, otros.

Importancia de los parques nacionales y de las zonas protegidas.

Procedimientos.

Investigación y presentación creativa de algunas actividades humanas y fenómenos naturales que alteran los hábitats.

Descripción de las consecuencias para los seres vivos, de la destrucción de los hábitats.

Mencion de algunas acciones personales y gubernamentales para la protección del ambiente.

Determinación de algunas acciones que puede y debe ejecutar a nivel personal y colectivo en procura de la protección del ambiente.

Investigación de la importancia de los parques nacionales, las zonas protegidas y las instituciones dedicadas a velar por la protección de las especies y sus hábitats.

Valores y actitudes. El estudiante:

Comparte la información obtenida.

Toma conciencia de actividades humanas y fenómenos naturales que alteran y destruyen los hábitats y de las consecuencias para su propia existencia y la de otros seres.

Valora, conserva y defiende el medio ambiente y el patrimonio natural del país.

Manifiesta creatividad y disposición favorable al participar en campañas que promueven el respeto y la protección por las areas protegidas, así como con la ejecución de acciones con las que se pretende disminuir el impacto de la humanidad sobre los hábitats.

Aprecia el papel que desempeñan las zones protegidas en la conservación del patrimonio natural para las generaciones futuras.

Criterios de evaluacion. El estudiante:

Señala las principales causas naturales y actividades humanas que alteran y destruyen los hábitats.

Determina los riesgos y la problemática que producen las actividades humanas y los fenómenos naturales.

Juzga las principales acciones para la protección ambiental.
Enumera los esfuerzos que realiza para contribuir en la protección ambiental.
Explica la importancia de los parques nacionales.

4. **Contenidos. Relación del crecimiento de la población, desarrollo sostenible y calidad de vida.**

Efectos del crecimiento acelerado de la población humana en Costa Rica y otros sitios del mundo.
Incremento en la destrucción de hábitats, en la demanda de espacio físico para la agricultura y la urbanización; por recursos energéticos, alimentarios, de esparcimiento y recreación.
Repercusión en la especie humana, especies silvestres locales y migratorias.
Importancia del desarrollo sostenible en la calidad de vida y en el mantenimiento del equilibrio de la biosfera.
Relación entre desarrollo sostenible y la preservación de la riqueza biológica.
Desarrollo e importancia de la Ecología y sus contribuciones.
Importancia de la relación hombre-naturaleza.
Efectos negativos del consumismo y posibles soluciones.

Procedimientos.

Análisis de la información referente al crecimiento de la población, desarrollo sostenible y calidad de vida.
Establecimiento de relaciones de causa y efecto, correspondientes al crecimiento de la población, demanda de recursos, espacio físico y la destrucción de hábitats, en la calidad de vida y en el mantenimiento del equilibrio ecológico.
Investigación de la importancia del desarrollo sostenible en la calidad de vida de la humanidad y la continuidad de la vida en el planeta.
Análisis crítico de la importancia de la riqueza biológica y el desarrollo sostenible.
Búsqueda, selección y registro de información relativa a la importancia de la ecología como ciencia y sus contribuciones.
Análisis crítico de la actitud del hombre en relación desigual de dominio y explotación irracional de la naturaleza.
Descripción de los efectos negativos y algunas soluciones en la relación del hombre-naturaleza.

Valores y actitudes. El estudiante:

Valora el medio natural como recurso indispensable y elemento importante para la calidad de vida y su compromiso de mejorarlo y conservarlo.
Toma conciencia de la responsabilidad individual y colectiva en la consecución del mejoramiento en la calidad de vida en el desarrollo sostenible y la disposición favorable a actuar de forma que se asegure su logro.

Criterios de evaluacion. El estudiante: !

Enumera efectos negativos y positivos del crecimiento acelerado de la población humana en Costa Rica y otros sitios del mundo.
Interpreta la importancia del desarrollo sostenible en la calidad de vida y en el equilibrio de la biosfera.
Explica la importancia de la Ecología pare la vida en el planeta.
Comunica posibles soluciones de los efectos negativos hombre-naturaleza.

D. EJE TEMATICO: INVESTIGANDO EL UNIVERSO.

1 . **Contenidos. Origen y evolución del planeta. Cambios más evidentes de la tierra, de acuerdo con el registro geológico.**

Concepto de registro geológico.
Fósiles. Importancia de los fósiles.
Formación y cambios que ha sufrido la atmósfera hasta la actualidad.
Características de la era del dominio de los dinosaurios.
Probables causas de la extinción de los dinosaurios.
Presencia y dominio del hombre en la Tierra y sus efectos en el ambiente global del Planeta.
Expectativas de cambios para la tierra y los seres que la habitan en la actualidad.
Usos de la ciencia y la tecnología, sus efectos en la población y el equilibrio del planeta.
Condiciones de la Tierra necesarias para la vida.
Semejanzas y diferencias de la Tierra con los otros planetas del Sistema Solar.
Forma, tamaño, posición, movimientos, y atmósfera.
Posibilidades de la existencia de la vida en otros cuerpos celestes del Sistema Solar.

Procedimientos.

Investigación de los cambios que ha sufrido la tierra a través del tiempo.
Construcción del concepto de registro geológico y establecimiento de la relación entre las rocas sedimentarias y el registro fósil y las evidencias de vida pasada.
Investigación acerca de los fósiles, su formación e importancia en el registro de la vida.
Determinación de la importancia del registro geológico como archivo y reservorio de hechos, fenómenos y procesos relacionados con la dinámica, transformación y evolución del planeta incluyendo la vida (Historia de la Tierra).
Comprensión de las hipótesis de la evolución del planeta, asi como la formación y cambios que ha sufrido la atmósfera hasta la actualidad.
Descripción de las características de la era del dominio de los dinosaurios.
Investigación de las posibles causas de la extinción de los dinosaurios y las hipótesis planteadas al respecto.
Determinación de las razones por las cuales el hombre ha logrado el actual desarrollo, las acciones y los efectos de su actuación en el ambiente global del planeta.
Determinación de las condiciones necesarias para la vida en el planeta.
Establecimiento de las semejanzas y diferencias de la Tierra con los otros planetas del Sistema Solar.

Valores y actitudes. El estudiante:

Manifiesta curiosidad por la evolución de la Tierra y su mejoramiento en el orden natural y social.
Aprecia los fósiles por su valor como reservarios de la historia de la tierra.
Manifiesta creatividad, espontaneidad e interés en la elaboración de sus trabajos.
Valora la presencia del hombre y su actuación en el planeta.

Criterios de evaluacion. El estudiante:

Nombra los principales cambios ocurridos al planeta Tierra y explica la importancia del registro fósil.
Expone en forma creativa sus trabajos sobre la evolución del planeta.

Nombra las principales características de la era del dominio de los dinosaurios y posibles causas de su extinción.
Enumera las razones de la presencia y dominio del hombre y sus efectos en el planeta.

List of schools, classes, and number of students taught -- 1994

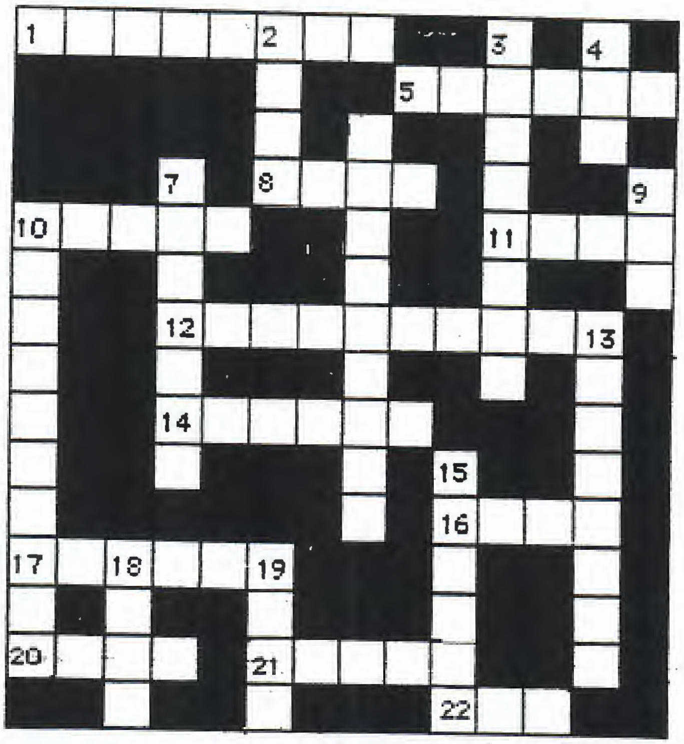
Escuela	Comunidad	Grado	Número de estudiantes	Número de visitas
Eloy Mora Carrilo	San Antonio Abajo	4	18	12
Carít	Carít	6	16	18
Luis Mongé Madrigal	Picagres	4,5,6	11	10
Bajo Burgos	Bajo Burgos	4,5,6	13	12
Nazario Valverde Jiménez	Piedades	6	8	11
Bella Vista	San Rafael	4,5	20	10
Bella Vista	San Rafael	6	6	5
Bella Vista	San Rafael	2,3	23	8
Roberto López Varela	Barbacoas	2	31	6
Roberto López Varela	Barbacoas	4	26	6
Roberto López Varela	Barbacoas	5	24	6
Roberto López Varela	Barbacoas	6	23	9
Floralia	Floralia	4,5,6	19	14
Rosario Salazar Marín	San Rafael	4,5	16	11
Rosario Salazar Marín	San Rafael	6	13	5
Cañales Arriba	Cañales	5,6	16	15
República de Paraguay	Desamparaditos	4,5	24	19
Llano Grande	Llano Grande	3,4	16	10
12 escuelas	**18 clases**	**29 grados**	**323 estudiantes**	**187 visitas**

List of schools,classes and numbers of students - 1995

Escuela	Comunidad	Grado	Número de estudiantes	Número de visitas
Cañales Arriba	Cañales	5	25	8
República de Paraguay	Desamparaditos	4,5	20	14
Llano Grande	Llano Grande	4,5,6	18	17
Roberto López Varela	Barbacoas	4	35	7
Roberto López Varela	Barbacoas	5	23	10
Nazario Valverde Jiménez	Piedades	5	16	4
Nazario Valverde Jiménez	Piedades	6	12	3
Bajo Burgos	Bajo Burgos	4,6	9	6
Eloy Morua Carillo	San Antonio Abajo	4	15	10
Luis Mongé Madrigal	Picagres	4,5,6	10	12
Carít	Carít	4	21	13
9 escuelas	**11 clases**	**17 grados**	**204 estudiantes**	**104 visitas**

APPENDIX 6

CRUCIGRAMA DE LA NATURALEZA



HORIZONTALES

1. La clase de los cocodrilos y las culebras.
5. Uno de los cinco reinos de los seres vivos.
8. Planta de tallo comestible.
10. La capa superficial de la tierra.
11. Una de las necesidades de los seres vivos.
12. Todo lo que existe en el mundo.
14 Una ave de rapiña muy grande en Costa Rica.
16. Lo que los seres vivos necesitan para respirar.
17. Una fuente de piedras.
20. Anfibio especial de Puriscal.
21. El mamífero más grande de la fauna silvestre de Costa Rica.
22. Un tipo de ecosystema.

VERTICALES

2. La segunda luz más brillante en el cielo.
3. Uno de los cinco reinos de los seres vivos.
4. La fuente de toda la energía en nuestro planeta.
6. Una de las necesidades de las plantas que están en el suelo.
7. Uno de los cinco reinos de los seres vivos.
9. Un tipo de ecosistema.
10. Las cosas bióticas que están viviendo (dos palabras).
13. Lo que está alrededor de nosotros.
15. El felino más grande de todos los bosques de América.
18. Un ave en peligro de extinción en Costa Rica.
19. La casa de un pájaro.

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