The Challenge of Climate Change in the Classroom

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Abstract: A comprehensive approach to climate change education is necessary to address numerous environmental issues. Such an all-encompassing ecological pedagogy is multifaceted providing an overview of the science behind major global environmental issues within the context of the physical environment of Earth including global climate change, resource extraction, water and air quality, urbanization, geohazards, and pollution. The main goal of the curricula is to engage students in rigorous analyses of data that can be compared with global trends. This research discusses the development of an upper-level college course on Climate Change created as part of an interdisciplinary Honors Seminar Series. The course makes use of multimedia instructional techniques to examine the physical, economic, and political dynamics of climate change. The curriculum includes an appraisal of assorted global warming websites as well as computer-based simulations and analysis of relevant climate data using current technologies such as Geographic Information Systems (GIS). Among the most powerful tools of a GIS are its modeling capabilities, which allow simulation of various climate change classroom scenarios such as storm surge and sea level rise. Relevant aspects include changes in coastal land use, wetlands, and shoreline configuration. Students also examine the role of music as a means of raising awareness of issues such as global warming. The topic of climate change is extremely complex and the challenge for educators is to enlighten students through ways and means that that are truthful, understandable, and comprehensive.

Key-Words: Climate change, Global warming, Environmental education, College curricula, GIS

1 Introduction

The reality of climate change is unfolding at a rapid rate. The Intergovernmental Panel on Climate Change (IPCC), comprised of the world's best atmospheric scientists, recently revealed that the eight warmest years on record have all occurred since 1998, and the 14 warmest years on record have all occurred since 1990. The global mean surface temperature for 2005 was the warmest since temperature observations began, 2007 and 1998 are tied for Earth's second warmest year in a century, the warmest year on record in the United States was 2006, and the world has not been as warm as it is now for at least a millennium [1].

Atmospheric concentration of carbon dioxide has increased from a pre-industrial value of 280 parts per million (ppm) to current levels of 387 ppm. This is the highest level in 650,000 years and is expected to double pre-industrial levels during this century, which could raise global temperatures 2 to 5 Celsius degrees over the next hundred years. Despite efforts to stabilize greenhouse gas concentrations by some countries, global warming will continue as a result of climate system inertia [2]. The impacts of climate change are readily apparent around the planet. Retreating glaciers and extreme precipitation events cause flooding in some areas while elsewhere water bodies are evaporating from the heat. Tropical diseases are spreading as hurricanes become stronger and more destructive. If global warming continues as the IPCC and others suggest, locations from the equator toward the poles will begin to experience higher temperatures, which could ultimately lead to more severe droughts, rainstorms, heat waves, and floods in the near future [3]. Locations in the Arctic and temperate latitudes are likely to experience warmer and stormier winters. Summers might be hotter with less precipitation, and summer rains will be the result of thunderstorms rather than showers. Regional aspects such as variations in hills, lakes, coastlines, and soils will affect local climate, so that some areas could experience higher or lower temperatures than the mean global changes [4]. An increase in temperature of 1 to 3 Celsius degrees over the next century would be equivalent to shifting isotherms toward the poles by 150 to 550 kilometers [5]. Thus, higher latitude locations can expect to be exposed to greater increases in temperature.

Global warming and climate change are among the most serious environmental problems the world community faces today. Each individual is involved and needs to be properly informed. This information should include the evidence, the impacts, and actions that can be taken to minimize the negative effects of altering Earth's climate system. To this end, a college-level

Honors Seminar course on climate change was developed using a multimedia approach that includes computer-based techniques to examine the physical, economic, and political dynamics of global warming with the goal of increasing awareness of the evidence, impacts, and mitigation strategies.

2 Climate Change Pedagogy

The seminar on climate change takes an interdisciplinary approach attempting to synthesize diverse ideas, observations, and forecasts concerning global warming. Through a review of the literature, presentations, and discussions as well as an analysis of websites and videos, students gain insight into how climate change is altering the planet, potential impacts on the future, and useful planning tools to address its effects. The following examples demonstrate how achievement of these goals and objectives are attained.

2.1 Storm Surge and Sea Levels

Storm surge is a rise in water level as gale force winds drag surface water toward the shore allowing the water to pile up into a mass. The low atmospheric pressure in a tropical cyclone also contributes to storm surge causing water levels to rise. The combination of wind blowing toward the coast forcing surface waters landward and low atmospheric pressure pulling water higher elevate sea level and storm surge heights.

Storm surge along low-lying coastal plains can be extremely devastating when the rise in sea level allows water to flow far inland. It is predicted that by the year 2100, approximately 600 million humans will live on coastal floodplains lower than the 1000-year flood stage [6]. The majority of residents in the Caribbean, the accompanying infrastructure, and many socioeconomic activities are located within a few hundred meters of the coastline [7]. The physical size of the smaller, low elevation islands, limits their capacity to handle extreme weather events and the accompanying storm surge. Additionally, if the global mean sea level rises as predicted, the present high water mark will be reached more often resulting in a substantial increase in the amount of land area that is at risk of inundation [8].

Flooding and erosion also will adversely affect the tourism industry through the loss of beaches, saltwater intrusion, infrastructure damage, and other forms of coastal degradation. The problem is compounded because many existing tourist facilities cannot meet the growing numbers and increased resource consumption of their current customer base and frequently experience problems such as water shortages. Many small islands meet their water demands through an exclusive source, which makes them especially vulnerable to a disruption in supply. For those islands that rely on precipitation stored during the rainy season, variations in precipitation patterns, such as those associated with climatic change, could be critical. For example, on Barbados, the entire groundwater supply is recharged during the short three-month rainy season, and only 15 percent to 30percent of the yearly precipitation actually reaches the aquifer.

One of the most critical ecological concerns within coastal communities is the threat of saltwater intrusion due to growing demand and over pumping. As the water table is lowered through over pumping, salt water encroaches into fresh water aquifers and the contamination is irreversible. With increases in both sea levels and population along coasts, intrusion likely will take place at pumping stations increasingly farther inland. On Trinidad and Tobago, over pumping has been exacerbated by rising sea levels and rising consumption, and it has caused a significant increase in salinity in some coastal aquifers [9].

Mangrove forests and salt marshes are integral components of coastal ecosystems offering inland residents a buffer against tidal extremes and storm surges. These ecosystems also provide feeding grounds and protective vegetative cover for numerous species of juvenile fish. However, many of these habitats are being degraded or eradicated through development and other forms of exploitation and will be further stressed by rising sea levels. Due to the inability to migrate rapidly, Jamaica's Port Royal mangrove forest could be totally decimated by rising sea levels [10]. Consequently, the loss of mangrove forests and salt marshes will destroy the habitat of numerous species of local wildlife as entire coastal ecosystems are degraded.

Coral reefs supply food and shelter for marine flora and fauna while providing natural barriers from storms. These rain forests of the sea also provide income in the form of tourism and fishing for many islanders. However, a global inventory of Earth's coral reefs estimates that already nearly 60 percent are at risk due to the actions of humans, and 90 percent of all living reefs have been damaged by coral bleaching [11]. During the next 30-50 years, coral bleaching will impact the reefs of the Caribbean to the greatest extent [12]. It is widely accepted that the relatively recent increase in sea surface temperature is the primary cause of the corals expelling from them the algae upon which they depend for food leading to their resultant bleaching and death.

2.2 Protecting Coral Reefs with GIS

Once students realize the threat from storm surge and rising sea levels is real, the class makes use of technologies such as Geographic Information Systems (GIS) to visualize what is being done to protect these ecosystems. Numerous environmental organizations make use of GIS as a principal tool in their protection

arsenal. For example, the Center for Coastal Monitoring and Assessment (CCMA) analyzes coastal and marine ecosystem conditions through research and monitoring. The CCMA assesses the impacts of climate change on coastal ecosystems through various means such as remote sensing and GIS. Projects include habitat mapping, especially in coral reef environments. The GIS is used to assess the baseline conditions of each coral reef and monitor any changes. Among the goals of the CCMA is to develop a GIS of the benthic habitats of all coral reefs within U.S. waters, including territories as well as an assessment of reef fish ecologies on these reefs. The CCMA already has mapped essential fish habitats of the U.S. Caribbean and provided color aerial photographs of near shore waters of Puerto Rico and the U.S. Virgin Islands.

However, perhaps the greatest contribution by the CCMA is the production of comprehensive, detailed maps of 2,360 square kilometers of the shallow-water benthic habitats of the Northwestern Hawaiian Islands. The products include a web site and CD-ROM that provides access to digital GIS data, maps, and satellite imagery depicting the location and distribution of shallow-water coral ecosystem habitats the islands. The GIS maps are characterized by unprecedented detail and represent the first comprehensive assessment of benthic habitats of the shallow water environments of the islands. Efforts also are underway to update the coral ecosystem habitat maps of Florida and to explore mapping coral ecosystems in the U.S. The CCMA is an outstanding example of an organization using GIS to provide the best available scientific information for resource managers and researchers, technical advice, and accessibility to data.

Similarly, ReefBase is the official database of the Global Coral Reef Monitoring Network (GCRMN), as well as the International Coral Reef Action Network (ICRAN). The ReefBase Project is housed at the WorldFish Center in Penang, Malaysia, with funding through ICRAN from the United Nations Foundation (UNF). ReefBase gathers available knowledge about coral reefs into one information repository. It is intended to facilitate analyses and monitoring of coral reef health and the quality of life of reef-dependent people, and to support informed decisions about coral reef use and management.

The numerous objectives of ReefBase include developing a relational database and information system for structured information on coral reefs and their resources that will serve as a computerized encyclopedia and analytical tool for use in reef management, conservation and research. Additionally, ReefBase collaborates with other national, regional, and international databases, and GIS facilities relating to

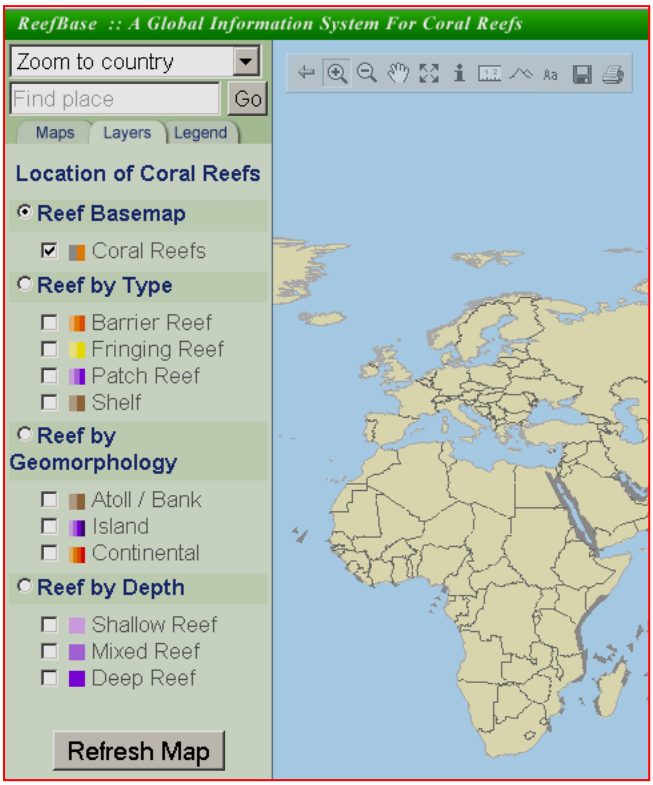

Fig. 1 The ReefBase Online GIS

reefs to provide a means of comparing and interpreting information at the global level.

The ReefBase online Geographic Information System (ReefGIS) allows students to display coral reef related data and information on interactive maps (Fig. 1). The ReefGIS offers layers with data related to the location of reefs by type such as barrier reef, fringing reef, patch reef, and shelf reef as well as reef geomorphology and reef depth. Other layers depict coral diseases, coral bleaching, and sea surface temperatures. There is even a layer of reefs that are currently being monitored and the name of the organizations charged with the task.

Among the most noteworthy undertakings by ReefBase is the development of the Millennium Mapping GIS. Using high-resolution Landsat images ReefBase is collaborating with NASA and other partners to create the first global uniform map of shallow coral reef ecosystems. The full image archive and the GIS shapefiles are available through ReefBase to provide new high-quality information about reef location, distribution, and extent.

2.3 GIS Sea Level Simulations

The Environmental Protection Agency (EPA) has created a GIS using the United States Geological Survey's (USGS) 1-degree digital elevation series and the National Oceanic and Atmospheric Administration's (NOAA) digital shoreline data to produce a series of

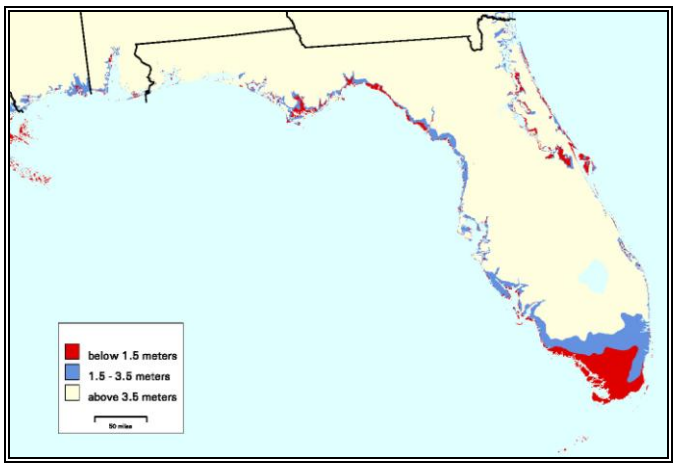

Fig. 2 GIS Flood Risk Map of Florida

maps illustrating coastal areas below the 1.5-meter and the 3.5-meter contours for the eastern United States. The results suggest that approximately 58,000 square kilometers of coastline along the Atlantic Ocean and the Gulf of Mexico lie below the 1.5-meter contour and face the possibility of being flooded within the next two hundred years if sea level rises 0.75 meters per century (Fig. 2).

A similar GIS has been developed for south Florida that incorporates elevation and land use data to depict those areas with elevations of less than 5 feet and 10 feet. The GIS reveals that significant urban areas in Miami-Dade County could undergo flooding during high tide or storm surge events. A large portion of the Florida Keys has elevations below 5 feet that are at risk of inundation should sea levels increase at the rates predicted by the IPCC and other researchers.

Digital Elevation Models (DEM) and Triangulated Irregular Networks (TIN) also are being used to create three-dimensional GIS of areas that might be at risk due to rising sea levels. Three-dimensional visualization of such models allows the user to zoom and rotate the scene from a variety of angles for a better comprehension of the negative impacts associated with sea level rise. This technique can be especially effective for presenting inundation scenarios to students.

Once the potential high water areas have been delineated, a GIS can be further developed to integrate a variety of related applications, such as surveys, inventories, monitoring, and modeling. Surveys and inventories of coastal ecosystems, including coral reefs, mangrove forests, and other biota can be incorporated into a GIS to assess those ecosystems at higher risk. Other surveys that are useful for determining vulnerability along coasts consist of population distribution such as residential, commercial, and recreational areas. Similarly, the infrastructure that supports these centers such as power generation and fresh water sources should be added to the GIS.

Efficient monitoring requires the assessment of various coastal data baselines and the evaluation of subsequent alterations in spatial patterns through the use of GIS. Relevant aspects might include changes in coastal land use, wetlands, and shoreline configuration. Such analysis is useful for students as well policymakers and various stakeholders with different value judgments [13]. While monitoring involves real-time components, perhaps the most powerful tool of a GIS is its modeling capabilities allowing the user to simulate sea level rise scenarios while offering complete control over the conditions of the simulations which are made manageable through the use GIS.

2.4 Simulating Sea Level Rise on Campus

The climate change classroom computer simulation begins with a base map of Florida and the establishment of mean sea level for various coastal counties based on topographic quadrangle contour lines, which are the most valuable data for determining which locations might be inundated. Digital images available from local county governments are incorporated into the GIS to enhance visualization. Students then adjust sea level according to estimated rates of increase associated with each hurricane category. For example, a category 1 hurricane could have a storm surge of 4 to 5 feet while storm surge for a category II is estimated at 6 to 8 feet. A category III hurricane might be accompanied by 9 to 12 feet of storm surge while the rare category IV and V hurricanes could bring a wall of water from 13 to 18 feet high.

Once the potential inundated regions have been delineated, students can determine at-risk areas along coasts based on population distribution within residential, commercial, and recreational areas. Similarly, the infrastructure that supports these centers, such as power generation and fresh water sources, can be assessed. The exercise also is useful for establishing the location of storm shelters and evacuation routes.

The class examines a local example of the application of GIS techniques used to model the risk of inundation associated with sea level rise scenarios. The example uses resources that are easily accessible. Daytona Beach, Florida, is situated at 29 degrees north latitude and 81 degrees west longitude along the east coast of central Florida. The beach is on a barrier island facing the Atlantic Ocean. Embry-Riddle Aeronautical University, where the class campus is located, lies approximately three miles to the west. While this location is advantageous for the tourism industry, Daytona Beach is susceptible to tropical storms, hurricanes, and associated storm surge.

Daytona Beach is one of the few areas of the United States still supporting driving on the beach with nearly 16 miles of hard-packed sand open to automobile traffic. The beach also is home to a variety of animals that depend on the dunes, which lie west of the driving lanes, such as mice, snakes, crabs, and nesting sea turtles including leatherbacks, greens, and loggerheads, all of which are listed as endangered.

This combination of economic and environmental activity would be greatly affected by rising sea level. Therefore, Daytona Beach seems a logical choice for GIS modeling. The initial stage of the process involved obtaining 7.5-minute quadrangle maps from the USGS, which has digitized these maps, created the associated DEMs, and offers the results to the general public with grid sizes of 30 meters and elevations rounded to the nearest foot.

ArcGIS was the software used to model Daytona Beach and is the most widely used desktop GIS in the world. Virtually any geographic spatial data can be incorporated into ArcGIS, and the software simplifies complex analyses and data management by allowing the user to visually model each task in a logical workflow. Among the local data entered into the GIS were conservation lands, parcel ownership, hydrology, marina locations, aquifer recharge areas, vegetation, streets, and zoning. These files are available at no cost over the Internet through the local county government.

Data depicting elevation were added to the ArcGIS 3D Analyst extension, which allows the user to view a surface from multiple viewpoints, query a surface, determine what is visible from a chosen location on a surface, and perform three-dimensional navigation. One-meter resolution Digital Orthophoto Quarter Quad (DOQQ) images developed with the relatively new ADS40 sensor were draped over the elevation surface creating a realistic perspective image that was integrated into the GIS.

A sea level increase of 1.5 meters was used in the spatial analysis (Fig. 3). The results suggest that most of the Daytona Beach barrier island would be inundated under such circumstances and coupled with a major weather event such as a category two or three hurricane could send storm surge as far as three miles inland from the present shoreline, possible flooding the university campus.

Fig. 3 Daytona Beach Sea Level Simulation

2.5 Climate Change Media

Several exceptional videos are available that speak to the need of students to become personally involved in an effort to mitigate climate change. *Global Warming: The Signs and the Science* is a film narrated by international recording artist Alanis Morissette. The program features numerous science experts who review a growing body of evidence concerning the consequences of a changing climate, and explores how individuals, communities, and organizations are creating new approaches to safeguard future generations.

Another film designed to spark discussion among students is *Who Killed the Electric Car?* The documentary is narrated by actor Martin Sheen and tells the story of the electric cars that first began to appear in California in 1996. The vehicles were quiet, quick, produced no exhaust, and ran without gasoline. Ten years later these futuristic cars were recalled, confiscated, and crushed by General Motors. The film offers insight into the economic and political power of automakers and the oil industry that should give us all cause for concern.

The forerunner among the climate change cinema is the Oscar winning documentary *An Inconvenient Truth*, which makes the convincing case that climate change is real, is caused by humans, and its effects will be cataclysmic if we do not act immediately. Former vice-president and winner of the popular vote in the 2000 U.S. presidential election, Al Gore presents a wide array of climate change science and data in a contemplative and compelling way. The movie essentially is a film of the slide show and lecture that Gore has presented to audiences all over the world. As we understand the personal events that shaped his character, Gore transcends politics with a heartfelt plea to reverse the harmful effects of global warming through personal responsibility based on the notion that climate change mitigation is a moral issue.

After receiving hundreds of emails from teachers interested in using *An Inconvenient Truth* to educate students about global warming, the producers have donated 50,000 copies of the DVD to teachers across the U.S. interested in using the film as a teaching tool in classrooms. The curriculum is aligned with national curriculum standards and is designed for use in Earth Science, Environmental Science, Physics, and Chemistry classes. Similarly, the British government sent copies of

An Inconvenient Truth to every secondary school in the United Kingdom, and the film is required viewing for all students in Norway and Sweden.

2.6 Internet Sites

The number of websites addressing the topic of climate change is almost endless and beyond the scope of this paper. However, it should be noted that great care is required to avoid non-scientific sites proposing that global warming is unsubstantiated and no cause for concern. Several of these fossil fuel funded organizations created to spread misinformation concerning climate change are outlined in the following section and on the website of the Union of Concerned Scientists (http://www.ucsusa.org).

The Greening Earth Society was founded on Earth Day in 1998 by a cooperative of coal-dependent utilities in the western U.S. to discredit climate change science and prevent regulations that might damage coal-related industries. Their approach is to promote the view that increasing levels of atmospheric carbon dioxide are good for humanity because higher levels of greenhouse gas emissions will help plants grow larger.

The Oregon Institute of Science and Medicine instigated the Petition Project in 1988. The purpose of the project was to discredit the IPCC by sending a mass mailing to thousands of scientists urging them to sign a petition rejecting the Kyoto Protocol. A forged National Academy of Sciences article that downplayed global warming accompanied the petition. The phony article was never peer-reviewed nor was it accepted for publication, and the Academy released a strong statement disclaiming any connection to this effort while reaffirming the reality of climate change. However, by that time the petition had been widely distributed across the Internet and damage from this misinformation continues today.

Founded in 1989 by 46 corporations and trade associations, the Global Climate Coalition funded several flawed studies on the economics of mitigating climate change along with a multi-million dollar advertising campaign against the Kyoto Protocol. Fearing a backlash from consumers, British Petroleum withdrew its membership in 1997 followed by other large corporations including Daimler Chrysler, Texaco and General Motors. However, the coalition remains a powerful and well-funded force focused on obstructing efforts to clarify climate change.

2.7 Music as a Medium

Clearly the most rewarding aspect of the class is the use of music as a medium for climate change education. Each student is required to provide the class with a YouTube or other music video link from an artist or group regarding climate change, the environment, and/or the need for political and personal responsibility regarding the planet. If they are musicians and want to accompany the video, students are encouraged to bring their instruments. Or better yet, just play the song themselves live for the class. Once students have selected a song, they send the link to the video, which is posted on the class website. Several songs are played on Music Monday at the beginning of class and the lyrics are openly discussed.

Students are encouraged to suggest videos and lyrics from artists that support the scientific claims regarding climate change and the need for political and personal responsibility. Through the music selection, even the shyest students have the opportunity to express their ideas concerning global warming and possible solutions, which provides each a voice in the learning process. This genre of American music has an abundance of illustrations beginning with the early days of environmental activism and continues today with the recent Live Earth events. For example, in 1968 the band Spirit released their haunting ecological anthem *Nature's Way*:

It's nature's way of telling you, summer breeze
It's nature's way of telling you, dying trees
It's nature's way of receiving you
It's nature's way of retrieving you
It's nature's way of telling you
Something's wrong

Two years later Quicksilver Messenger Service released their poignant portrait of industrial pollution entitled *What About Me*:

You poisoned my sweet water
You cut down my green trees
The food you fed my children
Was the cause of their disease
My world is slowly fallin' down
And the airs not good to breathe
And those of us who care enough
We have to do something.

Nearly forty years later, Melissa Etheridge's Grammy Award winning *I Need to Wake Up* continues the urgent call for action:

Cause I need to move
I need to wake up
I need to change
I need to shake up,
I need to speak out
Something's got to break up
I've been asleep and I need to wake up now

The selection of songs is always as diverse as the class of students. Some were silly, some were old, and some were so serious that it was difficult to dismiss the initial impact and continue with class. Space does not permit an analysis of each of the songs. Instead, the following three examples are examined because of their variety.

One of the oldest environmental songs selected was Marvin Gaye's *Mercy Mercy Me (The Ecology)*. It was released in 1971 and soon became one of Gaye's most famous recordings. In 2002 the song was recognized with a Grammy Hall of Fame Award.

Oh mercy, mercy me
Oh things ain't what they used to be
Where did all the blue sky go?
Poison is the wind that blows
From the north, east, south, and sea
Oh, mercy, mercy me
Oh, things ain't what they used to be
Oil wasted on the oceans and upon our seas
Fish full of mercury
Oh, mercy, mercy me
Oh, things ain't what they used to be
Radiation in the ground and in the sky
Animals and birds who live nearby are dying
Oh, mercy mercy me
Oh, things ain't what they used to be
What about this overcrowded land?
How much more abuse from man can you stand?

Another of the early environmental songs with a more playful feel is Joni Mtichell's 1970 hit *Big Yellow Taxi*. However, the version recommended by a student was a recent cover by Counting Crows. The lyrics were the same and the words are as relevant today.

They paved paradise and put up a parking lot
With a pink hotel, a boutique, and swinging hot spot
Don't it always seem to go
That you don't know what you've got till its gone
They paved paradise and put up a parking lot

They took all the trees, put em in a tree museum
And charged the people a dollar and a half to see em
Don't it always seem to go
That you don' know what you've got till it's gone
They paved paradise and put up a parking lot

Hey farmer farmer put away that DDT
Give me spots on my apples, leave the birds and bees
Don't it always seem to go
That you don't know what you've got till its gone
They paved paradise and put up a parking lot

A final example of the diversty of artists and musical tastes the class examined is Wake Up America by Miley Cyrus otherwise known as Hanna Montana. The choice of this song came as a surprise to most of the class, but once the words were analyzed the students conceded the tune had environmental value.

Oh, can you take care of her?
Oh, maybe you can spare her
Several moments of your consideration
Leading up to the final destination

Oh, the earth is callin' out
I wanna learn what it's all about but
Everything I read is global warming, going green
I don't know what all this means but
It seems to be saying

Wake up America
We're all in this together
It's our home so let's take care of it
You know that you want to
You know that you got to
Wake up America
Tomorrow becomes a new day
And everything you do matters
Yeah, everything you do
Matters in some way

3 Course Evaluation and Results

The course on climate change has been taught for four consecutive semesters. A standardized anonymous online course evaluation was developed and has been administered at the end of each semester. The survey is not a class requirement and is completely voluntary. Students are also given the opportunity to make anonymous comments on the class. The results suggest that the course has been well received and students are open to understanding more about our changing climate.

3.1 Questions and Analysis

The survey questions and results for the four consecutive classes on climate change are grouped and outlined below:

The instructor made the course objectives clear (Almost Always 92%).

The instructor organized and presented the course material effectively (Almost Always 91%).

The instructor was generally concerned with whether you understood the course material (Almost Always 92%).

The instructor was available for consultation either through office hours or appointment (Almost Always 91%).

The instructor returned examinations and/or assignments within a reasonable period of time (Almost Always 93%).

The instructor made you feel at ease to ask questions, disagree, and express ideas regarding the course material (Almost Always 96%).

The instructor, whenever appropriate, related the subject matter to practical applications (Almost Always 98%).

The instructor was enthusiastic about the subject (Almost Always 100%).

The instructor was fair and impartial in assessing your performance in the course (Almost Always 98%).

The text material used in this course was helpful in the study of the course (Almost Always 81%).

Considering everything, I would rate the instruction in this course as Excellent (91%).

3.2 Anonymous Comments

Students were permitted to make written comments on the course. Many of them took advantage of this opportunity. Below is a representative sample of these unedited observations:

Dr. Snow made this course the most fun course I've ever taken. He made every class fun and interesting and I really learned a lot on the subject of climate change.

I loved the class. I learned a lot about Global Warming and Climate Change, plus it was enjoyable at the same time.

I really enjoyed the class. The work load was good, and working in partners for the projects was very nice.

Climate Change was a great course. Let's bring on Advanced Climate Change for Spring of '08! I liked the wedge game. I think we should have done that earlier in the semester.

Very awesome professor who is up to date with new research and studies related to weather and climate.

I've never had more fun! I feel like I've learned a lot about the climate as well as technologies being developed. I can't wait to put things into practice. What a great time!

Best course ever!! Really opens your mind to new things and he does it in an exciting manner! Everyone should be given the opportunity to have Dr. Snow.

Dr. Snow made a topic that I wasn't so sure I would be interested in and made it really fun!

Never thought it would be climatology, but this was possibly the greatest class ever.

I learned a lot about the issues relating to global warming over the semester which was great..

A very good class. I've always been interested in weather, climate change, and the social impacts on climate, so this class fit me like a glove.

Professor Snow was very enthusiastic about the material and presented it very effectively, all the while allowing us to explore it ourselves and contribute what we learned to the classroom discussion. If I could take it again, I would.

The concern of the course was not the tests and the homework so much as the basic ideas of the course material. Dr. Snow was more concerned with our outlook of the world, and understanding the basic concepts than he was with the complex knowledge and information that we would all end up forgetting anyway.

The class was very open to discussion and that allowed for in-depth conversations

Since the world today is so media based I learned a lot from our documentaries on climate change. Having the visual and audio explanation on what is going on in our world today was extremely effective. Also, learning from each other by putting on presentations helped me to learn the material.

The movies helped show a connection to real life. We can read about different things that are happening but when the class can actually see it on TV, it creates a better understanding over the material that we are learning. The class was also relaxed which allowed me to have fun learning. Having this atmosphere enabled me to get more out of the class.

Dr. Snow is the best professor that I have ever had. He kept the class engaged, and at the same time I learned a ton about climate change. To Dr. Snow I am forever grateful for what he taught me, and because of him, I want to change the environment. I think I am going to go to grad school for Meteorology because of what he has taught me.

4 Future Recommendations

A comprehensive approach to an ecological education is necessary to address numerous environmental issues beyond climate change. The college-level curriculum for such an all-encompassing ecological pedagogy would be multifaceted and include the following possible topics:

Natural Systems Ecology provides an overview of several distinct fields of study such as physiological ecology, dynamics of energy and element cycles, population ecology, population interactions, community ecology, and evolutionary ecology.

Environmental Law and Policy examines the laws and policies pertaining to issues such as population, energy, pollution, land management, waste disposal, economic growth, and ecosystem management, as well as some of the theoretical underpinnings of how economic and ecological burdens and benefits are distributed within society.

Environmental History and Philosophy provides a systematic historical and philosophical analysis of prevailing Western perspectives of the environment. Students begin by exploring the Classical and Judeo-Christian roots of Western thought, after which they consider how attitudes toward the nonhuman world have evolved since the collapse of the hierarchically structured medieval world and in the wake of modern science.

Environmental Leadership& Community Involvement examines theories of leadership, group and community dynamics, grassroots and community organizing, and methods of dispute resolution. Students analyze historic social conflicts and the mechanisms that ultimately resolved those conflicts, with particular focus on the labor, consumer, and environmental movements, and international differences in the ways such movements play out in disparate political and social systems.

Global Environmental Issues provides an overview of the science behind major global environmental issues within the context of the physical environment of Earth including global climate change, resource extraction, water and air quality, urbanization, geohazards, and pollution. The main goal of the course is for students to engage in rigorous analyses of data that can be compared with global trends and analyses.

5 Conclusions

This paper discusses the development of an upper-level college course on Climate Change created as part of an interdisciplinary Honors Seminar Series. The curriculum includes an appraisal of assorted global warming websites, computer-based simulations and analysis of relevant climate data, as well as a review of the literature and other media including documentaries.

In the short period that people have inhabited Earth in terms of geologic time, they have brought about massive changes in the environment. These changes have had a significant impact on Earth's climate. Humans have been altering the environment since they first controlled fire, domesticated animals, and originated agriculture. The advent of a technological society, such as that in which we now live, created further changes. Destruction of the environment in the quest for raw materials, creation of artificial lakes, generation of energy, expansion of farmlands, urbanization, and other processes have significantly changed the face of the planet. The result of these cumulative changes is the modification of the energy interchange that occurs at the surface of Earth, and thus, climate change [14].

We must learn to overcome the dichotomy that exists between accepting the importance of nature while devaluing the environment through our chosen lifestyles. We must ensure that economic growth does not come at the expense of the environment [15]. Also, we should supply sufficient and satisfactory methods for developing and implementing guiding ecological principles rather than relying solely on the rule of law. And, we need to formulate an all-inclusive philosophy of nature that will facilitate valuation. One means of achieving these ends is through higher education.

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