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A Quantitative Study Using Constructist Learning Activities to Connect Biology Concepts to Local Environmental Issues in a Non-Major Introductory College Biology Course

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A QUANTITATIVE STUDY
USING CONSTRUCTIVIST LEARNING ACTIVITIES
TO CONNECT BIOLOGY CONCEPTS
TO LOCAL ENVIRONMENTAL ISSUES
IN A NON-MAJOR INTRODUCTORY COLLEGE BIOLOGY COURSE

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ABSTRACT

Among the general population, there has continued to be a struggle to improve environmental literacy with the knowledge, attitude, and awareness of basic environmental issues locally and nationally. Despite efforts through many formal and informal programs, the result nationally has indicated little to no understanding of basic environmental issues (Coyle, 2005). Many educators such as Sobel (1996, 2004) and Louv (2005) have documented the lack of positive outdoor experiences or environmental behaviors. The purpose of this study was to incorporate local environmental examples through constructivist learning techniques within a general biology non-major course to promote an increase in environmental literacy and positive environmental behavior.

Within both a pilot and full study, students from three classes (control, forum only, and forum and discussion) were given a pre-survey to collect their current level of environmental literacy as well as their demographic information. In Classes B and C (Class A - control) students were given articles, videos, and activities through online forums to study the effects of saltwater intrusion within coastal areas; Class C also included in-class discussions after the forum activity. After the instructional period, a post-survey with in-class assessments were given to measure a change in student knowledge, awareness and attitude of local environmental issues.

General biology non-major students showed no significant difference between the pre- and post-survey results, but a nonparametric analysis of the post-survey data indicated a significant difference between Class A (control) and Classes B and C (experimental classes) with all questions sets; except Class C was not significantly different in attitude with the other classes, but Class A and B were significantly different from each other.

With the in-class assessments, a nonparametric analysis indicated a significant difference between Class A to Class B in both assessments. Class C was not different from Class B in either assessment and only indicated a significant difference with Class A in the effects of osmosis on fish assessment.

These results indicate that implementing local environmental examples through constructivist learning techniques within a general biology non-major course would improve environmental literacy and positive environmental behavior within the general population.

CHAPTER 1
INTRODUCTION

Statement of the Problem

Research indicates that most adults do not understand basic environmental issues (Coyle, 2005; Yale, 2014), yet they are expected to make informed decisions about these complex issues and support policies that affect their lives. For example, a major problem in coastal Louisiana is land loss caused by saltwater intrusion from subsidence, enlargement of canals and bayous by wave action, as well as the effects of storm surges on freshwater systems. In the case of saltwater intrusion, as an example, few Louisiana residents know that as more saltwater enters freshwater systems, plants are affected at the cellular level when, through osmosis, water is released from cells in response to the presence of the surrounding saltwater. The result: dehydration and death of the plants. When plants are lost in the coastal systems, the roots holding the soil in place are also lost, which then results in more open water within the coastal marshes. By directly linking the biological concept of osmosis at the cellular level to coastal erosion, college age students will better understand the effects of saltwater intrusion and improve their environmental literacy.

Given the importance of how the environment impacts our lives, an opportunity exists to help one segment of the adult population, freshman non-major biology students, begin to connect information about their local environment to what they are learning in college. Specifically, non-major biology students in a freshman general biology class can be engaged with constructivist learning activities that will link basic biological concepts with current local environmental issues. By using a constructivist approach within a non-major introductory biology class, participating students can assimilate new biology concepts that are made more relevant and meaningful by the use of local environmental examples.

Educational research has indicated that the constructivist approach can enhance learning by linking prior knowledge and result in mindful and meaningful learning. In 1998, Novak stressed the importance of prior knowledge in the learning process. He indicated learning would be enhanced with the use of prior knowledge. Novak also thought that by making knowledge relevant, students would have the desire to learn and the result would be for an overall positive learning process.

However, in 1997, Langer wrote that it was acceptable for students not to remember or have prior knowledge of a subject in order to relearn and reapply new information. Furthermore, she maintained that rote learning led to less retention or understanding. Thus, by relating biological content in an introductory college non-major biology course to local environmental issues and examples, it would be expected that students would apply their new (or relearned) biological knowledge to improve their overall learning retention.

Langer (1997) stressed the importance of being active in learning and Novak (1998, 2010) indicated the importance of making connections through linking prior and present concepts together. By using local environmental issues and examples to connect with previously learned knowledge of biology, Novak surmised that students would increase their understanding. The use of local environmental issues would allow students to make meaningful connections to add experience and relevance to biology concepts.

Historical Context for the Environmental Movement

In the mid-1850s some of the pioneering conservationists and preservationists such as John Muir and Henry David Thoreau began to raise awareness of environmental issues (Cronon, 2003; Cronin and Kennedy, 1999). Their writings began to make the general public aware of the disappearance of natural areas, and that these once abundant resources are, in fact, limited. They

highlighted the need to return to simpler times by reconnecting to nature as well as the need to conserve and preserve natural resources.

Over many years as the public became concerned about the environment, laws were enacted to guide the use of our natural resources. In many instances these laws described the tension between a nation moving into the industrial era and those that recognized the need for environmental protection. For instance, laws were established to prevent the overuse of resources, such as the Yellowstone Act of 1872 (Ashworth, 1995). Still other laws were passed resulting in massive environmental destruction, such as the Mining Leasing Act of 1920 (Cronin & Kennedy, 1999). The conflict between economic development and environmental protection continued to increase through the years.

The work by Rachel Carson (1962), *Silent Spring*, resulted in increasing public awareness and concern over the effects of pollution on the general population by explaining the effect of dichlorodiphenyltrichloroethane (DDT) within the food web. DDT accumulations in body tissues (bioaccumulation) of birds at the top of the food web (like bald eagles and other birds of prey) resulted in the reduction of bald eagle populations by weakening egg shells; thus viable offspring were not produced (Ashworth, 1995; Dunlap, 1978). The effects of pollution in the environment became a growing concern for the general public.

The concern about pollution initiated the enactment of environmental laws and regulations for the improved quality and conservation of air, water, soil, energy, and biodiversity (Ashworth, 1995). However, politically, there continued to be conflict between economic interests favoring growth versus environmental interests favoring conservation.

Only with the occurrence of environmental disasters, were environmental policies strengthened, as seen with Chernobyl nuclear accident in 1986 and Exxon Valdez oil spill in

1989 (Kubasek, 2000). This trend continued into the 1990's and the 2000's with environmental disasters often followed by the implementation of stronger regulations. History has continued to repeat itself. As their predecessors, today's political leaders continue to face similar choices: economic development or environmental conservation policies. There continues to be a need to understand how to balance growth with environmental sustainability and reflect that balance in policy (Ashworth, 1995).

Environmental Education and Environmentally Responsible Behavior

With the continued growth in the environmental movement, educators began to establish guidelines for the environmental education agenda. Stapp et al. (1969) outlined objectives to govern how environmental education should be approached. National and international groups added to the establishment of guidelines to assist educators in defining the environmental education agenda (United Nations Educational, Scientific and Cultural Organization (UNESCO), 1975, 1976). The first Intergovernmental Conference on Environmental Education was held in Tbilisi, USSR, in 1977 (UNESCO, 1977), which further developed the environmental education agenda.

As the field of environmental education grew, researchers began to study the effects of environmental education on society to determine what should be expected from students in the environmental education curriculum with regard to knowledge, skills, attitudes and values. To evaluate environmental education, Hungerford, Peyton, and Wilde (1980) developed four levels of learning: ecological foundations, conceptual awareness, investigation and evaluation, and environmental action.

In 1990, the U.S. Congress passed the National Environmental Education Act, which tasked the U.S. Environmental Protection Agency to provide national leadership in order to

increase environmental literacy. In response, the EPA established the Office of Environmental Education to implement this program and to promote environmental education and guidelines. The National Environmental Education and Training Foundation (NEETF) provided educational resources and funds for environmental education workshops. Hungerford and Volk (1990) recognized that these resources were needed for support since environmental educators would be going beyond basic content.

An assessment by Coyle in 2005 evaluated the current state of the country in regard to environmental education and found that U.S. adults failed in a survey of their basic knowledge of environmental issues. For instance, in his survey of U.S. adults, he found that 45 million out of 216 million citizens believe that the ocean is a source of drinking water (Coyle, 2005). In the meantime, the No Child Left Behind laws (NCLB, 2002) focused the curriculum on math and reading while de-emphasizing other subjects such as science and social studies. Sobel (1996, 2004), Louv (2005) and Coyle (2005) have suggested ways to reengage students in order to promote positive environmentally responsible behavior. Strife (2010, 2012) indicated the importance of the environmental education of school children for their emotional and overall development into responsible citizens.

Environmental Literacy and its Relationship to Positive Environmental Behaviors

In 1968, Roth introduced the term "environmental literacy" in regard to how well citizens understood environmental issues. With the push toward an environmental education curriculum, it became clear that parameters were needed to establish what defined an environmentally literate person. Roth (1992) defined levels of an environmentally literate citizen, which included nominal, functional, and operational. These levels were helpful in recognizing the varying degrees of environmental literacy that the citizen had achieved in an area of particular concern.

Roth also recognized that citizens could be at different levels of environmental literacy depending on their engagement and knowledge of each environmental topic.

For the nominally environmentally literate individual, one would be able to communicate with the use of very basic meaning in describing environmental concepts. For the functionally environmentally literate individual, one would have more knowledge, awareness, concern and behavior compared to the nominal level. The individual would be able to go beyond basic concepts to take primary and secondary sources of data and to evaluate, analysis, and seek solutions based on a personal sense of values and ethics towards environmental issues. For the operationally environmentally literate citizen, the individual would have more breadth and depth in knowledge, awareness, concern, and behavior comparable to the functionally literate person. This individual would be able to advocate and synthesis findings, going from local to global issues, understandings, and solutions about the environment with a mindset to consciously make better decisions.

Educators recognized that for citizens to become environmentally literate, they would need to extend their concern and knowledge about topics throughout their lives. Orr (1992) proposed that citizens need to develop relationships with the environment through positive learning experiences in their youth, and then extending into adulthood, much like Rachel Carson, E.O. Wilson, and Aldo Leopold had experienced in their lives. The need for positive learning experiences in both formal and informal settings was emphasized to promote long-term environmental interest and knowledge (Coyle, 2005).

Louv (2005), Stone and Barlow (2005), and Goleman, Bennett, and Barlow (2012) have written several books to better assist educators in making outdoor experiences available for students, promoting positive exposure and enriching experiences beyond the classroom. The

goals of these books were to inspire educators to do more for environmental literacy by promoting knowledge, awareness, and positive environmental behaviors.

Rationale for the Research

Despite the work involved in the area of environmental movements, education, and literacy, the majority of our citizens have not demonstrated knowledge of, awareness in, or an attitude towards promoting environmentally positive behavior. Coyle's (2005) study indicated in its findings that U.S. citizens were not more aware of environmental issues than U.S. citizens prior to the publication of Carson's *Silent Spring* in 1962.

As seen in the research of Odom (1985), Zuckerman (1994), Christianson and Fisher (1999), and Fisher, Williams, and Lineback (2011), many college students continue to lack understanding of basic biological concepts and are unable to connect basic biological concepts with specific environmental issues. Sobel (1996, 2004) suggested that the use of local versus global environmental examples might be more relevant to student learning. While global environmental problems tend to be too far removed from the student, combining the importance of learning about the local environment and understanding basic biological concepts could prove beneficial in improving knowledge in both areas.

As a present day example of relating local environmental issues to scientific concepts in Louisiana, saltwater intrusion is a local environmental problem. By linking basic biological concepts such as osmosis and diffusion in plants to the effects of saltwater intrusion, non-major biology students might achieve a better understanding of these concepts in relation to local environmental issues.

Of great importance is the realization that the way the college curriculum is currently structured, many non-biology major students may be required to only complete one science

course. Thus, freshman biology may be the last opportunity to help students connect the concepts they learn about in the biology course with local environmental examples. These students will be our future voters, so it is critical to better prepare our students to be environmentally literate adults and exhibit environmentally positive behavior. This researcher proposed to link biology content through constructivist activities to enhance understanding of current local environmental issues in order to achieve this goal.

Research Questions

Primary Question: Does exposure to local environmental issues linked to basic biology concepts affect non-biology major undergraduate students' level of environmental literacy?

Sub-question 1: Can exposure to local environmental issues affect students' awareness and attitude in an environmentally positive way?

Sub-question 2: What outdoor activities did undergraduate non-biology students experience within the last year to learn about environmental issues?

Sub-question 3: What social media did undergraduate non-biology students use to learn about environmental issues?

Sub-question 4: What secondary educational practices and activities did undergraduate non-biology students experience to learn about environmental issues?

Sub-question 5: What resources do undergraduate non-biology students use to learn about environmental issues?

This research tests the effects of the constructive learning techniques in the teaching of a non-majors biology course (independent variable - IV) linked to local environmental issues on the changes in participants knowledge, awareness, and attitude (dependent variable - DV). The null hypothesis (H_o) stated that teaching technique would not affect knowledge, awareness, or

attitude between each of the classes tested. The alternative hypothesis (H_a) stated that teaching technique would affect knowledge, awareness, or attitudes between each of the classes tested.

The research study tested the means between the two treatment groups with the use of in-class assessments (Class B – online forum only; Class C – online forum and in-class discussion). With the in-class assessment on knowledge, the researcher was testing the effects of the constructivist learning techniques (IV) on the knowledge and awareness (DV) between the treatment classes. The null hypothesis (H_o) stated that teaching technique would not affect knowledge and awareness between the classes tested. The alternative hypothesis (H_a) stated that that teaching technique would affect knowledge and awareness between the classes tested.

Research Timeline

The pilot study occurred in the spring of 2014. Adjustments to the research survey were made over the summer of 2014. The full dissertation study and data collection occurred in the fall of 2014.

Research Design

The quantitative research design for this study, involved a pre- and post-survey to assess understanding of basic biological and environmental science concepts, awareness of environmental issues, and their actions toward environmental issues. A five-point Likert-scale survey with the "I do not know" option allowed participants to respond with "strong agree", "agree", "neutral", "disagree", and "strongly disagree". Demographic data were also collected with the pre-survey.

Three class groups were used to compare learning approaches with the incorporation of basic environmental issues. Class A was the control group (n=89) where students would be instructed in the traditional lecture format. Class B (n=100) consisted of two classes (face-to-

face and online), with both groups receiving additional assignments through online discussion tools in Moodle that linked environmental issues to basic biological concepts without in-class discussion (i.e., discussion only took place in Moodle). Class C (n=71) received the same additional assignments as Class B through online discussion tools in Moodle. In addition, Class C also received in-class discussions linking basic concepts to local environmental issues.

A pilot study was conducted in the spring of 2014 in order to test the validity using reverse questions and reliability using Cronbach's alpha of the instruments (pre- and post-survey). The in-class assessment instrument results also were analyzed. Adjustments were made on the instruments (pre- and post-survey and in-class assignment) prior to the administration of the full survey in the fall of 2014.

Population and Sample

The study population consisted of non-biology major undergraduate students enrolled in an initial non-majors introductory biology course at a regional university in southeast Louisiana.

The pilot and full dissertation research studies used three lecture classes of undergraduate non-major introductory biology students. All students participating in the study were 18 years or older. Students enrolled in the non-biology course based on their schedule, so entire classes were selected for each of the treatment groups. Since participants were in a class of their own choosing, the samples were based on convenience (Babbie, 1990; Johnson & Christensen, 2008, 2012; Nardi, 2006; Teddlie & Tashakkori, 2009).

Instrumentations

The researcher developed the survey instrument (Appendix A), which consisted of 43 questions within three constructs (knowledge, awareness, attitude) using a five-point fully

anchored Likert rating scale (strongly disagree, disagree, neutral, agree, agree and strongly agree). Respondents were also given the option to indicate “I do not know”.

Environmental questions consisted of basic topics relating to wetland loss, saltwater intrusion and other localized environmental issues. The survey was administered online by the researcher using Google Documents to allow for the collection the survey data. The pre-survey also collected basic demographic information and both the pre-survey and post-survey had questions targeted to the students’ environmental knowledge, awareness and attitude towards local environmental issues (Appendix A). In addition, students were asked about their use of social media with other learning sources as well as their involvement with outdoor activities and educational experiences.

After the pre- and post-surveys had been completed, Class A, Class B and Class C were given in-class assessments to assess their knowledge of basic biology terms and their application to local environmental issues (Appendix B and C). The assessments were a follow up to the materials used within the class such as forums, class discussion and traditional lecture. Ratio data was collected for analysis (number of correct answers) (Johnson & Christensen, 2008, 2012). The resulting differences between teaching techniques were analyzed.

Data Collection, Analysis, and Assumptions

With the use of Google Documents, participants were able to submit their pre- and post-surveys by using a computer, tablet, or smart phone. The data, once submitted, were imported into an Excel spreadsheet, and then downloaded. The data were encrypted to ensure student privacy and stored in a locked filing cabinet within a locked office.

An analysis of covariance (ANCOVA) was conducted since data would be collected on intact classes for the pre- and post-survey (Hinkle, Wiersma, & Jurs, 2003). The pre-survey

acted as the covariant in the ANCOVA. The ANCOVA allowed for partial adjustments to pre-existing differences between groups, which increased precision by decreasing the error variance (Fields, 2012; Hinkle, et al., 2003; Johnson & Christensen, 2008, 2012). The covariant was measured on intervals using a Likert-scale. This approach allowed for statistical control of the dependent variable (Field, 2012; Hinkle, et al., 2003; Tabachnick & Fidell, 1983).

By using the pre-survey as the covariant in the ANCOVA, it allowed all three classes to have the same starting point prior to the start of the experiment. It was considered superior to the ANOVA since it increased statistical power along with control; this technique also reduced the probability of a Type II error, when used appropriately, to meet the assumptions for both ANOVAs and ANCOVAs (Field, 2012; Hinkle, et al., 2003). The post-survey denoted change in knowledge, awareness, and/or attitudes measured as the dependent variable. The primary independent variable would be the use of constructivist learning activities (Moodle forum and discussions).

For the in-class assessments, an ANOVA was used to compare the means between the samples of the same population. The ANOVA tested the difference between teaching techniques for Class A (control), Class B (forum only) and Class C (forum and discussion) and knowledge, which also addressed the primary research question. It would also decrease Type I Errors which rejected a H_o, when it was true.

For the ANOVA, the assumptions addressed were 1) normality, 2) independence, 3) homogeneity, 4) sample size, and 5) outliers (Field, 2012; Hinkle, et al., 2003). For the ANCOVA, there were two additional assumptions that needed to be tested: linear relationship and homogeneity of regression.

Table 1.1 shows which instrument was used to answer each of the research questions. The instrument used was based on the questions to be answered and would determine the type of statistical analysis that would be run.

Table 1.1
Instruments and analysis employed for each research question.

Research Questions:	Instrument	Analysis
Primary Question: Does exposure to local environmental issues linked to basic biology concepts affect non-biology major undergraduate students' level of environmental literacy?	Survey - Pre/Post Data In-class Assessment	ANCOVA ANOVA
Sub-question 1: Can exposure to local environmental issues affect students' awareness and attitude in an environmentally positive way?	Pre/Post-survey	ANCOVA
Sub-question 2: What outdoor activities did undergraduate non-biology students experience within the last year to learn about environmental issues?	Pre-survey	Descriptive
Sub-question 3: What social media did undergraduate non-biology students use to learn about environmental issues?	Pre-survey	Descriptive
Sub-question 4: What secondary educational practices and activities did undergraduate non-biology students experience to learn about environmental issues?	Pre-survey	Descriptive
Sub-question 5: What resources do undergraduate non-biology students use to learn about environmental issues?	Pre-survey	Descriptive

Reliability and Validity

A pilot study conducted prior to the start of the full dissertation research study tested the validity of the survey instrument. Evidence was gathered to determine if the survey and in-class assessments had validity issues. The use of a statistical software program, IBM SPSS Statistics 22, was used to test content validity (i.e., do the survey questions answer the hypotheses?). Also, reverse response questions were used within the survey structure to test how consistently

participants had answered the questions (Babbie, 1990; Johnson & Christensen, 2008, 2011; Nardi, 2006; Reynolds, Livingston & Willson, 2009).

Reliability was a concern when constructing the survey instrument since it would be important to have consistent results from respondents. Test-retest reliability was used to evaluate reliability through the correlation coefficient statistical procedure. The limitation was the carry over effect (twelve-weeks) from the pre-survey to the post-survey, but the control group would have had the same effect (Johnson & Christensen, 2008, 2011).

The coefficient alpha (i.e., Cronbach α) test also was conducted to ensure that the survey addressed the research questions. This analysis would reveal the errors by content sampling, but it also would have indicated the heterogeneity of the test content. With a Cronbach α of .70 or higher, reliability would be confirmed (Babbie, 1990; Johnson & Christensen, 2008, 2011; Nardi, 2006; Reynolds et al., 2009). The pilot study results were used to increase reliability of the instruments prior to the administration of the pre- and post-survey as well as the in-class assessments. The data was used to make corrections and adjustments to the research instruments.

Limitations

Since student participation was strictly voluntary, there was a concern for a low sample size in each of the three classes selected for this study. Students were able to opt-out of the experiment at any time and were not required to answer every question. The questionnaire was also subjective, so student perspective would affect how students responded to questions concerning previous educational or family experiences.

Summary

As Novak (1998, 2010) suggested, students learn from assembling prior knowledge to new information or reworking old concepts. Research had shown that the constructivist approach to learning was beneficial for undergraduate students (Christianson & Fisher, 1999; Fisher et al., 2011; Friedler et al., 1987; Meir et al., 2005; Odom, 1995; Sanger et al., 2001; Zuckerman, 1994). Through a constructivist approach, non-major introductory biology college students would readdress basic biological concepts by applying them to local environmental issues.

Bailey (1903), Carson (1962), Wilson (1984), Sobel (1996, 2008), and Louv (2005) had all indicated that learning is enhanced when individuals develop relationships with the environment. With the use of local environmental examples, students might find biology content more relevant and meaningful. This strategy might allow students to connect prior knowledge with the new knowledge about both biology content and environmental issues.

In addition, these techniques might improve the environmentally positive behavior of this group of young adults. For most non-major introductory biology students, this would be their last science course. It would be beneficial to use this course to expose students to environmental issues by building their knowledge, making them aware, and hopefully guiding them to act toward a positive environmental behavior.

Definitions of Key Terms

<u>Active Learning</u>: actively engaged in learning through reading, discussion, and problem solving.

<u>Attitude</u>: a person’s favorable or unfavorable feelings with regard to a particular object or idea.

Constructivist Approach to Learning: an educational approach to learning and understanding that is based on prior knowledge and experience of the learner and how they assemble new knowledge.

Environmental Education: teaches children and adults how to learn about and investigate their environment, and to make intelligent, informed decisions about how they can take care of it.

Environmental Literacy: the capacity of a person to perceive the health of environmental systems and take appropriate action to maintain, restore, or improve them.

Environmentally Responsible Behavior: an action performed by either an individual or a group that improves or maintains the environment for the well-being of society.

Mindful Learning: a flexible state of mind in which we are actively engaged in the present, noticing new things and sensitive to context.

Meaningful Learning: relating new information to prior knowledge making it relevant to the learner.

CHAPTER 2
REVIEW OF LITERATURE

The importance of our nation’s natural resources has long been a topic of debate in terms of how best to use them. Although this has been called the land of plenty, the realization that our natural resources are limited forces us to rethink how best to manage them for longevity. As our needs grow, so does the use of these natural resources. The recognition of what our future could look like without regulations led to differing views about how best to govern these resources: preservation/conservation versus exploitation. Do we simply enjoy nature without disrupting it or do we use the resources for our own development? There should be a balance between both schools of thought, but that balance has not always been respected or maintained.

With our nation’s needs and with continuing political debate, many of our natural resources have been overused, under protected, and lost forever. This resulted in not only laws geared toward the protection of those resources, but also for protection of ourselves. Pollution and overuse have resulted in ecological disasters that have led to continued problems.

As the understanding of ecological systems has continued to unfold, so has our understanding of the interdependency we share with nature. Through education, the balance has been depicted to our citizens, yet the general population does not fully understand the importance of maintaining a balanced system for future generations (Coyle, 2005).

This literature review presents a brief account of the historical context of the environmental movement to better protect our resources and the critical role environmental education has played in developing our citizens' understanding of ecological systems. Previous research has indicated the best practices of environmental education through constructivist teaching strategies to encourage environmentally responsible behaviors (DiEnno & Hilton, 2005).

Historical Context for the Environmental Movement

Literary works have laid the foundation of current views concerning the natural environment and our relationship with it. A paradigm shift from the use of natural resources to the conservation and preservation of them began in the mid-1850's literature (Cronon, 2003). The writings of Henry David Thoreau paved the way for his contemporaries to think about the natural world and its future. His two books, *The Maine Woods* (1848) and *Walden* (1854), addressed the need for conservation and preservation of virgin forests and lands (Cronon, 2003), and reminded people about the importance of nature in our daily lives.

Other influential environmental writers included George Perkins Marsh, author of *Man and Nature* (1864), who warned readers of the overuse of land by the practice of clear-cutting (Cronon, 2003). John Muir, founder of the Sierra Club in 1892, stressed conservation of our natural resources and advocated for the preservation of large tracks of land in many of his writings (Gifford, 1992). John Muir's work had a cascading affect by influencing political and ecological leaders, such as U.S. President Theodore Roosevelt and Aldo Leopold. Roosevelt, once in office, established the U.S. Forest Service, Federal Bird Reservations, National Forests, National Game Preserves, and National Parks (Cronin & Kennedy, 1997; Gifford, 1992). Leopold introduced the importance of studying the ecology of species by including their habitat. He was torn between the debates of conservation versus economic growth (Ashworth, 1995; Sierra Club, n.d.). Leopold indicated that people cannot separate economics from the environment and stressed the benefits of developing a personal relationship with nature.

Federal laws followed in the 20th century to regulate the use and protection of these resources: Air Pollution Control Act (1955, 1961), Air Quality Act (1967), Safe Drinking Water Act (1974), Federal Lands Policy and Management Act (1976), and Pollution Prevention Act

(1990) (Kubasek, 2000). Despite these moves toward the conservation of natural resources, regulations and acts were also passed to promote economic growth: Mineral Leasing Act (1920) and the Surface Mining Control and Reclamation Act (1977) (Kubasek, 2000).

These pro-industrial acts and regulations affected the general health of wildlife, lands, and also local people. In the 1940's, one such example was the development of the synthetic chemical dichlorodiphenyltrichloroethane (DDT). DDT originally was used to target mosquitoes in order to combat malaria, but expanded as a general insecticide to protect crops and gardens (Ashworth, 1995; Kubasek, 2000). The use of DDT killed all insects, beneficial as well as pests, and polluted the ecosystem by disrupting the food web and threatening species survival. Rachel Carson, a marine biologist and well-respected nature writer, began to criticize the chemical industry and its use of DDT (Ashworth, 1995; Carson, 1962; Griswold, 2012; Kubasek, 2000). At the time, there were no regulations or management plans in place to test the effects of synthetic chemicals, such as DDT, on the environment or wildlife (Carson, 1962; Revkin, 2012).

Carson's research resulted in her groundbreaking book, *Silent Spring* (1962), which highlighted how chemical run-off from farms went into the waterways and ended up in the food supply through bioaccumulation. This occurred when small fish ate insects contaminated with DDT and in turn were eaten by larger fish which were eaten then by larger fish and fowl such as pelicans and eagles (Ehrlich, Dobkin, & Wiheye, 1998; Revkin, 2012). Nesting birds laid eggs with thin, brittle shells, so viable offspring were not produced. The effects of DDT on egg production almost eliminated species such as eagles, pelicans, osprey and even robins (Carson, 1962; Ehrlich et al., 1998; Mitchell, 1946; Revkin, 2012). Beside birds, bioaccumulation could affect mammals, even humans. In *Silent Spring* (1962), Carson wrote that:

> For the first time in the history of the world, every human being is now subjected to contact with dangerous chemicals from the moment of conception until death. In the less

> than two decades of their use, the synthetic pesticides have been so thoroughly distributed throughout the animate and inanimate world that they occur virtually everywhere. They have been recovered from most of the major river systems and even from streams of groundwater flowing unseen through the earth. Residues of these chemicals linger in soil to which they may have been applied a dozen years before. They have entered and lodged in the bodies of fish, birds, reptiles, and domestic and wild animals universally such that scientists carrying on animal experiments find it almost impossible to locate subjects free from such contamination. They have been found in remote mountain lakes, in earthworms burrowing in soil, the eggs of birds – and in man himself. For these chemicals are now stored in the bodies of the vast majority of human beings, regardless of age. They occur in the mother's milk, and probably in the tissues of the unborn child. (p. 15-16)

Carson had three goals in mind when writing *Silent Spring*: 1) create a literature piece to survive time, 2) alert the public to the use of chemicals in the environment and humans, and 3) force government to better regulate the use of chemicals and study their long term effects (Brinkley, 2012; Griswold, 2012). Her legacy continued with the development of the Environmental Movement.

This movement expanded our views of the environment and our need to protect it. New careers developed and our educational system worked to provide the requirements needed by including an environmental education curriculum in colleges and universities. With better understanding of the environment, there was an expansion of knowledge, awareness, and action to promote positive environmental behaviors (Roth, 1968, 1992).

Environmental Education and Environmentally Responsible Behavior

Environmental education's historical development preceded and is more extensive than that of the Environmental Movement. The leaders/founders of the Environmental Movement had been influenced by nature studies in their youth. Early philosophers such as Jean-Jacques Rousseau (1712-1778) encouraged students to study the environment and believed in educating children in a natural setting using hands-on activities. Louis Agassiz (1807-1873) was another influential educator who emphasized the importance of nature in the education of children

(Menand, 2001). Wilbur Samuel Jackman, who was credited with founding the Nature Study Movement, wrote *Nature Study for the Common School* (1891):

> Natural science, concerned largely with the earth and the living things it supports, affords the earliest and the only direct means of introducing the child to his earthly habitation. The life, health, and happiness of the individual are dependent upon his knowledge of the things about him, and upon the understanding that he has of their relations to each other and to himself. This knowledge and apprehension of relations can only be acquired by actual personal contact and experience with the things and forces which make up and govern the universe. (p. 1)

In 1908, Liberty Hyde Bailey founded America's oldest environmental educational organization, the American Nature Study Society, which promoted nature education along with professional development for educators with workshops, publications, materials, and field trips (Cornell University Library, 2004). Bailey maintained that "nature-study is studying things and the reason for things, not about things" (1903, p. 16). He believed that through experience comes sympathy: "Children should be interested more in seeing things live than in killing them…. I should prefer to have the child become so much interested in living things that it would have no desire to kill them. The gun and sling shot and fish pole will be laid aside." (Bailey, 1903, p. 17). Bailey indicated that children should develop a personal relationship with nature that would result in an interest in the conservation of natural areas.

John Dewey (1859-1952) was another educator/philosopher who valued the interaction between man and the environment. Dewey believed a naturalistic approach to learning by doing would lead to a lifetime of educational experiences, including the integration of many disciplines (Dewey, 1929, 1938; Simpson, Jackson, & Aycock, 2005).

With a push toward educating the public about the environment in order to encourage policy change, educators began to define environmental education. Stapp (1969) and his

colleagues developed the first working definition of environmental education to help establish a framework to begin the educational process. He stated:

> …for environmental education to achieve its greatest impact, it must: 1) provide factual information which will lead to understanding of the total biophysical environment; 2) develop a concern for environmental quality which will motivate citizens to work toward solutions to biophysical environmental problems; and 3) inform citizens as to how they can play an effective role in achieving goals derived from their attitudes. (p. 35)

Stapp believed that through the implementation of environmental education, citizens would then be better prepared to make decisions and promote environmentally positive behavior. Stapp et al. (1969) defined the goal of environmental education as “aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution” (p. 34).

As the field of environmental education continued to expand, studies on how best to address and implement change continued to emerge. Since environmentally positive behavior of citizens was the goal of a successful environmental education program, researchers began to identify factors that could influence this.

Hines, Hungerford and Tomera (1986, 1987) found that knowledge and skills were important factors for change, but the personality of the individual and his or her desire to act were also important. Knowledge and skills could be dealt with in a school setting, but the desire to act was a more complex issue to address because it could be influenced by a multitude of factors. Research indicated that an individual who had the desire to act would more likely do something environmentally positive as compared to individuals who were not motivated towards action. Hines et al. (1986, 1987) concluded that “knowledge of issues, knowledge of action strategies, and locus of control, attitudes, verbal commitment, and an individual’s sense of

responsibility" were determining factors (p. 1). They also indicated that additional research was needed to evaluate all interactions together versus addressing one component at a time.

Hungerford and Volk's research (1990) indicated that there were three variables that led to positive environmental behavioral change: entry-level variables (i.e., environmental sensitivity, knowledge of ecology, and attitudes toward pollution, technology, and economics), ownership variables (i.e., in-depth knowledge about issues and personal investment in the environment with knowledge of both positive and negative consequences of behavior and a personal commitment to resolutions), and empowerment variables (i.e., knowledge and skills in using environmental action strategies, locus of control, and intention to act with in-depth knowledge about issues). The combination of all three variables should lead to environmentally responsible behaviors of citizens. The model showed that knowledge led to awareness, which led to action (behavior change). They also noted that behavior change was often associated with single issues such as endangered species or safe drinking water.

In their study, Hungerford and Volk (1990) recognized three main concerns: 1) environmental quality continued to decline because citizens were not being environmentally responsible, 2) environmental education was secondary to overall educational practices as many environmental programs focused on awareness, which then did not led to a change in citizen behavior, and 3) environmental education materials did not promote skills in evaluating environmental problems or skills in solving these problems since there was not a sense of empowerment or ownership. Hungerford and Volk (1990) concluded that "our efforts are learners who may act in an environmentally positive manner with relation to one issue (or set of issues), but who do not have the knowledge, skills, and willingness to assume environmental responsibility in their day to day lives" (p. 267).

In 1996, David Sobel, in *Beyond Ecophobia: Reclaiming the Heart in Nature Education*, emphasized the importance of students returning to nature in order to explore their communities, their neighborhoods, and their schools. He reintroduced the need for students to connect with their surroundings as Thoreau, Bailey, Muir, Carson and other earlier writers had indicated. Sobel believed that environmental education had focused too much on the destruction of the environment (i.e., deforestation, hypoxia, extinction of species, and other natural and man-made disasters). Sobel referred to this situation as *ecophobia* and defined it as the fear of ecological problems and the natural world. He suggested educators needed to move away from the fear of nature and the adverse effects humans had on it, and focus on cultivating positive relationships between the learner and the environment. He reasoned that this shift would allow those relationships to promote positive environmental behavior.

After 40 years of environmental education with hundreds of organizations working to educate U.S. citizens about the environment, Kevin Coyle with the National Environmental Educational and Training Foundation (NEETF) and the Roper Group in 2005 published their findings on how environmentally aware the American people were. Data was collected from 1,500 participants who were randomly selected to take part in a telephone interview. The numbers were evaluated and the results were very disappointing. Only a third of American adults were knowledgeable about environmental issues. In spite of all the laws, organizations established, and education programs, American citizens were no more aware of environmental issues than citizens were before the writings of Rachel Carson.

The Coyle (2005) report showed that Americans viewed themselves as being environmentally aware, even if they simply heard of the topic versus actually being knowledgeable about it. The study indicated that regardless of age, educational level, or income,

U.S. adults failed to understand basic concepts, environmental science, or cause/effect relationships. Based on their findings, citizens would be considered untrained and unskilled based on the acceptable criteria for an environmentally educated citizenry.

Coyle's research indicated that 90% of knowledge and learning occurred outside of school. Most of the information citizens were getting originated from their children, television, or places like zoos or nature centers. The information getting to the public was a very reduced and simplified account of what was going on in the environment, a footnote more or less. Another finding was that citizens were retaining old information as well as misconceptions rather than updating their understanding of environmental issues. For example, participants believed that chlorofluorocarbons (CFCs) were still damaging the ozone layer, yet CFC's were banned in 1978.

In 2005, Richard Louv wrote *Last Child in the Woods* as a response to the *No Child Left Behind Act* (2001). Louv's book brought to light the need for every child to have access to natural settings and an opportunity to learn about the natural world. Louv introduced the concept of Nature Deficit Disorder in response to children being removed from environmental experiences by educators with shortened recesses, fewer field trips, and less hands-on activities. In his opinion, students were not being educated to acquire knowledge, skills and understanding, but were being taught to pass standardized tests. Children needed to experience the outdoors daily, to think, to wonder, to explore. Between the classroom and home, children were plugged into the Internet or video games much of the time. Children were losing their ability to recognize problems, but most importantly, solve those problems through critical thinking.

As environmental educators explored more facets of the effects on environmental education, there still remained a strong need to continue to push for a more comprehensive,

inclusive curriculum in this area. It was advantageous to focus on the informative, positive strategies to promote positive environmental behavior as Strife's (2010, 2012) findings indicated, as well as highlight the overall health benefits in a back-to-nature approach (Louv, 2005; Sobel, 1996, 2004).

Thoreau's *Walden* helped citizens reconnect to simpler, less stressful times. Muir and Roosevelt set the stage to preserve our national environment. Carson's *Silent Spring* alerted a nation to the perils of pollutants on the health of the environment and people. Louv's *Last Child in the Woods* shed light on the effects of taking nature out of childhood. As the process of environmental education continued to evolve, a push for positive environmental behavior and an environmental educational curriculum remained in the foreground of environmental educators and supporters.

Environmental Literacy and its Relationship to Positive Environmental Behaviors

Environmental literacy was a fairly new term that first emerged in the late 1960s on the heels of Rachel Carson's *Silent Spring*. With growing concern for the effects on health, the environment and the nation's natural resources, educators and environmentalists began working toward a better understanding of the environment and our role within it. Roth (1968) recognized that having an environmentally literate citizenry must include educators who would encourage the populace to be caring enough to be concerned and take responsibly for the challenges facing the environment.

Twenty-five years later, Roth (1992) reported that the initial definition of environmental literacy had gone through several revisions. The term could now be defined as necessary knowledge, skills, and behavior needed for an environmentally healthy existence. Roth indicated that there was a wide array of competencies in environmental literacy, ranging from zero to very

high. He identified three levels of environmental literacy: nominal, functional, and operational. Within each level, there were four stages (awareness, concern, understanding, action) which determined the varying degrees the environmentally literate citizen had achieved.

Roth (1992) stated what an environmentally literate citizen should know how to 1) identify environmental problems as they arise; 2) exam the issues before responding; 3) correct environmental issues by changing consumer and work habits, voicing concerns to authority figures, contacting legislators, group involvement, and financial support; 4) be a lifetime learner by using knowledge and skills to stay informed; 5) recognize interrelationships among other species and make humane decisions; 6) act as stewards for public and private property; 7) be able to relinquish individual rights/resources for the greater good of long-term conservation; 8) limit the size of families with the understanding of limited resources for the biosphere; 9) maintain diversity in the environment; and 10) make changes over-time in response to understanding the changes of resources, values, and culture for long-term sustainability (Dickey & Roth, 1972; Roth, 1992). Although Roth's definition included a broad range of characteristics for the environmentally literate citizen, he did not include an assessment to determine who had met that standard.

In the Tbilisi (UNESCO, 1977) document, the international committee defined environmentally literate persons as: 1) aware and sensitive to the total environment, 2) having a variety of experiences and a basic understanding of environmental problems, 3) having a set of feelings and values towards the environment which would motivate them into actively protecting and improving the environment, 4) being able to identify and solve environmental problems through the development of skills, and 5) actively involved in solving these problems. Thus, the Tbilisi focus was on environmentally responsible behavior in citizens.

Developing a Mindful and Meaningful Environmental Education Experience

As explored earlier, incorporating environmental education into the curriculum had been challenging. It was important to create a dynamic learning environment in order to raise the environmental literacy of the nation. Dr. Ellen Langer, author of *The Power of Mindful Learning* (1997), looked at the effects of mindless versus mindful learning and thinking. Langer held that people in a mindless thinking state cannot move beyond basic knowledge or incorporate what they already know to a new situation. Because of mindlessness, the learner started to demonstrate an automatic behavior, a set pattern to recite lists and definitions. The mind, like the body, had mindlessly responded to daily routines like pouring the coffee, grabbing the keys, locking the door, and driving to the work. The research indicated that we have conditioned ourselves to be on autopilot. A tragic example that appears regularly in the news of this type of automatic behavior is parents leaving babies in parked cars. Several babies a year have died after being forgotten in a hot vehicle by an absent-minded adult. The adult was mentally off track by being bogged down with daily stress and drove by the daycare thinking that the baby had been dropped off. This, of course, is an extreme example automatic behavior that resulted in 500 babies dying in hot vehicles from 1998-2010 (Rochmon, 2011).

Langer (1997) encouraged more mindfulness in daily activity and not mindlessness. She suggested that mindful learning meant to seek out and explore multiple perspectives in solving problems or looking at materials differently. She stated that "everything is the same until it is not" (p. 5). Langer recommended that educators not use the same notes each year, but for them to start fresh every semester making it new for the teacher and their students. Teachers should bring new perspectives into the classroom because students could not make connections unassisted. The goal should be to demonstrate the importance of the learning environment by

making it interesting. Routine methods resulted in rote learning, but creativity led to mindful learning.

Langer (1997) defined the mindful approach to learning with three characteristics: 1) the constant creation of new categories; 2) acceptance of new information; and 3) an unrestricted awareness of more than one perspective. If educators presented both the problem and solution, students would not become mindful. They would become rote learners with a goal to pass a test by only knowing what had been given to them. Educators stifled the learner with rules and regulations, then showed frustration when students did not exhibit creativity and problem solving skills. Langer encouraged thinking outside the box and not limiting oneself to one perspective. Researchers tended to either address problems from the top down (quantitative) or the bottom up (qualitative). Langer said that we should address a question or problem from a different angle, for instance from the side (mixed method). Mindfulness allowed for a variation in learning styles as well as solutions to problems. Langer and Moldoveanu (2000) believed that mindfulness should be considered as active learning. A mindful approach actively resulted in the whole individual being involved in the learning process.

Joseph Novak's book, *Assimilation of Knowledge* (1962), expanded on the concepts of how humans learn, meaningful learning, and the theory of education. Like Ausubel and Fitzgerald (1961), Ivie (1989) and Novak (1998, 2010) believed that prior knowledge was key to meaningful learning, which differed from Langer's ideas (1997). Although prior knowledge could have been obtained through rote learning, Novak recognized that rote learning was not long term learning and was easily forgotten. Prior knowledge also could contain misconceptions, but it was the key to making new concepts meaningful. If that prior knowledge was relevant, then it could become meaningful by making connections in the mind of the learner.

Novak also believed that the learner had to want to learn. If the learner had no interest, learning could not take place, which was seen in Langer's work (1997). The learner would take action to learn; as the environmental literate citizen would take action to promote positive environmental behavior.

Novak explored the success of education with that in mind. He stated that education had to include more than thinking. Feeling and action had equal importance in meaningful learning. He stated the "acquisition of knowledge (cognitive learning), change in emotions or feelings (affective learning), and gain in physical or motor actions or performance (psychomotor learning) enhance a person's capacity to make sense out their experiences" (p. 9). Wandersee (1985) also indicated misconceptions could be based on prior knowledge. If educators were aware of what those misconceptions were, then current research findings could be used to replace those misconceptions. To build on what students knew, the use of historical biological concepts could assist in replacing misconceptions with better understanding to make a positive learning experience. With awareness of the misconceptions, Wandersee (1985) and Friedler et al. (1987) indicated that prior knowledge could create a positive learning experience.

In Novak's *Learning, Creating, and Using Knowledge* (1998, 2010), his theory of education stated that "meaningful learning underlies the constructive integration of thinking, feeling, and acting leading to empowerment for commitment and responsibility" (p. 15). From a meaningful experience, either positive or negative, the learner could feel empowered or disempowered. Disempowerment was caused in most cases by rote learning since memorization of facts, figures, terms, and concepts did not come from experience; thus, it had no true meaning for the learner. Empowerment of the learner came by the incorporation of the learner's experience with prior knowledge, which would give control and power to the learner (positive

experience). By empowering the learner, prior knowledge became meaningful, and then the learner became empowered by owning that knowledge. By developing meaningful learning experiences, the need for rote learning would be eliminated (Novak, 1981, 1998, 2002, 2010). This would be the underlying theme in environmental education; through experiences came learning since the learner had created a relationship with the topic of interest.

Although Langer and Novak both strived for more understanding and long-term memory, Langer did not give meaning to prior knowledge. Novak, as an educator, built on prior knowledge by making it meaningful. Students made the connections and drew upon their own experiences to build those meanings in order to empower themselves as learners. This was also the basic concept for environmental education where experiences would build knowledge in the learner.

Constructivism and Environmental Education

Jean Piaget was a biologist whose research focused on the phylogeny of mollusks, but later turned to the cognitive development of children. He developed his theories based on observations and interviews with children (Inhelder & Piaget, 1957; Piaget, 1975; Piaget et al., 1969); one such example was his pouring the same amount of liquids into various shaped containers, then how children explained the volume of the liquid. Piaget believed that learning takes place over time with assimilation, the process of taking information in from the environment to add to current information, and accommodations, making adjustments based on assimilation of concepts. This led to equilibration, the coming together of the new and old information (Inhelder & Piaget, 1957; Mintzes, Wandersee & Novak, 1997; Piaget et al., 1969).

Although Paiget did not use the term constructivist, he has been accredited as one of the developers to constructivist learning theory. “Constructivist learning theory can be summarized

by understanding that each student comes to class with his or her own assumptions about how the world works; for knowledge to be retained, it needs to be presented in a way that fits this new knowledge into the student's existing worldview" (DiEnno & Hilton 2005, p. 15). Piaget's work was well received, but he did not take into account prior knowledge of the learner or contextual variables (Mintzes, Wandersee & Novak, 1997) as later educational theorist did.

Joseph Novak took into account the use of prior knowledge when composing his theory of constructism. Novak's interest in how learners constructed knowledge led to the concept he coined as human constructivism (1998, 2010; Mintzes, Wandersee & Novak, 1998, 2000, 2001), which was the ability of the learner to take prior knowledge and add new knowledge to it. In some cases, it meant to discard misconceptions in order to be replaced with new constructed knowledge which could also result in positive learning experiences.

A constructivist approach was explored for environmental education by researchers Ballantyne and Packer (1996); it was suggested that this approach would encourage students to become more aware and even question inconsistencies in their studies in order to make better decisions for themselves about environmental issues. This approach would allow students to develop their own understanding of the problem, which could result in positive environmental behavior. The researchers recognized that more studies were needed to understand the impact of this educational strategy on environmental education.

Christianson and Fisher (1999) explored the constructivist approach by looking at three introductory biology college courses. Christianson was interested in evaluating knowledge as well as misconceptions of diffusion and osmosis. Christianson indicated that the smaller class with more hands-on laboratory work along with the discussion performed better compared to

those in larger, less hands-on classrooms. He suggested that the constructivism approach would be favorable for student retention in the classes.

McClanahan and McClanahan (2002) used a variety of constructivist learning techniques in their large non-major biology classes. The researchers decreased the amount of traditional lectures to use reflections, mini-projects, brainstorming, and journaling (i.e., constructivist learning). Although the researchers did not have a control group, they made inferences based on previous teaching assessments. Students indicated that they had better educational experiences that lead them to a better understanding. They also indicated that mini-lectures within constructivist in-class activities enhanced both the activities as well as the learning outcomes by generating questions in order for them to deconstruct difficult concepts. At the end of the study, students were able to add to their overall knowledge through their experiences.

Michael and Modell (2003) also suggested similar constructivist activities for active learning with secondary and college science students such as reflections, cooperative learning, problem-solving, case based learning, and peer instruction. There are three points to their learning model: input state-to-learning experience-to-output state. As educators, it would be important to know what the students knew, be able to define how they could have a constructivist learning experience, and then be able to demonstrate knowledge at the end of the assignment. With college-level classes, instructors tended to assume that students would be prepared for the course without assessing their prior knowledge. Michael and Modell (2003) recognized the challenge of using this model with large lecture classes, but made active learning possible for all class sizes.

DiEnno and Hilton (2005) explored two teaching strategies in environmental education with their secondary students. They wanted to research the effects of traditional versus

constructivist teaching on student outcomes of knowledge, attitude and engagement concerning environmental issues. The participants were broken up into the traditional class, which had lectures and individual work activities, and the constructivist group, which had brief introductions followed by peer group activities. Both groups were exposed to the same information about non-native plant species, but the traditional group was not encouraged to discuss or share information while doing individualized activities. Since traditional lectures did not evoke feelings or emotions, the comparison with constructivist teaching allowed the researchers to suggest in their findings that the constructivist group showed a higher degree of benefits from the constructivist educational approach in both knowledge and attitude adding to a better environmental educational experience.

Freeman et al. (2007) studied the effects of constructivist learning in an introductory biology course for majors. Student failure rates were high, so researchers designed five active learning courses with the aim of increasing student retention. Students were rewarded for answering questions regarding previous materials at the beginning of each class. Throughout the class, students were asked to be interactive by answering structured questions with clickers. The researchers determined that constructivist learning increased student retention by engaging students with the use of clickers. The failure rate had decreased, but constructivist learning needed to be controlled with rewarded activities. Voluntary constructivist learning options did not produce the same level of student success.

With educators and researchers continuing to explore ways to best help students with environmental literacy and knowledge gain in general, Coertjens et al. (2010) addressed what effects school had, if any, on the environmental attitudes and awareness of their students. Since schools formally educate students over a period of years, it was assumed that schools shaped

how students felt about the environment, especially schools that subscribed to active learning through constructivist pedagogy. Schools recognized that students "are not a blank slate, and knowledge cannot be imparted without their making sense of it through a lens of their current conceptions" (p. 500). This prior knowledge or experience would be through films, field trips, or discussions with outdoor education being a factor as well.

With the use of a survey (Coertjens et al., 2010), students' science knowledge and environmental awareness and attitudes were determined. The study found that females where more pro-environment than male students, but males scored higher on science knowledge as seen in Kellert (1985) and Kellert and Berry's (1987) findings. Coertjens et al. (2010) also indicated that schools did influence environmental awareness and attitudes in their students with constructivist activities.

Packer (2009) found that service-learning projects incorporated into non-major biology labs showed overall improvement in student understanding between human activity and the environment. Packer wanted to provide a learning experience to link people to food production, so students were required to physically work on a farm three times during the course of the semester. Packer indicated through survey research that negative stereotypes about farming were replaced with more appreciative attitudes toward the work of farmers. The research also suggested an improved attitude and value of the environment from students at the end of the semester. Students rated their educational experience higher than that of previous traditional labs which led to environmentally positive behavior.

Clary and Wandersee (2010) had written many peer-reviewed studies based on the importance of constructivism. They discussed the importance of continuing to provide constructive learning assignments even within online courses. With the use of technology such

as Google Maps, students had the opportunity to “experience” virtual field trips. Through a constructivist learning project, students could go beyond the traditional materials to assimilate information to add to their knowledge.

Clary and Wandersee (2012, 2014) used constructive learning for climate change studies with online learners. To expose students to the issue of climate change, the researchers used online reports to process information and discuss results with peers through online discussion forums. With the posting of resources and critical-thinking questions, students were able to process their findings, which added to their body of knowledge. The result of this study indicated that students increased their level of climate change knowledge through constructivist learning.

Hartle et al. (2012) highlighted four essential criteria to assess and identify the four level of a constructivist approach to education: 1) eliciting prior knowledge with demonstrations, surveys, quizzes, interviews, discussions and concept maps; 2) creating cognitive dissonance by determining misconceptions, compare and contrast, demonstrate, and even create discomfort with difficult questions; 3) application of new knowledge and feedback with problem solving, presentations, use of new constructs and hypothesis testing; and 4) mega-cognition with reflections on earlier steps. The researchers wanted to provide applicable knowledge for higher education instructors to use in biology classes to open up constructive learning experiences for students.

With a rich source of peer-reviewed publications from a variety of journals and disciplines, it had been shown that constructivism had been an effective method for teaching K-16 students. Researchers showed that in secondary and college-level students, there were many misconceptions that had not been corrected until those students were exposed to constructivist

learning activities (Brownell et al., 2012; Lazarowitz & Lieb, 2006; Novak & Wandersee, 1990). To build on prior knowledge, those misconceptions needed to be corrected and forgotten in order to assemble new knowledge (Langer, 1997; Novak, 1998, 2010). With the use of prior knowledge (Fisher et al., 2011; Novak, 1981, 1998, 2002, 2010; Wandersee, 1985), researchers indicated that students can expand their depth and breadth of knowledge with constructivist learning techniques.

With the nation's children falling behind with low standardized test scores and failing schools, negative learning experiences resulted in a negative outcome on learners (Brisco & Ulerick, 1991; Langer, 1997; Novak, 1981, 1998, 2002, 2010). With the use of constructivist learning, students experienced positive feelings and attitudes in order to promote knowledge (Langer & Moldoveanu, 2000; Novak, 1981, 1998, 2002, 2010; Novak & Wandersee, 1990). Active learning activities, such as online forums, created a positive learning environment to enhance the content (Clary & Wandersee, 2010, 2012, 2014). With positive attitudes towards education, students would be more open to building their knowledge base which would translate into positive environmental behavior to increase environmental literacy.

Purpose of the Study

Among scientific and educational organizations, there has continued to be an evolution toward reform. The National Academy of Science (2009) proposed a closer interdisciplinary collaboration for a deeper understanding of biological systems. The reform in biology would translate into what would currently be needed for all citizens within the scope of this initiative. The National Research Council's (2003) publication, the *Bio2010: Transforming Undergraduate Education for Future Research Biologists* was a proposal to incorporate more in-depth connections between the disciplines.

The reform in undergraduate science teaching for the 21st century was considered a challenge for educators. To be effective, steps were needed to promote success of the student and educator. Fisher (2004) indicated that the first step would be identifying misconceptions in biological concepts (Fisher et al., 2011; Novak, 1981, 1989, 2002, 2010; Wandersee, 1985). Fisher (2004) said that one of the issues was that “commonsense beliefs are sometimes at odds with scientific theories” (p. 2). Because of this, instructors have to use effective teaching methods for technical knowledge as well as for how students’ think and learn. This process would allow students to construct their knowledge, which would be done through a constructivist learning method versus a traditional, rote method.

Bell (2008), Cothron, Giese, and Rezba (1989, 2000), and Harland (2011) developed teacher resources to promote hands-on science activities with integrated disciplines. The development of skills required practice in learning how to think and how to ask questions. With the use of a variety of resources, educators linked science with everyday activities to provide for an overall learning experience through constructivist learning.

There were a number of educational research articles that addressed the same topics through the years, focusing on the misconceptions undergraduate students had on diffusion and osmosis (Christianson & Fisher, 1999; Fisher et al., 2011; Friedler et al., 1987; Meir et al., 2005; Odom, 1995; Sanger et al., 2001; Zuckerman, 1994). Each paper addressed misconceptions of secondary or college students. Researchers tested various methods to dispel misconceptions and replace with correct knowledge through constructivist learning methods.

Roth (1992) defined an environmentally literate citizen as being one who understood basic concepts such as diffusion and osmosis. Since students constructed new knowledge based on prior knowledge (Novak, 1981, 2002; Novak & Wandersee, 1990), it would be important to

determine what knowledge the students had in order to help identify and dispel misconceptions. Once educators knew the starting point, it would be beneficial to incorporate constructivist learning methods into basic biology classes.

After reviewing the extensive literature on environmental education, environmental literacy, and constructivist learning, it would be advantageous to use environmental education in college freshman non-major biology classes. This would address the agenda described in Bio2010 in regard to an environmental science curriculum. Linking local environmental issues to a general biology course could help to accomplish these goals. In Coyle's report (2005) and Louv's book (2005), it would help to achieve an environmentally literate citizen to promote positive environmental behavior.

Despite undergraduate biology reform initiations, most undergraduate biology courses began with the same materials as that of a high school course. By using an environmental education component within the freshman non-major biology courses, students would obtain the core concepts with meaningful and mindful learning. By using constructivist learning activities, such as online discussion and real-world application, students would be able to connect basic biological concepts to local environmental issues, such as the effects of saltwater intrusion on Louisiana wetlands.

As Coyle (2005) and Louv (2005) addressed, there had been a disconnection with the natural world across all boundaries. With the use of local examples and constructivist learning techniques, students could regain prior knowledge and learn in a meaningful/mindful fashion. This approach could allow students to actively learn about the importance of coastal wetlands, the effects of saltwater intrusion, and the effects of diffusion and osmosis on Louisiana wetlands. This could impact students' levels of knowledge of basic biological concepts, increase awareness

of local environmental issues, and improve their attitudes regarding environmentally positive behaviors.

Wold (2014) reported in a survey that the majority of Louisiana citizens believed in climate change, with 91 percent agreeing that a strong coastal wetlands and economy are linked. 84 percent agreed that drilling could occur without harming the environment; 90 percent agreed the federal government should be responsible for coastal protection and U.S. energy; and 87 percent agreed that the oil industry has a responsibility to lobby Congress for better protection of coastal areas. The issue with Louisiana citizens was not instilling the importance of coastal areas, but developing solutions. Without fully understanding content, it would be difficult to develop solutions that promote positive environmental behavior.

Since many Louisiana citizens had experienced hurricanes and storm surges, local students would have prior knowledge of these topics. With pre- and post-surveys, educators could identify misconceptions prior to the constructivist learning activities. Students could have a hands-on learning experience by studying the effects of saltwater intrusion on plants, animals, and local urban areas. Through better understanding of content, possible solutions could be developed. Currently, the problems are accepted without the push to solve environmental issues in Louisiana.

CHAPTER 3
RESEARCH METHODS

This chapter provides detailed methods for this quantitative study, which focuses on the environmental literacy of non-biology majors in an introductory college biology course. The investigator uses pre- and post-survey and in-class assessments to determine how local environmental issues introduced by a variety of constructivist methods affected students' levels of environmental literacy and positive behavior.

Overview of Problem

The general adult population in the U.S. is not aware of basic environmental concepts or issues (Coyle, 2005; Louv, 2005; Yale, 2014). Few studies in higher education address environmental literacy among non-major introductory biology undergraduate students. These students represent the majority of the U.S. population, which is a non-scientific citizenry. At the university level, non-biology majors are required to complete one (or possibly two) basic science courses. The non-major introductory biology course addresses the same concepts that students studied in primary and secondary schools such as biochemistry, cell structure and function, energy, photosynthesis, respiration, cell division, and genetics.

Although the course content is more detailed when compared to a secondary biology course, students are still exposed to the same basic information. Misconceptions about basic biological concepts is not always addressed at the start of the semester, and these misconceptions would stay with the student if not dispelled (Novak 1998, 2010). The misconceptions need to be addressed, so new knowledge would be assembled by the student (Novak, 1998, 2010). In addition, students continue to struggle with basic concepts like osmosis and diffusion (Christianson & Fisher, 1999; Fisher et al., 2011; Odom, 1985; Zuckerman, 1994). The continue struggle with basic biological concepts has ramifications with students' understanding of

environmental issues, as students need to apply basic biological concepts to local environmental issues (Sobel, 1996, 2004).

Purpose and Research Questions

The purpose of this study is to test the effectiveness of connecting biology content to examples of local environmental issues within non-major introductory biology lectures in order to improve student understanding of biology concepts, develop environmental literacy in general, and promote environmentally positive behavior. The survey (Appendix A) is designed to collect data and information regarding attitudes about previous student experiences and interests in the environment. Also, the survey serves to determine where they obtained their current environmental knowledge as an indicator of their current level of environmental literacy.

This research study strove to answer the following questions:

Primary Question: Did exposure to local environmental issues linked to basic biology concepts affect non-biology major undergraduate students' level of environmental literacy?

Sub-question 1: Did exposure to local environmental issues affect students' awareness and attitude in an environmentally positive way?

Sub-question 2: What outdoor activities did undergraduate non-biology students experience within the last year to learn about environmental issues?

Sub-question 3: What social media did undergraduate non-biology students use to learn about environmental issues?

Sub-question 4: What secondary educational practices and activities did undergraduate non-biology students experience to learn about environmental issues?

Sub-question 5: What resources did undergraduate non-biology students use to learn about environmental issues?

With the use of a survey instrument, the researcher tests the impact(s) of the constructivist learning activities (independent variable - IV) on the possible changes in the knowledge, awareness, attitude and positive environmental behaviors of local environmental issues by participants (dependent variable - DV). The null hypothesis (H_o) states that teaching technique would not affect knowledge, awareness, and attitude between each of the classes tested. The alternative hypothesis (H_a) states that that teaching technique would affect knowledge, awareness, or attitudes between each of the classes tested.

$$H_o: = \mu_A = \mu_B = \mu_C$$

$$H_a: = \mu_A \neq \mu_B \neq \mu_C$$

The research study also tests the means between the control and two treatment groups with the use of in-class assessments (Class A – control; Class B – forum only; Class C – forum and discussion). With the in-class assessment (Appendix B and C), the researcher tests the affect(s) of the constructivist learning activities (IV) on the possible changes in the knowledge of local environmental issues by participants (DV). The null hypothesis (H_o) states that constructivist teaching activities would not affect knowledge between the classes. The alternative hypothesis (H_a) states that constructivist teaching activities will affect knowledge between the classes.

$$H_o: = \mu_B = \mu_C$$

$$H_a: = \mu_B \neq \mu_C$$

Research suggests that previous experiences would influence retention of knowledge as well as the assembly of new knowledge (Novak, 1989, 2010). Given the current state of environmental literacy within the U.S., it is hypothesized that creating a constructivist learning environment would enable students to use prior knowledge to assimilate new knowledge. To

this end, demographic information and specific survey questions is included to indicate the student's overall level of environmental literacy.

Research Timeline

Research occurred in two phases (Table 3.1). A pilot study is conducted to test research instruments and class activities. Adjustments are made to both, with the full research study occurring in the fall of 2014.

Table 3.1
Timeline of research study

Time Frame	Research Phase	Activities
Spring 2014	Pilot Study	Test survey instrument Test constructivist techniques Compare pretest and posttest assessments
Summer 2014		Analyze Pilot Study Run descriptive stats on demographics Adjust Full Study survey based on Pilot Study analyze
Fall 2014	Full Research Study	Pretest survey Constructivist activities Posttest survey Classroom assessments Collect and analyze data Interpret results

Research Design (Pilot and Full Studies)

The approach to this study (Figure 3.1) is the confirmatory quantitative research method and includes the statement of the hypothesis, data collection testing the hypothesis, and the analysis of the data (Johnson & Christensen, 2008, 2012). Quantitative data allows findings to be generalized across populations (Johnson & Christensen, 2008, 2012). The pilot study is conducted in the spring semester of 2014, with the full study conducted in the fall of 2014. The pilot study data collection, processing, and analysis is the same as that intended for the full

research study. The pilot survey results are analyzed and adjustments made to the survey instrument prior to administering it to the full dissertation study population (Babbie, 1990; Johnson & Christensen, 2008, 2012; Nardi, 2006; Reynold et al., 2009).

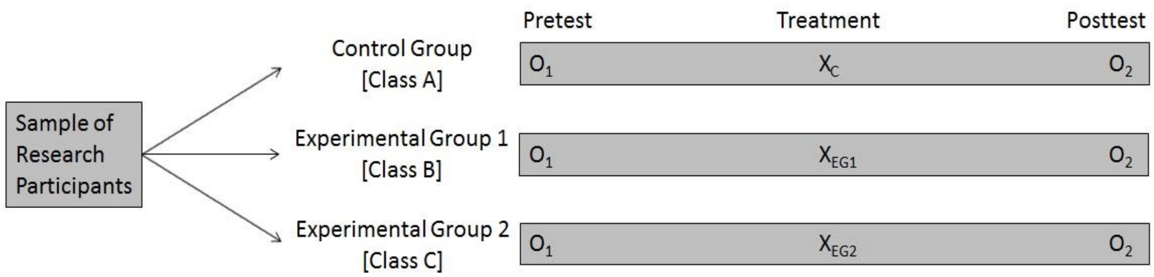

Figure 3.1: Experimental design flow chart modified from Johnson and Christensen, 2008, p 313.

Selection of treatment groups

Three non-major introductory biology classes are selected for this study. The classes are randomly assigned treatment activities prior to the start of the study: Class A (control), Class B (online forum only), and Class C (online forum and in-class discussion).

Classes meets twice per week (Monday/Wednesday) for the same amount of instructional time (75 minutes); students in an online class are included with Class B since they received the same instruction and treatment for the pre- and post-survey. All classes are given the same set of instructions for the pre- and post-surveys as well as a paper in-class assessment. Students are asked to volunteer for the research study. Students are allowed not to participate or are allowed to opt-out during the study without any negative impact.

Pre-survey and post-survey

The participants are given a pre-survey designed by the researcher to assess their current environmental knowledge, awareness, and attitude of local issues. The survey includes demographics and information regarding personal experiences within school and family settings.

At the end of the treatment, a post-survey was given. This design is meant to detect whether or not there was a change in knowledge, awareness, and attitude in the participants in response to the experimental treatment (e.g., constructivist activities). In-class assessments are used to measure knowledge and awareness after the post-survey assessment.

Students are given a pre-survey (Appendix A) through Google Documents prior to the start of formal instruction. The survey is given during class time and is taken on a computer or on their smart phone device. Researchers have indicated that the use of smart phones (mobile phones) in survey research resulted in a higher rate of participation as well as an increase in fully completed questionnaires (Vicente, Reis & Santos, 2009). By having students complete the pre- and post-surveys during the class time, it increases the likelihood of a higher return of student participation in order to generate meaningful results. The researcher is present to explain the nature of the study and addressed any questions or concerns. Once the student survey responses are collected they were downloaded and stored in a locked office cabinet as well as a password protected database. The submissions are also encrypted to protect the identity of the participants.

After twelve-weeks of instruction, students in all three classes complete a post-survey. The instrument contains the same questions pertaining to knowledge, attitude, and awareness and was in the same format as the pre-survey. Demographic questions are excluded since those were obtained during the pre-survey.

Description of treatment groups

Class A is the control group taught by another instructor within the Department of Biological Sciences. Students experience the traditional biology lecture class. Students are taught using the course textbook with instructor notes covering major topics. Examples are

taken from the textbook, which tends to be geared toward general issues. They are not exposed to additional resources or lecture materials.

Class B is Experimental Group 1 taught by the researcher. Students experience the traditional biology lecture class with the use of the textbook. They are also assigned articles and videos that linked biology concepts to local environmental issues through the forum tool in Moodle, a course management system used by the university. For example, students study osmosis and diffusion with the use of articles and videos pertaining to saltwater intrusion and its effects on the flora, fauna and wetlands loss. These additional resources are addressed in a constructivist approach through the online forums and assignments to make students responsible for using the materials. Class B are given in-class assessments based on the concepts covered in the forums as a follow up to the post-survey (Appendix B and C).

Class C is Experimental Group 2 taught by the researcher. These students experience the traditional biology lecture class with the use of the textbook. They also are assigned articles and videos through the forum tool in Moodle that linked biology concepts to local environmental issues. Additionally, Class C uses constructivist in-class discussion techniques to reinforce online forum assignments and to explain how basic biology concepts are linked to local environmental issues. Class C is given in-class assessments based on the concepts covered in the forums and in-class discussions as a follow up to the post-survey (Appendix B and C).

Ethical Considerations and Study Approval

The Institutional Review Boards at Louisiana State University, Number E8567, on November 19, 2013 (Appendix G) and Southeastern Louisiana University, Number 2014-091 on November 23, 2013 (Appendix H) is approved for this research study. The Human Subjects Verification certificate, number 1300945, issued on October 11, 2013 (Appendix I) is required

by both institutes prior to IRB approval. All participants volunteer to participate in the study. Prior to the start of the survey, instructions are given in writing with the survey as well as verbally by the researcher. The completion of the survey demonstrates a student's consent to participate. Participants also are asked within the survey, if they agreed to voluntarily participate (Appendix A). There is no penalty for a student choosing not to participate.

Population and Sample

The research is conducted at a southeastern regional institute which began as a junior college in 1925 and later became an accredited four-year university in 1938. There currently is five academic colleges with eighteen departments and forty-five undergraduate degree programs with a student population of 14,240 including 253 international students from 49 countries, as reported in 2012. The demographics for the student population are 62% female and 38% male. The ethnicity distributions are 69.5% white, non-Hispanic and 26.7% minority. The average ACT score are 22.4 (Southeastern Louisiana University, n.d.). The research study population sample also indicates the same demographic distribution as that of the university.

At the university, the study population consists of non-biology major undergraduate students who are enrolled in a first semester non-majors introductory biology course. The pre-survey instrument is used to collect demographic information (Appendix A). This also is important in determining the age of the participants. Students under the age of eighteen are excluded from the study.

Students are made aware that participation in this research project is strictly voluntary with the option to withdraw from the study at any time. Students are not penalized for not participating in the study. The class is part of the researcher's regular teaching schedule as a

faculty member within the Department of Biological Science. The control class is taught by another instructor as part of their regular teaching schedule in the same department.

For both the pilot and full dissertation research study, intact classes are used. Convenience sampling technique is used in the selection of students since entire classes are used for this study. Since participants are in a class, convenient sampling is also taking place (Babbie, 1990; Johnson & Christensen, 2008, 2012; Nardi, 2006). Students are conveniently present for the study (while in class), which Johnson and Christensen state is a non-random sampling technique (2008). Three undergraduate non-major introductory biology lecture classes are used for this survey research study.

Instrumentation

The online survey is created using Google Documents (Appendix A). The questions consisted of demographic information such as gender, age, home state and/or parish/county, secondary educational experiences and activities, as well as family experiences and activities. Students are asked their current area of study, educational and outdoor interests, environmental knowledge, awareness and attitude towards local environmental issues. Students also are asked to respond to items related to their use of social media as well as how involved they are with community volunteer activities.

The researcher developed the survey instrument, which initially consists of 60 questions. The pilot study (spring 2014) assists in scale reduction to address “survey fatigue’ (Pather & Uys, 2008) and improve reliability coefficient, as well as improving readability and addressing the skip logic issue associated with long surveys (Shepharda et al., 2011). The full dissertation survey (fall 2014) is reduced to 43 quantitative questions with three groups of questions using the five-point fully anchored Likert rating scale (strongly disagree, disagree, neutral, agree, agree

and strongly agree). Respondents also are given the option to indicate “I do not know”. Environmental questions consist of basic topics. One or more fundamental principles of biology are tied to each local environmental example through forum discussion and/or in-class discussion of examples within the classroom.

The survey contains several demographic questions as well as those pertaining to knowledge, awareness, and attitude about the environment. For the demographic questions, nominal (label/category) data is collected. The following categories represent the nominal data collected from the survey (Table 3.2).

Table 3.2
Demographic data collected

Demographic Type	Data collected
Personal Demographics	Age Gender Race/Ethnicity Education Level Degree Plan
Academic Demographics	Secondary Education: School type – public, private, other Academic interest/activities – clubs, competitions Courses – science class options, laboratories Environmental interest/activities - science class options, laboratories Community interest/activities – clubs, volunteer

Data questions are coded by category name. The questionnaire is divided into four categories based on questions focused on the respondents’ knowledge of, attitude towards, awareness of, and activity level in the local environment. The 5-point Likert-scale is fully anchored with the option choices of “strongly disagree”, “disagree”, “neutral”, “agree”, and “strongly agree”. Participants self-assessed their own level of knowledge, attitude, and

awareness. Although each item would be analyzed independently within this study, the interval data questions are coded into the following categories as indicated in Table 3.3.

Table 3.3
Survey data categories

Category	Examples of data
Wetlands (Environmental Issues)	Knowledge – content information (15b, 15m, 15p, 16d, 16e, 16g , 16o, 16q, 16s, 17f, 17g, 17i, 17l, 17p) Awareness – heard of (15c, 15d, 15g, 15i , 15j, 15l, 15q, 16b, 16i, 16p, 16t, 17c, 17h, 17n, 17o) Attitude – belief system (15a, 15f, 15h, 15r, 16f, 16h, 16m, 16r, 17a, 17d, 17m, 17r, 17s, 17t)
Knowledge Source for Environmental Information	High school - course College – course, forum, lecture Social Media News Family/Friends – discussion, outings/activities
Types of Activities student does and for how long	Educational – aquarium, botanical gardens, nature center, zoo Nature – beach, camping, fishing, hiking, hunting, horseback riding, photography picnicking Recreation – biking, boating, running, walking Sport – school, intramural

Class A, Class B and Class C complete the same in-class assessment after the completion of the post-survey instrument. Students are given the assessment with instructions and a series of questions pertaining to information obtained in the lectures, forums, and in-class discussions administered to their particular treatment (Appendix B and C).

Data Analysis

With the use of the demographics obtained from the survey, students would be categorized into homogenous categories based on high school experiences, geography, and

current educational status. Other demographics would also be noted like age, gender, and family experiences to determine differences among groups for descriptive statistics of the population. By sub-categorizing the respondents, this would assist with data validation (Kitchenham & Pfleeger, 2003).

Statistical package software, SPSS Statistics 22, is used for all the data collected for the pre- and post-survey as well as the in-class assessments. Probability sampling analysis is conducted in order to determine the total population, population mean, and population variance. Cronbach's alpha is used to test reliability of data collected standard error (Kitchenham & Pfleeger, 2003).

Data for the primary research question (and sub-questions) is obtained in the pre- and post-survey. In order to statistically control and explain variation in the dependent variable in pre- and post-survey experimentally designed studies, an analysis of covariance (ANCOVA) is recommended (ANCOVA, n.d.; Hinkle, et al., 2003) (Table 1, p. 12). Since intact classes are being used within this pre-and post-survey study, the pre-survey could be the covariant in an ANCOVA. The ANCOVA could allow for partial adjustments to preexisting differences between groups, which could increase precision by decreasing the error variance (Fields, 2012; Hinkle, et al., 2003; Johnson & Christensen, 2008, 2012). Covariants could be measured on an interval scale. The Likert-scale within this study could fit this description since the distance between each interval could be equal to each other (University of Central Arkansas, n.d.). This approach allows for statistical control of the dependent variable when there is variation (ANCOVA, n.d.; Field, 2012; Hinkle, et al., 2003; Tabachnick & Fidell, 1983). By using the pre-survey as the covariant in the ANCOVA, it allows all three classes to have the same starting point prior to the start of the experiment. It increases statistical power along with control and

reduced the probability of a Type II error (failing to reject a H_o, when it is false). When used appropriately, it meets the assumptions for both ANOVAs and ANCOVAs (ANCOVA, n.d.; Field, 2012; Hinkle, et al., 2003). The post-survey identifies changes in knowledge, awareness, and/or attitudes measured as the dependent variable. The primary independent variable is the constructivist learning activities.

For the in-class assessments, an ANOVA is used to compare the means between the samples of the same population. The ANOVA could test the difference between teaching techniques between Class A (control), Class B (forum treatment) and Class C (forum, in-class discussion treatment) and knowledge which also addresses the primary research question. It could also decrease Type I Errors which could reject a H_o, when it is true.

Since the ANCOVA is an extension of the ANOVA, the ANCOVA is still subject to the same assumptions as the ANOVA as well as two additional ones. The assumptions and how to test for them are (ANCOVA, n.d.; Field, 2012; Hinkle, et al., 2003):

1) Normality: Testing for normality is achieved through measurements of central tendency (mean, median, and mode), skewness and kurtosis for each DV. The use of probability plots, and the Shapiro–Wilk test could be the best power to give significance. If violated, increasing the sample size could correct this assumption.
2) Independence: Through convenience sampling, this could be achieved by having groups that were independent of each other. Convenience sampling was done in this study.
3) Homogeneity: The variance would be similar and could be tested using the Levene's test which could be done by using statistical software to conduct the ANCOVA. If

violated, the data could be transformed and a more robust test like Brown-Forsythe test.

4) Sample size: The sample size could contain more than 20 participants with Class A: *N* = 89; Class B: *N* = 100, Class C: *N* = 71. To increase power, the sample could be increased.
5) Outliers: The data could be checked for correct entry and for any unusual items. A box plot would be used to check for outliers. If violated, outliers could be removed from the data set with a record as to which data points are removed and the analysis rerun.

For the ANCOVA, there are two additional assumptions, they were as follows:

6) Linear relationship: If there is not a linear relationship and adjustments are made, the data could be biased. Checking the relationship between the DV and covariant early by using a scatter plot helps to reduce this.
7) Homogeneity of Regression: It is assumed that the relationship would be linear between groups with parallel slopes. This is confirmed with an F-test with a .05 level of significance. If this is violated, then there would be a relationship between the covariant and the IV and the covariant would not be used.

Effect sizes for ANCOVA would need to take into account overall measures (*r*-family) or specific contrasts or comparisons (*d*-family). The effect size would tell the degree to which a phenomenon exists as well as determine significance. It is the difference between two means where an increase in *n* would increase the chance of a significant result. Once the assumptions and size effect size is accounted for, the statistical tests could be run (ANCOVA, n.d.; Field,

2012; Hinkle, et al., 2003; Johnson & Christensen, 2008, 2012; Reynolds et al., 2009; Tabachnick & Fidell, 1983).

The steps to test the primary research question along with each of the sub-research questions are as follows (Hinkle, et al., 2003):

1) Stated the Hypothesis (H_o and H_a)
2) Set the Criterion for Rejecting the H_o: F with K – 1 and N – K – 1 degrees of freedom.
3) Computed the Test Statistics using a statistical software program.
4) Interpreted the Results: The post hoc test that could be used would be Tukey's for both the ANOVA and ANCOVA. Tukey's is a multiple comparison test that would assist in identifying means that are significantly different from each other. With the ANCOVA, there needs to be two adjustments. The first is with the sample means. The second adjustment is with the mean square within-groups.

Reliability and Validity

A pilot study prior to the start of the full dissertation research study is completed to test the validity of the instrument. A threat to validity is constructing an instrument that does not address the topic being questioned, known as construct underrepresentation. A second threat to validity is construct-irrelevant variance where questions are asked that were not related to the research itself (Reynolds, Livingston & Willson, 2009). Evidence is gathered to determine if the survey and in-class assessments had validity issues. Content validity is examined to determine that survey questions did represent questions designed to answer the hypotheses. A statistical software program is used to generate an analysis of variance. Also, reverse response is used to

test how participants are answering the questions (Babbie, 1990; Johnson & Christensen, 2008, 2012; Nardi, 2006; Reynolds, Livingston & Willson, 2009).

To gather evidence to support the validity of the internal structure of the survey/in-class assessment, a factor analysis is run through IBM SPSS Statistics 22. Homogeneity shows internal structure which is also run to meet the assumptions of ANCOVA. The pre- and post-survey control-group design decreases internal validity of the experiment and it also decreases the effects of history or maturation since the control group is the same effect (Johnson & Christensen, 2008, 2012). It is important to determine the validity of the instruments in order to support the accuracy and appropriateness of the test scores in interpreting the results.

Reliability is a concern when constructing the instrument. It is important to have consistent results from respondents, so it would be the experimental factor affecting change. To estimate the reliability of a test, the reliability coefficient is determined with the true score variance with the error variance. Test-retest reliability is used to test reliability through the statistical procedure of the correlation coefficient. The limitation is the carry over effect from the pre- to the post-survey, but the control group would have the same effect (Johnson & Christensen, 2008, 2012).

The coefficient alpha (i.e., Cronbach α) test is also conducted to insure that the survey addressed the research questions. Analysis reveals the errors by content sampling, but it also indicates the heterogeneity of the test content. With a Cronbach α of 0.70 or higher, reliability would be confirmed (Babbie, 1990; Johnson & Christensen, 2008, 2012; Nardi, 2006; Reynolds, Livingston & Willson, 2009). The pilot study results are used to increase reliability of the instruments prior to the administration of the pre- and post-survey as well as the in-class assessments. The data is used to make corrections and adjustments to the instruments.

Limitations

Since student participation is strictly voluntary, there is a concern for a low sample size in each of the three classes selected for this study. Students are able to drop out of the experiment at any time and are not required to answer every question. There are 116 students who participated in both the pre- and post-survey, Class A (control) has 40 students, Class B (online forum only) has 37 students and Class C (online forum and in-class discussion) has 39 students. Classes are also at different times of the day which would affect student performance (Class A – 12:30 PM, Class B – 9:30 AM, Class C – 11:00 AM). Since the survey is subjective, student perspective is affected by how students respond to questions concerning previous educational or family experiences in nature. As Novak (1998, 2010) suggested, students need to have an interest in order to learn.

There is concern that some students in a non-majors introductory biology class are simply not interested in local environmental issues or in promoting positive environmental behavior. There has also been concern in the reliability (Cronbach's alpha) and validity (reverse questions) of the survey instrument since it is developed for this study without prior use other than a pilot study.

CHAPTER 4
RESULTS

Overview

This quantitative study focused on the environmental literacy of non-biology major introductory undergraduate students. The quantitative data is collected through an online survey instrument using Google Docs. The pre- and post-survey data is collected into an Excel spreadsheet. The data is coded and organized into categories to address the primary research question along with the five sub-questions of the study. Students are also given in-class assessments to quantitatively measure knowledge of local environmental issues gained during the course: effects of osmosis on fish (Appendix B) and lighthouse erosion assessment (Appendix C).

The purpose of this study is to determine if constructive teaching techniques using basic biological concepts paired with local environmental issues would affect environmental literacy (i.e. positive environmental behavior) in undergraduate non-major biology students. The results of this study are addressed in this chapter.

Pilot Study

Overview of Instrument

In spring 2014, a pilot study is used to develop the research instruments (pre- and post-survey, in-class assessment). The pre-survey collects student demographics such as gender, age, race/ethnicity, educational level and degree plan. Student secondary academic and educational experiences are obtained: school type, academic interests, activities, and courses as well as community interests and activities. Students are asked what types of outdoor activities they participated in such as educational, nature, recreational, and sports and how much time they spent doing those activities within the last year. Students are asked 60 subjective questions

focused on environmental literacy: knowledge, attitude, and awareness. The post-survey includes the environmental literacy questions and the student's interest level in learning about environmental issues.

Demographics of Non-Major Biology Students

In the pilot study, 167 students are enrolled in three sections of a non-majors introductory biology course, but not all students participate in the study. Students are given the option to opt-out of the study or are removed by the researcher if under the age of eighteen. Of those participating in the pilot study, not all students complete all the assignments. Of the 105 who participated in the pre-survey, the distribution by class are as follows: 44 in Class A (control), 28 in Class B (forum only), and 33 in Class C (forum and discussion).

With regard to gender, 63.8% are females and 36.2% males. The distribution of males and females are similar in classes B and C. Class A have a larger gap between female and male students. The participants are largely 18-19 year olds (65.7%) and largely Caucasian (65.7%), while a significant number are African American 25.7%. The sample consists largely of Freshman (69.5%) and Sophomores (20.0%).

The majority of students in the pilot come from the arts (37.1%), humanities and social sciences (22.9%), and business (20.0%). Roughly 10% are education majors, 8% are nursing & health science majors, and 1% majored in science & technology. Business majors are heavily represented in the experimental classes (Class B and C) compared to the control class (Class A) which has more education majors. It is unnecessary to include student's major within their degree plan, so that question is eliminated.

Reliability and Validity of the Pre- and Post-Survey

Students answer 60 questions in the pre- and post-survey, which includes 23 knowledge questions, 18 awareness questions, and 19 attitude questions (Appendix A). A reliability analysis, Cronbach's alpha, is run to test the internal consistency of questions for both the pre- and post-surveys with questions grouped into four sets: entire question set [60 questions], knowledge questions, awareness questions, and attitude questions. As seen in Table 4.1, the results indicated that there was internal consistency within the instrument. Pre- and post-survey entire question set, knowledge questions, awareness questions, and pre-survey attitude achieves Cronbach's alpha (α) scores of 0.7 or higher, which indicates that there is internal consistency within the questions sets. With the post-survey attitude questions, Cronbach's alpha are lower compared to the other sets of questions, but remain within the acceptable range for internal consistency. No questions are removed from the pre- and post-survey attitude question set since the difference in the Cronbach alpha score are not large enough to justify removal.

Table 4.1
Cronbach's alpha of questions in the pre- and post-survey (Pilot Study)

	Pre-survey		Post-survey	
Questions: (number of items)	Cronbach's Alpha (α)	Cronbach's Alpha Based on Standardized Items	Cronbach 's Alpha (α)	Cronbach's Alpha Based on Standardized Items
Entire Set (*N*=60)	0.936	0.933	0.948	0.946
Knowledge (*N*=23)	0.921	0.921	0.918	0.917
Awareness (*N*=18)	0.837	0.837	0.858	0.855
Attitude (*N* =19)	0.720	0.714	0.787	0.782

Note: *N* = number of questions

To reduce the possibility of survey fatigue, 17 questions are removed: 9 from the 18 knowledge questions; 5 from the 19 attitude questions; and 3 from the 18 awareness questions. The remaining questions provide adequate coverage of the intended constructs (see Appendix A

for the survey instruments). The Cronbach's alpha (α) of the resulting scales are acceptable (Table 4.1).

The pilot study is conducted prior to the start of the full dissertation study tests the validity of the survey instrument, so the removal of survey questions is also due to redundancy in questions or not answering the primary research question or the sub-questions. Also, reverse response questions (15j to 15l, 16t to 17d; see Appendix A) is used within the survey instrument to test how consistently participants had answered questions. The reverse questions are recorded and a comparison of mean scores with ± standard deviations shows little difference (Table 4.2).

Table 4.2
Mean difference between reverse questions (15j to 15l; 16t to 17d) for validity

Question from survey (see Appendix A)	A (control) N = 40		B (forum only) N = 25		C (forum/discussion) N = 29		Sample Population N = 94	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
15j	3.15	1.49	3.12	1.30	3.14	1.25	3.14	1.36
15l	3.05	1.32	3.42	1.28	2.93	1.34	3.12	1.32
16t	2.38	1.86	2.00	1.83	2.60	1.63	2.35	1.78
17d	2.30	1.67	2.08	1.71	2.72	1.66	2.38	1.65

Note: *N* = number of participants; *M* = mean; *SD* = standard deviation

Data Analysis of the Pre- and Post-Survey (Primary Question for the pilot study)

Of the 57 students who participated in both the pre- and post-survey, Class A (control) had 19 students, Class B (forum only) has 21 students and Class C (forum and class discussion) has 17 students. An ANCOVA is initially planned, but the assumptions are violated such as outliers, normality, and homogeneity which make this data set unsuitable for the ANCOVA.

The Kruskal-Wallis H test analysis, a non-parametric test, is conducted on the pre-survey data sets (entire question set, knowledge questions, awareness questions, and attitude questions), which results in retaining the null hypothesis for all question sets. Since there are no differences

between classes with the pre-survey data question sets, the Kruskal-Wallis H test analysis of the post-survey question sets is run. With each of the questions set, the results indicate that there is a significant difference between Class A (control) and Class B (online forum only).

In-class assessment: land erosion of the Madisonville and Manchac lighthouses. At the end of the instructional period, 98 of the 167 students participates in the in-class assessment to measure their knowledge on the effects of osmosis with saltwater intrusion on wetlands in Lake Pontchartrain with 59 students in Class A (control), 17 in Class B (forum only), and 22 in Class C (forum and discussion). A descriptive comparison along with images of Manchac and Madisonville lighthouses in Lake Pontchartrain is given in regard to the effects of saltwater intrusion on erosion. Students are asked five questions that would apply their knowledge of osmosis and its effects on saltwater intrusion (Appendix C). Class A (control) is not exposed to this example, so their knowledge is gained just from lecture using basic non-environmental examples of osmosis. Class B is given this example through forum discussion only, so they are exposed to this example prior to the in-class assessment. Class C is given this example through online forum and in-class discussions, so they are exposed to this example through the forum and the classroom. The internal consistency of the assessment of the five questions is low with a Cronbach's alpha (α) score of 0.544 which makes it unreliable, but there is agreeableness subscale that consisted of two of the five questions ($\alpha = 0.879$) making those questions reliable for analysis. The in-class assessment is not altered since the subscale reliability is high and the sample sizes in the experimental classes (Classes B and C) are very low compared to Class A (control). The assumptions to the ANOVA are all violated, so this data is unsuitable for the ANOVA. The Kruskal-Wallis H test is also run which indicated no difference between classes, so the null hypothesis is retained.

Data Analysis of the Pre- and Post-Survey of Student Awareness and Attitude (Sub-Question 1)

Four questions in the pre-survey addresses student awareness and attitude in learning about environmental issues. The pre- and post- survey awareness and attitude questions show an acceptable reliability (Table 4.1). An additional question is evaluated in the pre- and post-survey in regard to their interest in learning about environmental issues. Based on mean differences, there is no change in awareness and attitude of students in their regard to learning about the environment.

Description of the Pre-Survey of Student Outdoor Activity Level (Sub-Question 2)

To determine outdoor activity levels, students are asked to indicate the amount of time spent outdoors weekly and to self-identify outdoor activities they participate in along with the amount of time spent on those activities over the course of a year (Appendix A – Questions 23 and 24 with 19 activities). A reliability analysis is run to test the internal consistency resulting in an acceptable Cronbach's alpha (α) score of 0.841.

Description of the Pre-Survey of Student Social Media Use (Sub-Question 3)

Five questions in the pre-survey address student awareness and attitude about social media. A reliability analysis is run to test the internal consistency of questions which resulted in an acceptable Cronbach's alpha (α) score of 0.710, but one question is removed from the pre-survey to reduce the total number pre-survey questions. Question 18, a social media question is altered since the original question allows students to type in their response. With 85 of the 105 participants not responding to the question, social media choices are added for students to select such as Facebook, Twitter, Tumbler, news/TV, and Instagram.

Description of the Pre-Survey of Student Secondary Education Practices and Activities (Sub-Question 4)

Students answer four questions in the pre-survey to address their awareness and attitudes toward learning about environmental issues. A reliability analysis is run to test the internal consistency of questions which resulted in a low Cronbach's alpha (α) score of 0.632. Three of the questions are removed to reduce the survey since internal consistency is improved.

Since the majority of students are freshman, a demographic question that originally is addressing college-level interests and activities are altered to address student activity levels and exposure to environmental education at the secondary level. Students also are asked a set of demographic questions about secondary academic competitions with their level of participation or having environmental science courses with their enrollment in them which is combined versus having them as separate questions.

Description of the Pre-Survey of Student Use of Other Resources (Sub-Question 5)

Five questions in the pre-survey addresses resources students attributed to their learning about environmental issues such experiences in nature, secondary biology class, local news, family, and friends. A reliability analysis is run to test the internal consistency of questions which results in a low Cronbach's alpha (α) score of 0.665. Although the removal of questions improves internal consistency, one question is removed from the pre-survey to reduce the total number pre-survey questions.

Full Study

Overview of Instrument

In the fall 2015 full dissertation study, students are given the revised pre- and post-survey based on the pilot study results. The pre-survey instrument collects student demographics, educational and environmental experiences, and 43 subjective questions focused on

environmental literacy: knowledge, attitude, and awareness with the use of Likert-scale which consisted of six possible responses (1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, 5 – strongly agree, 0 – I don't know, with some students choosing not to respond). The post-survey instrument includes 43-subjective questions about environmental literacy and the student's interest level in learning about environmental issues. The pre- and post-survey data is collected into an Excel spreadsheet. Students are also given two in-class assessments to quantitatively measure knowledge of local environmental issues during the course: effects of osmosis on fish (Appendix B) and lighthouse erosion assessment (Appendix C). Like in the pilot study, convenience sampling techniques is used to separate students into three classes for the full study: Class A (control), Class B (online forum only), and Class C (online forum and in-class discussion).

Demographics of Non-Major Biology Students

For the Full Research Study, there are 260 enrolled students in one of four sections (one online course was merged with Class B) in the non-majors introductory biology courses, but not all students participated in the study. Students are given the option to opt-out or are removed from the study if they are under the age of 18. Of those participating within the full study, not all students completed all the assignments. Of 188 who participated in the pre-survey, there are 59 students in Class A (control), 68 in Class B (online forum only), and 61 in Class C (online forum and in-class discussion). There are 116 students who participated in both the pre- and post-survey, Class A (control) has 40 students, Class B (online forum only) has 37 students and Class C (online forum and in-class discussion) has 39 students.

Gender. There are 53.7% females, 45.2% males, and 1.1% skipped the question in the sample population. Female students outnumber male students except in Class C where there are more male students than females (Table 4.3).

Table 4.3
Gender distribution percentage between each class and sample population

Gender	Class A (control)	Class B (forum only)	Class C (forum/discussion)	Sample Population
Female	74.6%	50.0%	37.7%	53.7%
Male	25.4%	48.5%	60.7%	45.2%

Age. With regard to age, 73.9% are 18-19 year olds, 12.2% are 20-21 year olds, 6.4% are 22-23 year olds, 1.1% are 24-25 year olds, and 6.4% are greater than age 25. The non-majors biology course are at the freshman level and it is expected that the majority of students are within the 18-19 age level as seen within each of the classes and sample population (Table 4.4).

Table 4.4
Age distribution percentage between each class and sample population

Age	Class A (control)	Class B (forum only)	Class C (forum/discussion)	Sample Population
18-19	74.6%	63.2%	85.2%	73.9%
20-21	13.6%	14.7%	8.2%	12.2%
22-23	6.8%	8.8%	3.3%	6.4%
24-25	1.7%	0%	1.6%	1.1%
< 25	3.4%	13.2%	1.6%	6.4%

Race/Ethnicity. The sample consists of 22.3% African American, 1.6% Asian, 68.6% Caucasian (White), 3.2% Hispanic, 0.5% Native American, and 2.7% other with 1.1 % preferred to not respond. This race/ethnicity trend is seen within each of the classes as well (Table 4.5).

Table 4.5
Race/Ethnicity distribution percentage between each class and sample pollution

Race/Ethnicity	Class A (control)	Class B (forum only)	Class C (forum/discussion)	Sample Population
African American	18.6%	25.0%	23.0%	22.3%
Asian	0%	2.9%	1.6%	1.6%
Caucasian (white)	71.2%	64.7%	70.5%	68.6
Hispanic	6.8%	1.5%	1.6%	3.2%
Native American	0%	1.5%	0%	.5%
Other	1.7%	4.4%	1.6%	2.7%
Prefer not to respond	1.7%	0%	1.6%	1.1%

Education level. The education level/college year of the sample is as follows: 65.4 Freshman, 25% Sophomore, 5.9% Junior, 2.79% Senior, and 1.0% other. Since this course is for non-major biology students at the freshman level, it is expected that the majority of the students would be freshman (Table 5.6).

Table 5.6
Educational level distribution percentage between each class and sample population

Educational Level	Class A (control)	Class B (forum only)	Class C (forum/discussion)	Sample Population
Freshman – Yr 1	54.2%	57.4%	85.2%	65.4%
Sophomore – Yr 2	37.3%	26.5%	11.5%	25.0%
Junior – Yr 3	6.8%	10.3%	0%	5.9%
Senior – Yr 4	1.7%	2.9%	3.3%	2.7%
Other	0%	3.%	0%	1.0%

Degree plan. The distribution with regard to major follows: 25.0% Arts, Humanities, & Social Sciences, 39.9% Business, 17.0% Education, 7.5% Nursing & Health Sciences, 3.2% Science & Technology, 3.7% other and 3.7% skipped question. Note that non-major biology introduction college students should not include the Colleges of Nursing & Health Sciences or Science & Technology; these students should be in a higher biology section. The majority of

students came from the arts, humanities, and social science, business and education degree programs as expected with business majors heavily represented in the experimental classes (Class B and C) is compared to the control class (Class A) having more arts, humanities, and social science majors (Table 4.7).

Table 4.7
Degree Plan distribution percentage between each class and sample population

	Class			
Degree Plan	A (control)	B (forum only)	C (forum/ discussion)	Sample Population
Art, Humanities & Social Studies	39.0%	23.5%	13.1%	25.0%
Business	23.7%	41.2%	54.1%	39.9%
Education	22.0%	20.6%	8.2%	17.0%
Nursing & Health Science	6.8%	4.4%	11.5%	7.4%
Science & Technology	6.8%	1.5%	1.6%	3.2%
Other	0%	4.4%	6.6%	3.7%
Skipped	1.7%	4.4%	4.9%	3.7%

Reliability and Validity of the Pre- and Post-Survey

The instrument for the full research study is based on results gathered from the pilot study. A reliability analysis is run to test the internal consistency of questions for both the pre- and post-surveys with questions grouped into four sets: entire question set [43 questions], 14 knowledge questions, 15 awareness questions, and 14 attitude questions (Appendix A).

The pre- and post-survey has a high level of internal consistency, as indicated by Cronbach's alpha (α) (Table 4.8). The data sets are within the acceptable Cronbach's alpha (α) with the exception of post-survey attitude questions. With the post-survey attitude questions, the removal of questions should not increase internal consistency Cronbach's alpha.

Table 4.8
Cronbach's alpha of questions in the pre- and post-survey (Full Study)

	Pre-survey		Post-survey	
Questions: (Number of items)	Cronbach's Alpha(α)	Cronbach's Alpha Based on Standardized Items	Cronbach's Alpha (α)	Cronbach's Alpha Based on Standardized Items
Entire Set (*N* = 43)	0.923	0.920	0.864	0.860
Knowledge (*N* = 14)	0.861	0.860	0.805	0.807
Awareness (*N* = 15)	0.810	0.812	0.716	0.712
Attitude (*N* = 14)	0.782	0.776	0.585	0.581

Note: *N* = number of questions

The full study includes reverse response questions (15j to 15l, 16t to 17d; see Appendix A) to address possible validity issues within the survey instrument. The reverse questions are recoded and a comparison of mean scores with ± standard deviations showed little change between the questions which indicates validity (Table 4.9).

Table 4.9
Mean difference between reverse questions in pre-survey (15j to 15l; 16t to 17d)

	Class							
Question from survey (see Appendix A)	A (control) *N* = 59		B (forum only) *N* = 68		C (forum/discussion) *N* = 61		Sample Population *N* = 188	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
15j	3.25	1.29	3.36	1.37	3.13	1.26	3.25	1.30
15l	3.23	1.28	3.41	1.40	3.02	1.33	3.22	1.34
16t	2.40	1.95	2.75	1.83	2.30	1.85	2.49	1.88
17d	2.15	1.89	2.50	1.89	2.32	1.66	2.34	1.81

Note: *N* = number of participants; *M* = mean; *SD* = standard deviation

Data Analysis of the Pre- and Post-Survey (Primary Question)

The primary research question for this study compares the effects of instructional methods of basic biology concepts to environmental literacy in students within the three classes through the use of pre- and post-survey as well as two in-class assessments to test students'

knowledge level. Of the 260 students originally are enrolled, 116 students did participate in both the pre- and post-survey, Class A (control) has 40 students, Class B (forum only) has 37 students and Class C (forum and class discussion) has 39 students. The null hypothesis (H_o) states that teaching technique would not affect knowledge, awareness, and attitude between each of the classes tested. The alternative hypothesis (H_a) states that teaching technique would affect knowledge, awareness, and attitude between each of the classes tested. To test the hypothesis, an analysis of covariance (ANCOVA) is used.

The assumptions for the ANCOVA are met with 1) continuous dependent variables, 2) independent variable is categorized with three independent groups, and 3) independence of observations. An analysis is conducted to test for outliers, normality, and homogeneity prior to running an ANCOVA with each of the data sets (i.e., pre- and post-survey entire question set, post-survey knowledge questions, pre- and post-survey awareness questions, pre- and post-survey attitude questions). After inspection of the boxplots for values greater than 1.5 box-lengths from the edge of each of the boxes, it is found that outliers were present. Data is checked for data entry or measurement errors; there is none. It is determined to leave the outliers within the data set since removal resulted in additional outliers.

As assessed by Shapiro-Wilk's test ($p < 0.05$), all question sets is violated the assumption of normality. Homogeneity of variances, as assessed by Levene's test ($p < 0.05$) for equality of variances, is also violated. With numerous violations of the assumptions, it is determined that an ANCOVA was not suitable which means that the analysis to the data sets are adjusted to a non-parametric test, the Kruskal-Wallis H test (Table 4.10).

Table 4.10
Instruments and analysis employed for each research question.

Research Questions:	Instrument	Analysis
Primary Question: Does exposure to local environmental issues linked to basic biology concepts affect non-biology major undergraduate students' level of environmental literacy?	Survey - Pre/Post Data In-class Assessment	Kruskal-Wallis H Test
Sub-question 1: Can exposure to local environmental issues affect students' awareness and attitude in an environmentally positive way?	Pre/Post-survey	Kruskal-Wallis H Test
Sub-question 2: What outdoor activities did undergraduate non-biology students experience within the last year to learn about environmental issues?	Pre-survey	Descriptive
Sub-question 3: What social media did undergraduate non-biology students use to learn about environmental issues?	Pre-survey	Descriptive
Sub-question 4: What secondary educational practices and activities did undergraduate non-biology students experience to learn about environmental issues?	Pre-survey	Descriptive
Sub-question 5: What resources do undergraduate non-biology students use to learn about environmental issues?	Pre-survey	Descriptive

The nonparametric test, Kruskal-Wallis H test, is run on the pre-survey data with each question set (i.e., entire question set, knowledge questions, awareness questions, attitude questions). The results indicate that the null hypothesis is retained with each of the data sets. This indicates that there is no difference between classes which allowed for the Kruskal-Wallis H test to be run on the post-survey question sets.

With the post-survey entire question set (Appendix A), the Kruskal-Wallis H test is run to determine if there is a difference between classes. As assessed by the boxplot, the distributions of average scores are similar for all groups. The median entire question set score differential are statistically significant between classes, $\chi^2(2) = 22.778$, $p = 0.000$. In the pairwise comparison with the post hoc analysis, a significant difference between Class A – control (*Mdn* = 2.72) and

Class B – forum only (*Mdn* = 3.22) (p = 0.000), and Class A (*Mdn* = 2.72) and Class C – forum and discussion (*Mdn* = 3.09) (p = 0.018) is shown, but not between Class B and C. Therefore, the null hypothesis is rejected and the alternate hypothesis is accepted.

With the post-survey knowledge questions (Appendix A), the Kruskal-Wallis H test is run to determine if there is a difference between classes. As assessed by the boxplot, the distributions of average scores are similar for all groups. The median knowledge question score differential is statistically significant between classes, $\chi^2(2) = 1.157$, p = 0.000. In the pairwise comparison with the post hoc analysis, a significant difference between Class A – control (*Mdn* = 2.71) and Class B – forum only (*Mdn* = 3.39) (p = 0.000), and Class A (*Mdn* = 2.71) and Class C – forum and discussion (*Mdn* = 3.14) (p = 0.023) is shown, but not between Class B and C. Therefore, the null hypothesis is rejected and the alternate hypothesis is accepted.

The Kruskal-Wallis H test was is to determine if there is a difference between classes with the post-survey awareness questions (Appendix A). As assessed by the boxplot, the distributions of average scores are similar for all groups. The median awareness question score differential is statistically significant between classes, $\chi^2(2) = 14.727$, p = 0.001. In the pairwise comparison with the post hoc analysis, a significant difference between Class A – control (*Mdn* = 2.93) and Class B – forum only (*Mdn* = 3.33) (p = 0.001), and Class A (*Mdn* = 2.93) and Class C – forum and discussion (*Mdn* = 3.20) (p = 0.043) is shown, but not between Class B and C. Therefore, the null hypothesis is rejected and the alternate hypothesis is accepted.

The Kruskal-Wallis H test is run to determine if there is a difference between classes with the post-survey attitude questions (Appendix A). As assessed by the boxplot, the distributions of average scores are similar for all groups. The median attitude question score differential are statistically significant between classes, $\chi^2(2) = 9.482$, p = 0.009. In the pairwise comparison

with the post hoc analysis, a significant difference between Class A – control (*Mdn* = 2.79) and Class B – forum only (*Mdn* = 3.11) ($p = 0.006$), but not between Class A (*Mdn* = 2.79) and Class C – forum and discussion (*Mdn* = 3.00) or Class B and C. Therefore, the null hypothesis is rejected and the alternate hypothesis is accepted.

In-class assessment: land erosion of the Madisonville and Manchac lighthouses. At the end of the instructional period, 135 of the 260 students participate in the in-class assessment (Appendix C) with 71 students in Class A (control), 28 in Class B (forum only), and 36 in Class C (forum and discussion). A descriptive comparison along with images of the Manchac and Madisonville Lighthouses in Lake Pontchartrain is given, in regard to the effects of saltwater intrusion on erosion. Students are asked six questions that would apply their knowledge of osmosis and its effects of saltwater intrusion on the environment (Appendix C). Class A (control) is not exposed to this example, so their knowledge is gained from traditional lecture using basic non-environmental examples of osmosis. Class B is given this example through forum only, so they are exposed to this example prior to the in-class assessment. Class C is given this example through forum and in-class discussion. The internal consistency of the lighthouse in-class assessment of the six questions is low ($\alpha = 0.708$). The deletion of items to improve Cronbach's alpha are not possible. Prior to running the ANOVA, an analysis is conducted to test for outliers, normality, and homogeneity with outliers. The assumptions are violated with outliers, normality with the Shapiro-Wilk's test ($p < 0.05$), and homogeneity with the Levene's test for equality of variances ($p < 0.05$), which is an ANOVA unsuitable to run.

The Kruskal-Wallis H test is run to determine if there is a difference between classes with the lighthouse assessment. As assessed by the boxplot, the distributions of average scores were similar for all groups. The median lighthouse assessment scores are statistically significant

between classes, $\chi^2(2) = 11.517$, $p = 0.003$. In the pairwise comparison with the post hoc analysis, a significant difference between Class A – control (*Mdn* = 0.33) and Class B – forum only (*Mdn* = 0.67) (p = 0.004) is shown, but not between Class C (*Mdn* = 0.5) or any other class combination. Therefore, the null hypothesis is rejected and the alternate hypothesis is accepted.

In-class assessment: effects of osmosis on fish. A second in-class assessment is given at the end of the instructional period with 127 of the 260 students participating (Appendix B) with 63 students in Class A (control), 28 in Class B (forum only), and 36 in Class C (forum and discussion). A scenario is given to students regarding what happens to fish, if placed in environments that are unfavorable to them such as freshwater versus saltwater aquariums. Students are asked eight questions that applies their knowledge of osmosis with the effects of saltwater on fish (Appendix B). Class A (control) are not exposed to this example in the traditional lecture. Class B is given this example through forum only. Class C is given this example through forum and in-class discussion. The internal consistency of the lighthouse in-class assessment of the eight items is high ($\alpha = 0.832$). With an unbalanced sample size, there is an increased negative effect that violated the assumptions of the ANOVA. Although ten outliers from Class A were removed, normality and homogeneity continues to be violated, so the ANOVA is not run.

The Kruskal-Wallis H test is run to determine if there is a difference between classes with the fish assessment (Appendix B). As assessed by the boxplot, the distributions of average scores are similar for all groups. The median fish assessment score differential is statistically significant between classes, $\chi^2(2) = 13.659$, $p = 0.001$. In the pairwise comparison with the post hoc analysis, a significant difference between Class A – control (*Mdn* = 0.33) and Class B – forum only (*Mdn* = 0.67) (p = 0.003), and Class A – control (*Mdn* = 0.33) and Class C – forum

and discussion (*Mdn* = 0.67) ($p = 0.0016$) is shown, but not between Class B and C. Therefore, the null hypothesis is rejected and the alternate hypothesis is accepted.

The Kruskal-Wallis H test shows that the null hypothesizes with the primary question (entire data set, knowledge questions, awareness questions, attitude questions and both in-class assessments) are rejected with the alternate hypothesis accepted. The data results indicate that there is a difference between the control (Class A) and experimental class (Class B – online forum only) or classes (Class B – online forum only, Class C – online forum and in-class discussion).

Data Analysis of the Pre- and Post-survey of Student Awareness and Attitude (Sub-Question 1)

Sub-question 1 for this study compares the effects of instructional methods of basic biology concepts on environmental literacy (knowledge, awareness, attitude) in students between three classes (Class A control, $N = 59$; Class B – online forum only, $N = 68$; Class C – online forum and in-class discussion, $N = 61$). To answer this question, students are given the pre- and post-survey. The null hypothesis (H_o) states that teaching technique would not affect awareness and attitude in an environmentally positive way. The alternative hypothesis (H_a) states that teaching technique would affect awareness and attitude in an environmentally positive way.

To test the hypothesis, an analysis of covariance (ANCOVA) is originally planned. Cronbach’s alpha (α) reliability analysis was run to test the internal consistency of the awareness and attitude questions for the pre-survey and post-survey, which indicates a high reliability except with the post-survey attitude questions (Table 4.8). As reported with the primary question data, the assumptions are all violated which means that the ANCOVA is an unsuitable test (Table 4.10) and the Kruskal-Wallis H test shows only a difference between classes with the post-survey question sets.

For Question 19 which will address the level of student of interest in learning about environmental issues, an analysis is run to test the assumptions for outliers, normality, and homogeneity prior to running an ANCOVA. After inspection of boxplots, an assessment by Shapiro-Wilk's test ($p < 0.05$) for normality, and Levene's test for equality of variances ($p < 0.05$) for homogeneity, it is determined that all the assumptions are violated making the ANCOVA unsuitable. Kruskal-Wallis H test is also run on both the pre- and post-survey data question, but the null is retained which indicates no significant difference between classes.

Although an ANCOVA is not appropriate for this data and Kruskal-Wallis H test indicates no significance between classes, mean differences with ± standard deviations indicatesa change in awareness between the pre- and post-survey responses as well as a difference between classes (Table 4.11). There is an increase in mean scores for Classes B and C with awareness of saltwater intrusion and hypoxia in Louisiana compared to Class A. Classes B and C also indicates an increase in mean differences compared to a decrease in mean scores in Class A with their awareness of Louisiana environmental issues. Overall, there is no change between the pre- and post-survey mean differences with Class A. For both Class B and C, students indicate an increase in awareness of Louisiana environmental issues.

Although an ANCOVA and Kruskal-Wallis H test is not appropriate for this data set, a comparison of attitude changes between classes of mean differences with ± standard deviations is used from the pre- and post-survey using the Likert-scale. Attitude questions show little-to-no increase in mean differences between the pre- and post-survey scores with all the classes (Table 4.12).

Table 4.11
Mean difference of pre- and post-survey attitude questions

		15c Salt-water intrusion is a major problem for Louisiana wetlands.			15g Hypoxia is a major problem within the coastal offshore Louisiana waters.			Average		
		Pre	Post	Dif	Pre	Post	Dif	Pre	Post	Dif
Class A	*M*	3.23	3.67	0.44	1.03	2.35	1.32	2.69	2.72	0.03
	SD	1.94	1.44	-0.50	1.63	1.98	0.35	0.93	0.74	-0.19
Class B	*M*	3.15	4.60	1.45	1.83	4.23	2.40	2.76	3.30	0.54
	SD	1.95	0.63	-1.32	1.88	1.21	-0.67	0.60	0.46	-0.14
Class C	*M*	2.95	3.89	0.94	1.56	3.62	2.06	2.62	3.12	0.50
	SD	1.84	1.54	-0.30	1.65	1.60	-0.05	0.75	0.58	-0.17
Sample Population	*M*	3.11	4.06	0.95	1.47	3.42	1.95	2.69	3.05	0.36
	SD	1.90	1.31	-0.59	1.74	1.78	0.04	0.77	0.64	-0.13

Note: *M* - mean; *SD* - standard deviation; Dif – mean difference

Table 4.12
Mean difference of pre- and post-survey attitude questions

		15r Restoring Louisiana wetlands should be a state concern.			16h Restoring Louisiana wetlands should be a national concern.			Average		
		Pre	Post	Dif	Pre	Post	Dif	Pre	Post	Dif
Class A	*M*	4.00	3.85	-0.15	3.44	3.85	0.41	2.54	2.76	0.22
	SD	1.28	1.55	0.27	1.59	1.16	-0.43	0.84	0.59	-0.25
Class B	*M*	3.98	4.50	0.52	4.00	4.28	0.28	2.84	3.12	0.28
	SD	1.49	0.78	-0.71	1.18	1.09	-0.09	0.53	0.45	-0.08
Class C	*M*	4.16	4.05	-0.11	3.51	3.95	0.44	2.70	2.95	0.25
	SD	1.12	1.35	0.23	1.43	1.29	-0.14	0.58	0.45	-0.13
Sample Population	*M*	4.04	4.14	0.10	3.66	4.03	0.37	2.70	2.94	0.24
	SD	1.30	1.28	-0.02	1.41	1.18	-0.23	0.67	0.52	-0.15

Note: *M* - mean; *SD* - standard deviation; Dif – mean difference

In Question 19, students are asked their interest in learning about environmental issues in the pre- and post-survey to reflect their attitude towards learning about the topic itself. Mean differences with ± standard deviations indicate that all classes have a slight interest in learning

about the environment, but very little-to-no change occur between the pre- and post-survey (Table 4.13).

Table 4.13
Mean difference of interest level between pre- and post-survey

Interest in Environmental Issues	A (control) Pre	A (control) Post	B (forum only) Pre	B (forum only) Post	C (forum/discussion) Pre	C (forum/discussion) Post	Sample Population Pre	Sample Population Post
M	3.41	3.56	3.85	3.78	3.49	3.57	3.59	3.64
SD	0.88	0.79	0.48	0.89	0.99	0.90	0.82	0.86

Note: *M* - mean; *SD* - standard deviation

Description of the Pre-Survey of Student Outdoor Activity Level (Sub-Question 2)

Sub-question 2 description of the amount of time non-major biology students spend outdoors between the classes (Class A control, *N* = 59; Class B – forum only, *N* = 68; Class C – forum and discussion, *N* = 61). The non-biology major students are given the pre-survey to evaluate their weekly activity level and type of activities (e.g., education, nature, recreation, sports) they engaged in within the past year.

In regard to the amount of time spend outdoors weekly, most students spend 1-5 hours outdoors (33.9%), followed by 32.3% spending 6-10 hours, to 19.9% spending 11-15 hours, to 8.6% spending 16-20 hours, and 2.7% spending 21+ hours. There are students (2.7%) who indicate not spending any time outdoors during the week.

When asked how much time students spend outdoors within four categories (education, nature, recreation, events) over the past year, the majority of students did not participant in outdoor activities. For the Outdoor Education category, the majority of students did not spend time at aquariums (60.8%), botanical gardens (91.4%), nature centers (75.3%), or zoos (59.5%). Of those students who did spend time engaged in Outdoor Education activities, the majority

spend 1-5 hours at an aquariums (35.5%), botanical gardens (7%), nature centers (19.4%), or zoos (26.5%).

For the Nature Activities category, the majority of students are not engaged in many nature activities such as camping, hiking, horseback riding, and hunting. The top nature activities with total outdoor hours were the beach (77.4%) and fishing (53.8%). As a whole, most students are not engage in any of the Nature Activity across the board.

For the Outdoor Recreational category, the majority of students spend more time biking (44.9%), boating (50.3%), running (66.8%), or walking (95.2%). There are still students who did not participate in outdoor recreational activities, but overall more students spend longer amounts of time engaged in these activities compared to education and nature activities. For the organized Outdoor Sports category, the majority of students (59.9%) spend time engaged in intramural sports with most of the students (64.7%) not participating in school sports.

In terms of outdoor experiences overall, students spend very little time engaged in nature or educational activities. The majority of their time spent outdoors is focused on recreational and sports activities with a large part of the sample population spending time less than five hours outdoors weekly.

Description of the Pre-Survey of Student Social Media Use (Sub-Question 3)

Sub-question 3 description of classes' use of social media on the environmental literacy of non-major biology students with local and national environmental issues. To answer this question, students are given the pre-survey to evaluate their use, awareness, and attitude of social media to learn about local and national environmental issues between the classes (Class A control, *N* = 59; Class B – online forum only, *N* = 68; Class C – online forum and in-class discussion, *N* = 61). Students answer four questions in the pre-survey to address their awareness

and attitude towards social media and the environment. A reliability analysis is run to test the internal consistency of questions which results in acceptable Cronbach's alpha (α) score of 0.765.

To make a comparison between types of social media students use to learn about environmental issues, they are asked to select which sources they use such as Facebook, Twitter, Instagram or other. A third of the students from each class did not answer this question. Of those that did respond, it is indicated that social media is used to learn about environmental issues with Facebook and Twitter (77.6%), followed by Instagram (57.8%), then other (44%). Each of the classes followed this same trend.

To make a comparison between classes in the pre-survey with each of the awareness and attitude questions concerning the use of social media, mean scores with ± standard deviations are used. All three classes indicate an unfavorable response to the use of social media to learn about environmental issues in Louisiana and less so about environmental issues nationally. The sample population also indicate that social media is not the best source for information and is not trustworthy (Table 4.14).

Table 4.14
Mean of social media use from the pre-survey

	Class							
Aspect	A (control) N = 59		B (forum only) N = 68		C (forum/discussion) N = 61		Sample Population N = 188	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Louisiana	2.83	1.39	2.59	1.41	2.60	1.21	2.67	1.34
National	2.77	1.49	2.68	1.41	2.71	1.27	2.71	1.39
best source	2.22	1.39	2.03	1.23	2.38	1.17	2.20	1.27
trustworthy	1.95	1.12	1.78	1.13	2.07	0.96	1.93	1.08

Note: N = number of participants; M - mean; SD - standard deviation

Description of the Pre-Survey of Student Secondary Education Practices and Activities (Sub-Question 4)

Sub-question 4 compares student high school demographics on the environmental literacy of non-major biology students with local and environmental issues. To answer this question, students are given the pre-survey to evaluate their activity level and exposure to environmental education along with their attitude and awareness towards learning about the environment in high school between the classes (Class A control, N = 59; Class B – online forum only, N = 68; Class C – online forum and in-class discussion, N = 61).

To make a comparison between classes with the attitude questions concerning their high school, mean scores with ± standard deviations are used from the pre-survey using the Likert-scale which consisted of six possible responses (1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, 5 – strongly agree, 0 – I don't know, with some students choosing not to respond). All classes (N = 186, M = 2.87, SD =1.35) indicate mean scores had ranged between 2.397 to 3.033 that represented a disagree-to-neutral response towards learning about biology and the environment in high school; Class A (N = 58, M = 2.40, SD = 1.52), Class B (N = 67, M = 3.12, SD = 1.26), C (N = 61, M = 3.03, SD = 1.15).

The high school demographics of the overall sample population indicate 24.1% students attended a private high school, 72.7% students attended a public high school, and 3.2% students attended 'other'. The majority of students in all three classes attended public high schools compared to a private school education with the distribution similar to the sample population.

When asked to indicate how often high school biology classes had hands-on lab activities, monthly labs (48.9%), is followed by weekly labs (30.1%), but the remainder of the students either did not know (9.1%), never had hands-on labs (9.1%), or claimed to not take a

biology class at all (2.7%). The same trend is seen in reviewing each class separately with most students having monthly lab activities except for Class B which had weekly and monthly labs.

With the use of the pre-survey instrument, students (39.2%) indicate their high school offered no academic science competitions, is followed by students (36.6%) not knowing if there were academic competitions offered, and the remainder of the students (24.2%), indicating there were academic competitions at their high school. When asked if they participated in academic science competitions, the majority of students did not (87.7%) with only 10.2% students participating and 2.1% not knowing if they participated or not.

For environmental education at the high school level, the majority of students (62.8%) said that local environmental issues were discussed in their science class. The majority of students (76.9%) said an environmental science class was offered at their high schools, but the majority of students did not take (57.8%) environmental science class.

Description of the Pre-Survey of Student Use of Other Resources (Sub-Question 5)

With the use of the pre-survey instrument, students indicate other sources used to learn about the environment. Students attribute their environmental information to personal experiences within nature as well as the local news compared to family and friends (Table 4.15). Although the mean scores with ± standard deviations can be used to compare where students accredit the other sources for their environmental information, the reliability of these questions was low with a Cronbach's alpha ($\alpha = 0.663$). Students indicate that their own experiences, followed by local news, then family and friends were sources for their environmental knowledge.

In regard to the time spent volunteering over the past year, most students spend time volunteering (69.5%) with the majority volunteering five hours or less (38.5%). As the volunteer hours increased, time spent by students volunteering decreased. For the sample population, there

is a large number of the students (30.5%) who did not participate in volunteering. This same trend is observed within each of the classes. For those students who volunteered to help improve the environment, the main activities are trash pick-ups (33.3%) and recycling (30.5%), but the majority of students (36.2%) did not participate in activities to improve the environment.

Table 4.15
Mean of other sources for environmental information in pre-survey

	Class							
Environmental information comes from:	A (control) N = 59		B (forum only) N = 68		C (forum/discussion) N = 61		Sample Population N = 188	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
own experience	3.14	1.31	3.47	1.60	3.30	1.27	3.31	1.41
local news	3.32	1.43	3.15	1.35	3.13	1.19	3.20	1.32
family	2.81	1.22	2.70	1.19	2.66	1.12	2.72	1.18
friends	2.44	1.38	2.36	1.16	2.28	1.03	2.36	1.19

Note: *N* = number of participants; *M* - mean; *SD* - standard deviation

CHAPTER 5
DISCUSSION AND CONCLUSION

Overview

The purpose of this research study is to determine if the use of constructivist teaching techniques, using basic biology concepts with environmental examples, would improve environmental literacy and promote positive environmental behaviors in non-major biology undergraduate students. Students are given a pre-survey to assess their current knowledge, awareness, and attitude towards environmental issues. It is believed that students can use prior knowledge (Fisher et al., 2011; Novak, 1981, 1998, 2002, 2010; Wandersee, 1985) to increase their depth and breadth of knowledge and understanding with constructivist learning techniques. A comparison is made between the control (Class A) which receives traditional instruction to that of the two experimental groups which receive a constructivist approach to instruction (Class B – online forum only; Class C - online forum and in-class discussion). A post-survey instrument is used to compare each population’s knowledge, awareness, and attitude after experimental treatment.

An in-class assessment is also given to follow-up with knowledge gained after the instructional period. Students are asked to assess the effects of saltwater intrusion on the fauna and flora of an ecosystem through online forums only (Class B) and online forums and discussion (Class C). In Clary and Wandersee's (2012, 2014) research, online discussion forums are used as an active learning tool for constructivist learning in college courses. Michael and Modell (2003) also indicate in their research that a constructivist teaching technique is used in traditional lecture classes.

Pilot Study

Discussion of the Survey Results

Population and demographics. A pilot study is conducted to develop and refine the research instruments with a pre- and post-survey and in-class assessment. The pre-survey collect the demographics of the non-major biology class which consist of mainly freshman level (69.6%), Caucasian (65.7%) female (63.8%) students in the 18-19 year old range (65.7%) who are working toward non-scientific degrees (80%). The majority of the pilot sample population has attended public high schools and indicated very little interest in environmental activities and courses. Most of their outdoor activities are school or recreation related with five-hours or less (62.9%) spent outdoors weekly. They indicate little-to-no interest in the use or trust of social media to learn about environmental issues. For their knowledge about the environment, they accredit personal experiences over other sources such as news, family or friends. The demographics give the researcher an overview of students' prior knowledge and experience which is based on secondary educational experiences as well as their variety of interests and level of activity outdoors.

The 60 question pre- and post-survey consist of 23 knowledge questions, 18 awareness questions, and 19 attitude questions, which are designed to address students' current knowledge, awareness, and attitude toward local environmental issues; and determine if exposure to these environmental issues are linked to basic biology concepts affected non-biology major undergraduate students' levels of environmental literacy. The 60 question pre- and post-survey has a high Cronbach's alpha (Table 4.1) for reliability and reverse questions indicate very little difference for internal validity (Table 4.2). As indicated in Chapter 4 results, the data sets violated the assumptions of the ANCOVA, so the Kruskal-Wallis H test is used. There are no

significant differences found between the classes in the pre-survey results, but there are differences found in the post-survey between Class A (control) and Class B (online forum only) within all data sets: entire question set [60 questions], knowledge questions, awareness questions, and attitude questions. Class C (forum and discussion) shows no difference between each of the other classes.

These results align with Clary and Wandersee's (2010, 2012, 2014) findings where online active learning techniques are useful, where students gain knowledge through active learning with the use of online forums. With the post-survey results with knowledge and awareness, Class B (online forum only) indicated a statistically significant difference compare to Class A (control), which indicate that this constructivist teaching approach did work with using basic biological concepts with local environmental examples to enhance student learning.

In-class assessment: land erosion at the Madisonville and Manchac lighthouses. The in-class assessment is designed to enhance knowledge gained in the course with meaningful (Novak, 1981, 2002, 2010; Novak & Wandersee, 1990) and active learning (Langer, 1997). Based on the statistical analysis, instructional methods did not result in a significant difference between Class A (control) compared to Class B (forum only) and C (forum and discussion). As an additional comparison, mean scores are used to compare classes with an increase from Class B (M = .34), to Class A (M = .42), to Class C (M = .49). Within the experimental classes, sample sizes are low for Class B (N = 17) and Class C (N = 22) compared to the control in Class A (N = 59). Although not statistically significant, this comparison shows that students who received online forum and in-class discussion instruction (Class C) benefit compared to traditional instruction (Class A) and online forum only (Class B), but students still struggle with applying basic biological concepts to local environmental issues.

Students in the pilot study indicate similar struggles with the in-class assessment with the concept of osmosis as seen in previous studies such as Odom (1985), Zuckerman (1994), and Fisher et al. (2011). While the null hypothesis is retained, which indicate no difference between classes, the mean score difference indicate that there is a benefit with the use of constructivist teaching.

The pilot study allows for changes to the survey instrumentation as well as better constructivist teaching techniques to apply to the full study.

Full Study

Discussion of the Survey Results

Population and demographics. For the full study, 260 students are enrolled in the non-majors introductory biology courses with 188 who participated in the pre-survey (Class A, N = 59; Class B, N = 68); Class C, N = 61). The pre-survey collects the demographics for the classes, which is similar to the pilot study. The sample population consist largely of freshman level (65.4%), Caucasian (68.6%), female (53.7%) students in the 18-19 year old range (73.9%) who were working towards a non-scientific degree (81.9%).

Discussion of primary question results. An ANCOVA is planned to analyze the primary question using the pre- and post-survey data from each of the data sets: entire question set, knowledge questions, awareness questions, and attitude questions.

The null hypothesis (H_o) states that teaching technique would not affect knowledge, awareness, or attitudes between each of the classes tested. The alternative hypothesis (H_a) states that teaching technique would affect knowledge, awareness, or attitudes between each of the classes tested. Although internal consistency is observed with each of the data sets except for post-survey attitude questions (Table 4.8) and validity is observed with reverse questions (Table

4.9), several assumptions to the ANCOVA are violated, such as outliers, normality, homogeneity and linearity within each of the data sets. Therefore, an ANCOVA is not run to address this question.

As stated in the Chapter 4, the pre-survey results for each of the data sets indicate no difference between classes, so the Kruskal-Wallis H test is used to determine if there was a difference between classes with the post-survey results (Table 4.10). With the entire question set [43 questions], knowledge questions, and awareness questions, the data analysis indicate that there is a significant difference between instructional methods between Class A (control) compared to Classes B (online forum only) and C (online forum and in-class discussion). There is no difference between the experimental classes (Class B and C). Therefore, the null hypothesis is rejected and the alternate hypothesis is accepted for each of those questions which show that constructivist teaching techniques do have a positive effect on the experimental classes.

With the 14 post-survey attitude questions (Appendix A), the Kruskal-Wallis H test indicate that there is a difference between Class A (control) and Class B (online forum only), but not between Class A and C (online forum and in-class discussion) or Class B and C. Therefore, the null hypothesis is rejected and the alternate hypothesis is accepted which shows that online forums have a larger effect on students compared to the control and the online forum with class discussion classes.

Within the experimental classes (Class B and C), students are exposed to the information linking biology concepts like osmosis to environmental examples such the effects of saltwater intrusion on fish and freshwater ecosystems. Class B is informed that they are responsible for making connections between basic biology concepts and local environmental examples through

the use of the forums. Class C is given online forum as well as in-class discussion; yet score poorly on this assessment compared to Class B. Class C also rates their attitude towards outside readings lower than that of Class B.

To make some comparisons between all the classes with each of the questions sets, mean scores are used to determine if there is a difference between the pre- and post-survey responses. For the 14 knowledge questions, Class A shows a difference in knowledge when comparing the two experimental classes (Class B and C) (Table 5.1). Although the difference in mean scores is not statistically significant, a shift is observed with the use of constructivist teaching techniques improving scores in the experimental classes. These results are supported by Clary and Wandersee's (2012, 2014) study with the use on online forums as a constructivist teaching technique.

As seen with the knowledge questions, the awareness and attitude questions also indicate a mean gain between the pre- and post-tests with the experimental classes (Class B and C) compared to Class A (control) (Table 5.1).

Table 5.1
Mean difference with mean gains of the pre- and post-survey between classes

Question		Class A (control)			Class B (forum only)			Class C (forum/discussion)		
		pre	post	gain	pre	post	gain	pre	post	gain
Knowledge	*M*	2.00	2.49	0.49	2.45	3.33	0.88	2.39	3.07	0.68
Awareness	*M*	2.68	2.72	0.04	2.76	3.30	0.54	2.61	3.12	0.51
Attitude	*M*	2.54	2.76	0.22	2.84	3.12	0.28	2.70	2.95	0.25

Note: *M* = mean; *SD* = standard deviation

For the 14 attitude questions, it is interesting to observe no real difference between all the classes with respect to their attitude towards environmental issues (Table 5.1). Kellert's (1985) and Kellert & Berry's (1987) previous research show that females tend to have more positive

environmental behaviors compared to males, but this study are not supporting those findings. It also is interesting that attitudes toward the environment are not increased more in this research study, since the majority of the study population is female (53.7%). This observation is especially interesting because of the differences sample population scores between male pre-survey means (M = 2.79) and post-survey means (M = 3.06) to female pre-survey means (M = 2.64) to post-survey means (M = 2.85). Although student attitude increases with both genders between the pre- and post-survey mean scores, the females remain disagreeable (M = 2) compared to males' neutral (M = 3) with their attitude towards the environment.

It is thought that exposure to environmental issues would increase environmental literacy (i.e. knowledge, awareness, and attitude) through participation in a positive learning experience with online forums to increase positive environmental behavior, as seen with Clary & Wandersee's (2010, 2012, 2014) studies. When asked to rank their attitudes about outside environmental readings using the Likert-scale (1-2 = disagreeable, 3 = neutral, 4-5 = agreeable), Class A remains negative (M = 2.50) to neutral (M = 2.95). For Class B, their attitude towards outside readings remain neutral in both the pre-survey (M = 3.28) and post-survey (M = 3.58). For Class C, their attitude decreases from the pre-survey (M = 3.11) to the post-survey (M = 2.95), which indicate a dislike for this activity. Overall, students appear to not find outside readings about the environment beneficial or a good use of their time.

Although the results are not statistically significant, the entire question set mean scores indicate a difference between the experimental classes (Class B and C) compared to the control (Class A). As indicated by Clarey and Wandersee (2010, 2012, 2014), online forums create meaningful and active learning experiences. Students in Class B and C benefit from using online forums to apply content to daily experiences and promote positive learning experiences with

improved knowledge through active learning. As Langer & Moldoveanu (2000) indicate in their study, students can actively process information to add new concepts to their knowledge. This also align with Sobel (1996, 2004), who holds that the use of local examples versus global examples can make learning more meaningful to the student.

Prior knowledge and active learning can add to the personal experiences of students (Fisher et al., 2011; Langer 1997; Novak, 1981, 1989, 2002, 2010; Wandersee, 1985); thus, improving environmental literary. Research findings indicate that students are not being exposed to environmental information through their outdoor activities, social media, secondary education or other activities like volunteering. The majority of the sample population (non-major biology students) is not engaged in formal or informal environmental educational experiences, so they are not expanding their knowledge, awareness, or attitudes which can increase environmental literacy. This is a focal point with researchers attempting to understand environmental literacy, where both formal and informal environmental activities are in decline, resulting in a decline in positive environmental behaviors (Coyle, 2005; Louv, 2005; Sobel, 1996). The trend seen in Coyle's (2005) work is observed in non-biology majors in an undergraduate introductory biology course.

In-class assessment: land erosion at the Madisonville and Manchac lighthouses. Students are asked to compare land loss around two lighthouses in Lake Pontchartrain. As a constructivist approach, Class B is given information regarding land loss due to saltwater intrusion (Appendix C) through an online forum with Class C receiving the same information along with in-class discussions. Class A (control) is not exposed to this information.

Because of violations to the assumptions of the ANOVA, the researcher used the Kruskal-Wallis H test, which indicates a statistically significant difference between the classes.

The null hypothesis (H_o) which states that teaching technique would not affect knowledge between each of the classes was rejected; therefore, the alternative hypothesis (H_a) is accepted which states that teaching technique would affect knowledge between each of the classes. The data indicates that there is a statistically significant difference between instructional methods with Class A (control) compared to Class B (online forum only). Class C (online forum and in-class discussion) is not statistically different between either Class A or B. Although not significantly different, Class C did indicates a gain in knowledge compared to Class A which shows that there is a benefit to the use of constructivist teaching techniques with online forums as well as in-class discussion.

Within the experimental classes, students are exposed to the information linking biology concepts like osmosis to environmental examples such as land loss around the Madisonville and Manchac lighthouses. Class B is informed that they are solely responsible for making connections between basic biological content with local environmental examples through the use of online forums. This findings support Clary and Wandersee's (2012, 2014) findings in that active learning with online forums do increase the knowledge level of the learner. Class B is able to connect local environmental issues to the concepts being studied in the class.

Class C is given online forum instruction as well as in-class discussion, yet scores poorly on this assessment compared to Class B. Class C also rates their attitudes toward the importance outside readings lower than that of Class B (Table 5.2). Class B remains positive between the pre- and post-survey with regard to the use of forums for linking biological content to environmental issue with an agreeable attitude mean score (Likert-scale, 4 = agree). Class C remains neutral (Likert-scale, 3 = neutral), but did decrease their attitude toward the online

forums. Class A remains disagreeable with the use of online forums (Likert-scale, 2 = disagree), but is not given forums during the study.

Table 5.2
Mean difference in attitude between pre- and post-survives with the use of forums in learning about environmental issues to biological content between classes

Use of Forums in Learning	A (control)		B (forum only)		C (forum/discussion)		Sample Population	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
M	2.89	2.90	4.05	4.00	3.70	3.43	3.56	3.45
SD	1.67	1.31	0.85	1.24	1.13	1.54	1.34	1.43

Note: *M* - mean; *SD* - standard deviation

In-class assessment: effects of osmosis on fish. With the in-class assessment of the effect of osmosis on fish, each of the classes is the same treatments as the previous in-class assessment (Class A – control, Class B – online forum only, Class C – online forum and in-class discussion). With the violations to the assumptions of the ANOVA, the Kruskal-Wallis H test is used and indicates a significant difference between the classes. The null hypothesis (H_o) states that teaching technique would not affect knowledge and awareness between each of the classes which was rejected; therefore, the alternative hypothesis (H_a) states that teaching technique would affect knowledge and awareness between each of the classes.

Based on the analysis, there is a statistically significant difference between instructional methods between Class B (forum only) and Class C (forum and discussion) compared to the Class A (control). The data indicates that students benefitted from constructivist instructional methods over traditional instruction when using environmental examples with basic biology concepts, as Ballantyne and Packer (1996) has found, when applying constructivist learning techniques within environmental education.

Although students in the experimental classes (Class B and C) are significantly different compared to the control; Class B and C indicates in their forum and in-class assessment responses (Appendix B) that they grapple with their explanation of the effects of osmosis. These finding are supported by earlier research (e.g., Christianson & Fisher, 1999; Fisher et al., 2011; Friedler et al., 1987; Meir et al., 2005; Odom, 1995; Sanger et al., 2001; Zuckerman, 1994) in that students continue to struggle with misconceptions and understandings of osmosis as a concept; like in this study, researchers uses constructivist teaching techniques to improve student knowledge of osmosis successfully, yet indicates students continued to have difficulty. Like Novak (1989, 2010) has shown in his findings, students in this study also attempt to create meaning with new information from their prior knowledge. In the forum responses (Appendix B), students use their past experiences fishing or around water to link to their new knowledge about osmosis and diffusion.

The findings from the primary question with in-class assessments supported Novak's (1989, 2010) and Langer’s (1997) findings in that the learner would need to have the desire or interest to learn, if learning was to take place. When reviewing student responses to online forums and in-class assessments within each of the classes (Appendix B, C, D); students indicate a poor attitude toward the use of learning about some of biological concepts such as photosynthesis, cellular respiration, and hypoxia. Within all classes, students struggle to use the proper terminology and make connections between osmosis, saltwater intrusion, and land loss; however, the data indicates that students benefit with constructivist instruction methods (Classes B and C) over traditional instruction (Class A) when using local environmental examples with basic biology concepts.

The findings align with other educational researchers in using constructivist teaching techniques for learning. For example, Ballantyne and Packer (1996) indicate that constructivist approach to environmental education is beneficial in improving environmental literacy, as indicated in these results. DiEnno and Hilton (2005) also conclude that constructivist teaching over traditional methods improved learning in students, which is consistent with the results of this study. DiEnno and Hilton also indicate a greater improvement with students who discuss topics, but that are not supported within this study. There is greater improvement with the experimental classes compared to the control; but when comparing the experimental classes to each other, data indicate that Class B (online forum only) outperforms Class C (online forum and in-class discussion) in knowledge, awareness, and attitude.

Discussion of the pre- and post-survey of student awareness and attitude (sub-question 1). Students answered 15 awareness and 14 attitude questions about environmental issues in the pre- and post-survey; and in a separate question, students are asked their interest in learning about environmental issues. The null hypothesis (H_o) states that teaching technique would not affect students' awareness and attitude in an environmentally positive way. The alternative hypothesis (H_a) states that teaching technique would affect students' awareness and attitude in an environmentally positive way. As discussed with the primary question and Chapter 4 results, an ANCOVA is not run for the pre- and post-survey awareness and attitude questions because of violations to the assumptions and low reliability. The Kruskal-Wallis H test results in no difference between classes, so the null hypothesis (H_o) is retained, meaning that constructivist teaching techniques did not affect the awareness or attitude of students to promote positive environmental behavior.

To make some comparisons between the classes with awareness and attitude, the mean differences between the pre- and post-survey questions are used (Table 4.11). After constructivist teaching techniques, it is interesting to see the average mean difference between the experimental classes (Class B, $M = 0.54$; Class C, $M = 0.50$) compared to the control (Class A, $M = 0.03$) with their level of awareness which shows that exposure to local environmental issues does improve awareness in the learner.

When comparing average mean difference in attitude, it is equally as interesting to observe no difference between any of the classes (Class A, $M = 0.22$; Class B, $M = 0.28$; Class C, $M = 0.25$). The comparison regarding student's interest in learning about environmental issues (Table 4.13), shows again, no difference observed with pre- and post-survey mean average difference between all the classes (Class A, $M = 0.15$; Class B, $M = -0.07$; Class C, $M = 0.05$). Student attitudes indicates no change toward positive environmental behaviors, with even a decrease observed in Class B; so student knowledge and awareness can increase, yet it does not mean that their attitude toward the issue will change.

These results is not supported an earlier study by Hungerford and Volk (1990), who said knowledge leads to awareness which will lead to attitude changes for students to develop more positive environmental behaviors. With attitude being a factor of environmental literacy, non-major biology undergraduate students indicate no change in attitude, so no change towards positive environmental behavior would occur.

However, this study did support the importance of attitude in influencing positive environmental behaviors; as indicated in Hines, Hungerford & Tomera's (1986, 1987) research, which observes that it was attitude that invokes change more so, than other factors. These results also reinforce Novak's (1998, 1990, 2002, 2010) and Langer's (1997) finding that indicate the

desire to learn can influence overall learning in students as well as their attitude. Students' attitudes are not influenced by an increase in knowledge or awareness of environmental issues as indicated when comparing the experimental classes to the control.

Description of the pre-survey questions (sub-questions 2-5). Students answer a series of subjective questions in the pre-survey to better understand their outdoor activities levels, use of social media, secondary educational experience and other sources students used to learn about the environment.

Outdoor activities (sub-question 2). Students are asked what outdoor activities they engage in within the last year as well as the amount of time spent outdoors weekly. Overall students spend very little time building experiences outdoors that pertain to increasing their environmental knowledge such as visiting aquariums, botanical gardens, nature centers or zoos; or to promote positive environmental behavior such as such as trash pick-ups, recycling, and tree planting. Although the majority of students indicate they spend 1-5 hours outdoors (33.9%) followed by students who spent 6-10 hours outdoors (32.3%), that time involve mainly recreational activities such as time at the beach (77.4%), running (66.8%) and/or walking (95.2%). This study indicated, like Louv (2005) and Sobel (1996, 2004), a decline in outdoor educational experiences, both formally and informally.

For those students who engage in environmental experiences, some students (38.5%) indicate that they spend five hours or less within the last year involved in environmentally-related activities; but, there is a large percentage of students (30.5%) who are not volunteering at all. This supports Weilbacker's (2009) findings in which students are less involved in outdoor activities. Within the pre-survey (Table 4.14), students attribute personal experiences as a source

for their environmental information, yet they spend very little-to-no time engaged in outdoor learning experiences or volunteering.

Social media use (sub-question 3). The sample population indicates that social media in general is untrustworthy, a poor source for environmental information, a poor source for learning about Louisiana environmental information, and a poor source for national environmental information (Table 4.14). Since many environmental and educational organizations use social media to get information to the public, it is interesting to observe the study participants' opinions about this information source. Although the use of social media is useful to improve the knowledge of environmental information, it is determined that students do not value this as a trustworthy source, making it an ineffective tool to use in teaching about environmental issues. This supports Keinonen et al.'s (2014) findings where students in Europe indicate the use of social media such as Facebook and Twitter as an unreliable source of information compared to school or other sources like newspapers, books, and television.

Secondary educational experiences (sub-question 4). To determine the previous science background of non-major biology students, secondary educational demographic is collected that indicate most student came from public high schools (72.7%), and experience monthly hands-on labs activities (48.9%). Students' attending private high schools tends to have more hands-on lab activities. Many public high schools did not offer science competitions to students, but those schools that did had very little participation from the non-major biology student (10.2%). Although students report that environmental issues are discussed in their biology class (62.8%), students indicate little-to-no interest in environmental issues as indicated in this study. The lack of academic activities and interest experienced by the sample population within this study supports the findings of Coyle (2005), Louv (2005), and Sobel (1996, 2004);

that, there continues to be a decline in the overall educational experiences which supports environmental literacy. Orr (1992) indicates that educators are viewing education as an inside activity versus as being outdoors.

Other sources of information (sub-question 5). Students are asked about other possible sources they use to learn about environmental issues. Although, their ratings are low-to-slightly negative (Likert-scale, 2 = disagree) or neutral (Likert-scale, 3 = neutral), students indicate they gain environmental information through personal experiences, followed by local news, then family and friends (Table 4.14). These findings align with Coyle's (2005) report, where he indicates that 83% of students obtain their environmental information from the media; which indicate that the general public gain their knowledge of environmental issues from news or weather stations. On the other hand, Coyle's (2005) study also state that 90% of learning about the environment occurred outside of schools, which did not support these findings since students are not seeking to learn more about the environment through their personal relationships or through personal experiences. Keinonen et al. (2014) also indicate that students found family and friends as unreliable sources for environmental information.

Study Limitations

Population

There are several limitations to this study. The sample population is not randomly assigned to classes, but is based on a convenience sampling technique (Babbie, 1990; Johnson & Christensen, 2008, 2012; Nardi, 2006; Teddlie & Tashakkori, 2009). Classes meet at different times of the day, which can affect student performance and/or responses between morning and afternoon time periods (Class A – 12:30 PM, Class B – 9:30 AM, Class C – 11:00 AM). Since participation is voluntary, students can opt-out at any time during the study or withdraw from the

course itself. This results in lower sample sizes with 260 original students in the full study population, but 188 students completing the pre-survey and only 116 students completing both the pre- and post-survey with 127 completing the in-class fish assessment and 135 completing the in-class lighthouse assessment. The sample population demographics also indicate that the majority of students are 18-19 year old, female, and Caucasian, which means low diversity compared to the general population.

Methodology

The survey is subjective, so the data relies on student perceptions regarding their current levels of environmental literacy, personal educational experiences, and use of social media, time spent outdoors, and the value of other sources for information. Since the study is quantitative, there is not a qualitative component that can be used to further explore student responses. Using a mixed method study can allow for follow-up questions to the survey to better understand the knowledge, awareness, and attitudes students had toward environmental issues. The post-survey results indicate low validity for student attitude, which may impact study results and conclusions.

One such issue is with social media, where students indicate that they did not use social media for environmental information. To follow up those questions, students can be asked how they do use social media, how much time they spend on social media, and how trustworthy it was outside of environmental issues. There are several articles indicating the benefits of social media in the classroom (Blaschke and Brindley, 2015), but a gap in the literature as to how students actually value its usage and trust.

Constructivist Teaching Techniques

Since the experimental classes did not show a significant difference between them, it would be beneficial to separate constructivist teaching techniques by having Class B (online

forum only) strictly use online instruction to link basic biology concepts with local environmental issues. Class C (online forum and in-class discussion) should not use online forums at all, but incorporate constructivists teaching techniques within the class directly such as in-class discussion environmental issues with the same materials used with Class B. This will allow for a clearer difference between Class B and C as to what constructivist teaching techniques work best for the non-major biology introductory college student.

Attitude and Interest Level

There is concern that students in a non-majors introductory biology class can simply not be interested biology in general, in local environmental issues, or in promoting positive environmental behavior. As Novak (1998, 2010) suggest, students need to have an interest in order to learn. This study indicates that students lack interest in environmental issues, which can influence constructivist learning activities used within the study. Student responses with online forums (Appendix B, C, D) and student opinion of teaching (Appendix E) indicate that some students did not value the constructivist teaching techniques despite the improvement observed between classes (control versus experimental classes).

Coertjens et al. (2010) indicate that school and instructors can influence student attitudes toward the environment positively. Although this study indicates a change with knowledge and awareness of environmental issues, attitude remained the same. In order for attitude to be influenced, additional time and/or teaching techniques is needed to promote the change versus working with students for 75 minutes at time, twice a week over a 16-week period.

Prior Knowledge

As several researchers indicate (e.g., Brownell et al., 2012; Lazarowitz & Lieb, 2006; Novak & Wandersee, 1990), prior knowledge with possible misconceptions need to be

addressed. In order to promote positive learning experiences through constructivist teaching activities, misconceptions need to be corrected and forgotten to assemble new information (Langer, 1997; Novak, 1998, 2010). Since this study focuses on linking basic biological concepts to local environmental issues to promote positive environmental behavior, there is not a baseline in determining what student's prior knowledge really is, so an objective based assessment can be beneficial. Questions asked are in statement form to address knowledge, awareness, and attitude regarding current environmental literacy. Students are not asked to define the basic terms used to determine if they understood what is being asked. After the pre-survey is given, students are asked to define some basic biological terms such as photosynthesis and cellular respiration. Student responses indicate a lack of knowledge regarding these concepts (Appendix F).

Conclusions

The majority of U.S. citizens are not demonstrating knowledge of, awareness in, or an attitude toward promoting environmentally positive behavior (Coyle, 2005). This study focuses on linking basic concepts to local environmental issues to promote environmental literacy and positive environmental behavior. Odom (1985), Zuckerman (1994), Christianson and Fisher (1999), and Fisher et al. (2011) all indicate in their studies that many college students continue to lack understanding of basic biological concepts, such as osmosis. Sobel (1996, 2004) suggests the use of local versus global environmental examples to make it more relevant to student learning. As a local Louisiana environmental example, the effects of saltwater intrusion on the flora and fauna is used to link osmosis to current environmental issues.

This study supports previous research in that students do continue to struggle with the concept of osmosis. Students are able to apply osmosis to the effects it has on fish, a single

organism; more so, than being able to apply it to an entire ecosystem such as land loss around the Manchac and Madisonville lighthouses. The control group (Class A) is not able to link osmosis to the two in-class assessments. The forum only class (Class B) is able to link the effects to osmosis to both fish and land erosion, but the forum and discussion class (Class C) is only able to make the connection with its effects on fish. The use of local environmental examples makes the concepts more relevant, as Sobel (1996, 2004) suggests, and student's prior knowledge of osmosis is enhanced with meaningful (Novak, 1981, 2002, 2010; Novak & Wandersee, 1990) and active learning (Langer 1997) through online forums and in-class discussion; all three classes are not able to explain or describe the overall effects of saltwater intrusion in the in-class assessments (Appendix B and C).

It is proposed that these positive learning experiences gained from online forums and in-class discussion can promote environmental interest and knowledge (Coyle, 2005; Clary & Wandersee, 2010, 2012). The improved knowledge, awareness, and attitude toward the environment can create an environmentally literate citizen, but the interest in wanting to learn need to be there, which is not seen within this sample population. The in-class assessments are based on online forum assignments with additional in-class discussion taking place for Class C only. Clary and Wandersee (2010, 2012, 2014) indicate that online forums are a useful tool to enhance student learning with positive learning experiences. Although there is a significant difference between the experimental classes and the control, many students do not view online forums as a positive learning experience, which contradicts the findings of Clary and Wandersee (2010, 2012, 2014). Although not part of the statistical analysis of this study since this is not a mixed method study, students' submitted responses demonstrate a poor attitude towards the environment as well as lack of understanding with the topic (Appendixes B, C, D, F). Students

also indicate on the course evaluation for the university that a negative aspect of the class was that the instructor talks too much about wetlands and global warming (Appendixes E).

Although positive learning experiences can promote interest to learn about the environment, which is an important aspect in the learning process (Novak 1981, 2002, 2010; Orr, 1992), this study indicate that students did improve their knowledge and awareness, but student attitude remain unchanged. Not all students view constructivist teaching techniques as beneficial, as see in students' responses and opinions (Appendixes B, C, D, E).

As Roth (1992) indicates in the levels of environmental literacy, nominal, functional, and operational; within each level, there are four stages (i.e., awareness, concern, understanding, and action) that determined the varying degrees the environmentally literate citizen have achieved. Students within this study are not achieving even the nominal level of environmental literacy by Roth’s standards, which includes being able to use basic terms to describe environmental concepts. As indicted earlier, all the classes in the study are not able to describe what was occurring with saltwater intrusion within freshwater ecosystems. Students also struggle with the use of proper terminology such as isotonic, hypertonic, and hypotonic. They are able to use simpler terms and descriptions to indicate what was occurring within fish and ecosystems (Appendix B and C).

The results of this study indicate that the non-major biology undergraduate student were not environmentally literate and generally showed a lack of interest in the local environmental issues presented as part of this study. While the post-survey results shows improvement between the classes, which results in an increase in environmental knowledge and awareness for the experimental classes compared to the control class, students within all three classes did not indicate a change in attitude nor indicate a change in positive environmental behaviors.

As part of defining individuals as environmentally literate, student attitude is considered equally important to that of knowledge and awareness. To invoke change, students would need to want to act in a positive manner toward the environment; since participants' attitudes toward environmental issues were unaffected, as demonstrated by the results of the pre- and post-survey, they would not be considered environmentally literate.

For positive environmental behavioral change, Hungerford and Volk's (1990) model shows that knowledge can lead to awareness, which can lead to action (behavior change), but this study indicates knowledge and awareness did not lead to change. Hines, Hungerford and Tomera (1986, 1987) said knowledge and skills are important factors for positive environmental change, but the personality of the individual and their desire to act is also important. Roth (1992) also recognized that citizens can be at different levels of environmental literacy depending on their engagement and knowledge of each environmental topic. This study re-enforces the importance of attitude of the student to promote positive environmental behavior as well as Novak's (1981, 1998, 2002, 2010) work with the importance of the learner wanting to learn. This can be the underlying theme in environmental education; through experiences comes learning since the learner has created a relationship with the topic of interest. Lack of interest in the topic can mean no difference in the learner towards positive environmental behavioral changes. Coyle (2005) identifies the lack of environmental literacy within the general U.S. population and this study has indicated the same within non-major biology undergraduate students. Although there is an increase in knowledge and awareness, attitude is also an important component for someone to be defined as environmentally literate. As discussed in limitations, students need to be exposed a variety of constructivist teaching techniques. Also, the limited amount of time within non-major undergraduate biology courses make it difficult to

promote change in attitudes from indifference to one that promotes environmentally positive behaviors.

Prior knowledge and active learning can add to the personal experiences of students (Fisher et al., 2011; Langer 1997; Novak, 1981, 1989, 2002, 2010; Wandersee, 1985); thus improving environmental literary. Research findings indicate that students are not being exposed to environmental information through their outdoor activities, social media, secondary education or other activities like volunteering. The majority of the sample population (i.e., non-major biology students) is not engaged in formal or informal environmental educational experiences so are not expanding their knowledge, awareness, or attitude which can increase its environmental literacy. This is a focal point with researchers attempting to understand environmental literacy, where the lack environmental activities both formally and informally is in decline, resulting in a decline in positive environmental behaviors (Coyle, 2005; Louv, 2005; Sobel, 1996). The trend seen in Coyle's (2005) work is observed in non-biology majors in an undergraduate introductory biology course.

Future Study

With the results indicating a significant difference between the experimental classes and the control with knowledge and awareness, it is be beneficial to determine why the experimental classes are not different significantly, with the forum-only class (Class B) outperforming the forum and discussion class (Class C). Instead of having forums as a component in both experimental classes, it can be interesting to have one class use the forum only approach and other class experiences a variety of constructivist activities within the classroom. It seems like Class C is dependent on the instructor to make connections between biological concepts with local environmental examples; whereas, Class B can make those connections themselves.

It may also be beneficial to have a baseline on students' understanding of basic terms like photosynthesis, cellular respiration, osmosis, and diffusion. Since the study addresses prior knowledge along with documented misconceptions with college students, it is useful to better understand what students currently know before applying constructivist teaching techniques. It is also interesting to survey the students on their knowledge, awareness, and attitude toward the environment at a later date to see if students retain this new knowledge and awareness.

It also can be interesting to add outdoor activities to the course such as marsh plantings, demonstrations by local experts, and using online experiences as “virtual fieldtrips” as Clary and Wandersee (2010) indicates. Since environmental literacy is dependent on invoking positive environmental behaviors in citizens, then establishing more outdoor activities (Coyle, 2005; Louv, 2005; Orr, 1992; Sobel, 1996) links to the environment would promote learning making it more meaningful (Novak, 1989, 2010) and mindful (Langer, 1997) for the learner.

A qualitative component can also be beneficial to better understand the student responses regarding the reliability of social media. There seems to be a gap in the literature about the use and benefits of social media on environmental education, yet every environmental organization uses social media to get their message out. The National Environmental Education Advisory Council (NEEAC, 2015) can also indicate their recommendations for future studies to include a social media component. The qualitative component would also be useful in gathering more information on student’s outdoor and secondary educational experiences.

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APPENDIX A: EDUCATIONAL RESEARCH SURVEY INSTRUMENT

Educational Research

Students in Ms. Michaelyn Broussard's GBIO 106-01 (M/W 9:30) are being asked to participate in a Louisiana State University dissertation research project. This educational research survey should take less than 20 minutes and is voluntary. Your response will not affect your grade or class standing in any way, but your cooperation and honesty is greatly appreciated.

The information you provide will be completely confidential, the coding list will be destroyed after the data is collected. The information gained from this survey or assessment will not be linked to your name at any time. If you have any questions regarding this survey, please contact Ms. Michaelyn Broussard (mbroussard@selu.edu).

Completion and return of this survey indicates voluntary consent to participate in this study along with the use of course assessments.

For information regarding your rights as a research participant, you may contact the Chair of the Institutional Review Board at (985)549-2077.

Your username (**email address**) will be recorded when you submit this form.
I am agreeing to participate in this survey research project and I am at least 18 years of age or older.

- Submit yes
- no

Enter the first 3 letters of your last name.

Enter the first 3 letters of your first name.

What type of high school did you attend?

- private
- no
- I do not know

If you attended high school in Louisiana, what parish did you graduate from (if not Louisiana, or what state)?

What year did you graduate from high school (or indicate if you have a GED)?

Did your high school participate in academic science competitions?

- yes
- no
- I do not know

Did you participate in academic science competitions?

- yes

- no
- I do not know

In high school, how often did you have hands-on labs with your biology science class?

- never
- weekly
- monthly
- I don't know
- I did not take a biology class

In high school, did you discuss local environmental issues in a science class?

- yes
- no
- I do not know

Did your high school offer an environmental science class?

- yes
- no
- I do not know

In high school, did you take an environmental science class?

- yes
- no
- I do not know

Indicate what types of extracurricular activities you did in high school (check all that apply).

- academic clubs
- arts (music, theater, choir ..)
- service clubs
- sports
- none

In regard to your views or current knowledge about the environment, please indicate your agreement or disagreement to the following statements.

	strongly disagree	disagree	neutral	agree	strongly agree	I do not know

	strongly disagree	disagree	neutral	agree	strongly agree	I do not know
I believe coastal Louisiana marshes should be restored.						
Wetland plants help to prevent coastal erosion.						
Salt-water intrusion is a major problem for Louisiana wetlands.						
Invasive species is a major problem in Louisiana wetlands.						
I feel it is too late to save the Louisiana wetlands.						
Hypoxia is a major problem within the coastal offshore Louisiana waters.						
My experience with nature allows me to understand environmental issues better.						
Social media has taught me about environmental issues in Louisiana.						
I am not aware of current Louisiana environmental issues.						
Nutria are a native Louisiana species.						
The effects of cellular respiration can be linked to hypoxia.						

	strongly disagree	disagree	neutral	agree	strongly agree	I do not know
I learned about environmental issues from the local news.						
Restoring Louisiana wetlands should be a state concern.						
I am aware of current Louisiana environmental issues.						

In regard to your views or current knowledge about the environment, please indicate your agreement or disagreement to the following statements.

	strongly disagree	disagree	neutral	agree	strongly agree	I do not know
I learned about environmental issues from my family.						
Native species can out compete invasive species.						
Hurricanes can help with hypoxia in the Gulf.						
Posting articles for discussion in Moodle, helps to link environmental issues with material I am studying in class.						
Wetlands improve water quality by filtering impurities out.						
Restoring Louisiana wetlands should be a national concern.						

	strongly disagree	disagree	neutral	agree	strongly agree	I do not know
I think salt-water intrusion is a problem in Louisiana						
Restoring Louisiana wetlands is not a state concern.						
Salt-water can affect the diffusion effect of an organism.						
Social media has taught me about environmental issues in the United States.						
Allowing the Mississippi River to flow into swamps and marshes helps build land.						
Fewer resources should go toward coastal restoration.						
Replanting cypress trees will restore a swamp.						
Salt-water intrusion is not a national problem.						

In regard to your views or current knowledge about the environment, please indicate your agreement or disagreement to the following statements.

	strongly disagree	disagree	neutral	agree	strongly agree	I do not know
Levee systems are not important in protection of neighborhoods.						

	strongly disagree	disagree	neutral	agree	strongly agree	I do not know
I believe I am well informed about local environmental issues.						
Salt-water intrusion is a national problem.						
Algae blooms in waterways indicate a healthy ecosystem.						
The Bayou Corne Sinkhole is a natural occurrence.						
Social media provide the best source for environmental information.						
Salt-water intrusion can cause dehydration in plant.						
Opening the Bonnie Carrie Spillway helps to help land in marshes.						
The Mississippi River needs to be levied.						
Linking the material we study in biology class to daily activity is difficult.						
I am aware of current United States environmental issues						
Invasive species compete with native species.						

	strongly disagree	disagree	neutral	agree	strongly agree	I do not know
Outside readings about environmental issues in biology are a good use of my time.						
Information on social media is trustworthy.						
I discuss environmental issues with my friends.						

If you use social media as a source for environmental information, please list which groups you follow (check all that apply).

- Facebook
- Twitter
- Instagram
- Other:

	Strongly disinterested	Disinterested	Neither	Interested	Strongly interested
Please indicate the level of interest you have in environmental issues.					

o

Indicate what types of extracurricular activities you do/plan to do at the college-level (check all that apply).

- academic clubs
- arts (music, theater, choir ..)
- service clubs
- sports
- none

How many times in the past year have you volunteered in your community?

- none

- 1-5
- 6-10
- 11-15
- 16-20
- Other:

If you have volunteered to improve the environment, please indicate what activities you participated in within the year (select all that apply).

- trash pick-up
- recycling
- planting trees
- raising funds
- never
- Other:

How many hours do you spend outdoors in a week?

- none
- 1-5
- 6-10
- 11-15
- 16-20
- Other:

Within the last year, how much time did you spend on the following activities (please answer each one).

	none	1-5 hours	6-10 hours	11-15 hours	16-20 hours	21 or more hours
Aquarium exhibits						
Beach						
Biking						
Boating						

	none	1-5 hours	6-10 hours	11-15 hours	16-20 hours	21 or more hours
Botanical Garden						
Camping						
Fishing						
Hiking						
Horseback Riding						
Hunting						
Outdoor Nature Center						
Outdoor photography						
Picnicking						
Recreational sports						
Running						
School related sports						
Theme Park						
Walking						
Zoo						

What is your gender?

- male
- female
- prefer not to answer

What is your current age?

- 17 or under

- 18-19
- 20-21
- 22-23
- 24-25
- Other:

What is your race/ethnicity (select the one with which you most identify)?

- African American
- Asian
- Caucasian (White)
- Hispanic
- Native American
- Pacific Islander
- Other
- I prefer not to respond

What is your current educational level?

- freshman
- sophomore
- junior
- senior
- non-degree
- I prefer not to respond

What is your current college?

- Arts, Humanities, and Social Sciences
- Business
- Education
- Nursing and Health Sciences
- Science and Technology
- Other:

Is this your last biology course?

- yes
- no
- I don't know

Send me a copy of my responses.

APPENDIX B: FORUMS AND IN-CLASS ASSESSMENTS OF EFFECTS OF OSMOSIS ON FISH

Forum 2

Cells:

http://www.sciencedaily.com/releases/2010/04/100427171800.htm
http://www.sciencedaily.com/releases/2010/09/100913093038.htm

- These articles are very different from each other, yet deal with metabolism/cells/cell structure.
- How do they fit into what you are currently studying?

Cell Phone:

- Surprised? Does this change your cell phone hygiene?

Osmosis/Diffusion: - see attachments to address questions

http://indianapublicmedia.org/amomentofscience/do-fish-drink/

- How does osmosis affect fish?
- How does diffusion affect fish?
- What does this have to do with Louisiana wetlands/plants?
- Does this help you understand osmosis and diffusion with local environmental issues - why/why not?

Conservation:

http://www.storyofstuff.org/movies-all/story-of-stuff/

- What did you think about the video?
- Are you guilty of buying and dumping?
- What can you do about or do you really just not care - why/why not?
- Can this effect our local environment - why/why not?

Add a new discussion topic

Discussion	Started by	Replies	Unread ✓	Last post
Forum 2	[redacted]	0	0	[redacted] Wed, Nov 19, 2014, 12:19 AM
Forum 2	[redacted]	0	0	[redacted] Tue, Nov 18, 2014, 11:23 PM
[redacted] forum	[redacted]	0	0	[redacted]

Moment of Science

HOME PODCASTS ARCHIVES ABOUT CONTACT

Do Fish Drink?

By JEREMY SHERE
Posted December 27, 2012

Like 325 people like this.

Fish live in water, but do they drink it?

Listen Now: Do Fish Drink? -2:01

Photo: Seven Pillars Lord Abbaddon (Flickr)

Water enters a fish's body through osmosis, which is when water diffuses from a higher to a lower concentration.

Photo: Seven Pillars Lord Abbaddon (Flickr)

Water enters a fish's body through osmosis, which is when water diffuses from a higher to a lower concentration.

Fish do drink water, but how they consume it depends on where they live. Water gets into a fish's body through osmosis, the process in which water diffuses from a higher to a lower concentration.

For example, if there is more water outside of a cell than inside, water will try to flow into the cell until there is the same concentration of water on either side of the cell's membrane. The body of a fish acts the same way, either absorbing or losing water depending on its surroundings.

Kidneys At Work

Whether a fish absorbs or loses water is based on the fact that all fish must maintain a certain amount of salt in their bodies to stay healthy. Fish that live in fresh water have a higher concentration of salt in their bodies than the surrounding water.

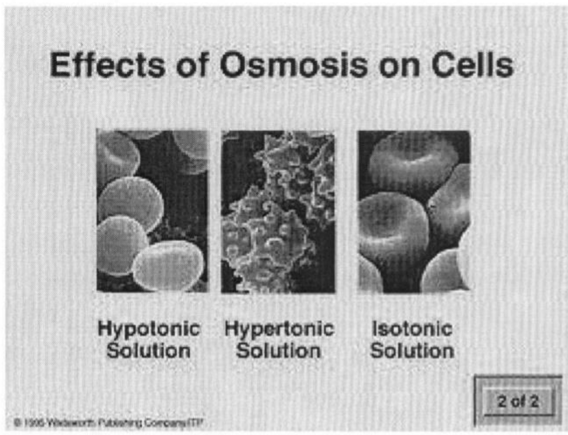
Consequently, water continuously flows into the fish's body to attempt to dilute the amount of salt in the fish until it is equal to the amount of salt in the surrounding water. Since fish cannot allow their salt content to be diminished, their kidneys work overtime to expel excess water in the form of urine.

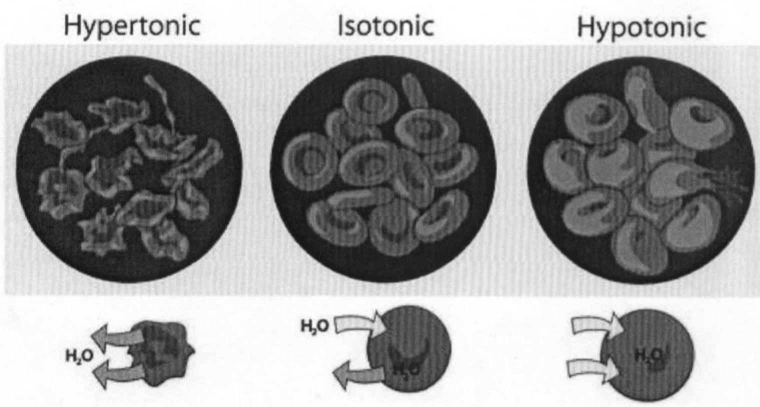
Salt Water Fish

Ocean fish have the opposite problem. Surrounded by salt water, their bodies contain a relatively lower concentration of salt than the ocean water. In this case, osmosis causes the fish to constantly lose water in order to equalize salt concentration inside and outside the fish.

To partially compensate for the water loss, ocean fish actually drink water through their mouths. To get rid of the excess salt they take in by drinking seawater, they excrete some salt through cells in their gills.

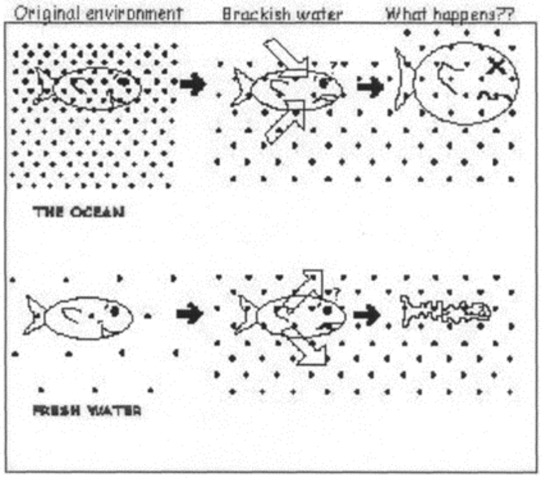
Effects of Osmosis and Diffusion on Blood Cells



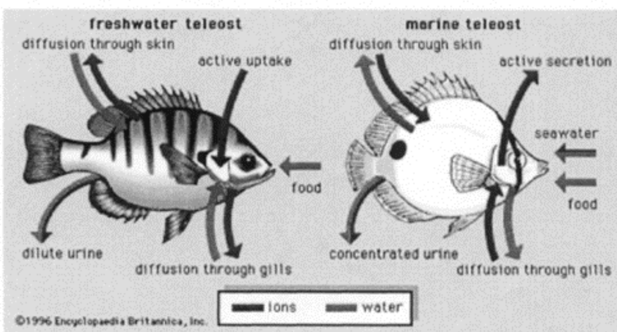


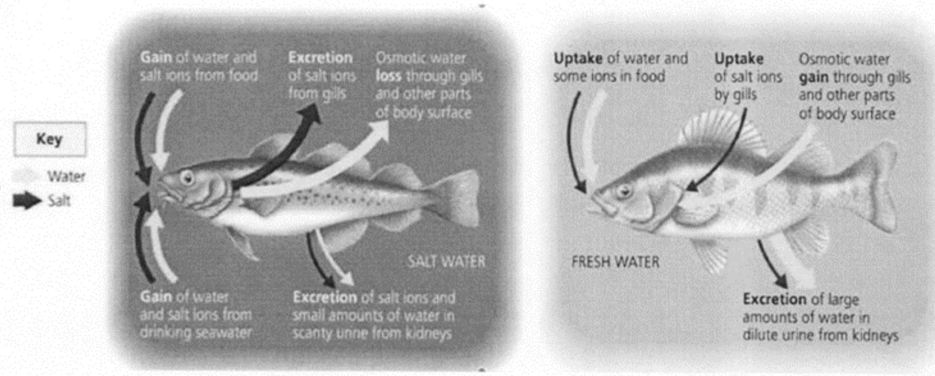
Red blood cells: http://www.kitsforkids.com/blog/2011/01/why-cant-saltwater-fish-live-in-fresh-water/

Effects of Osmosis and Diffusion on Fish

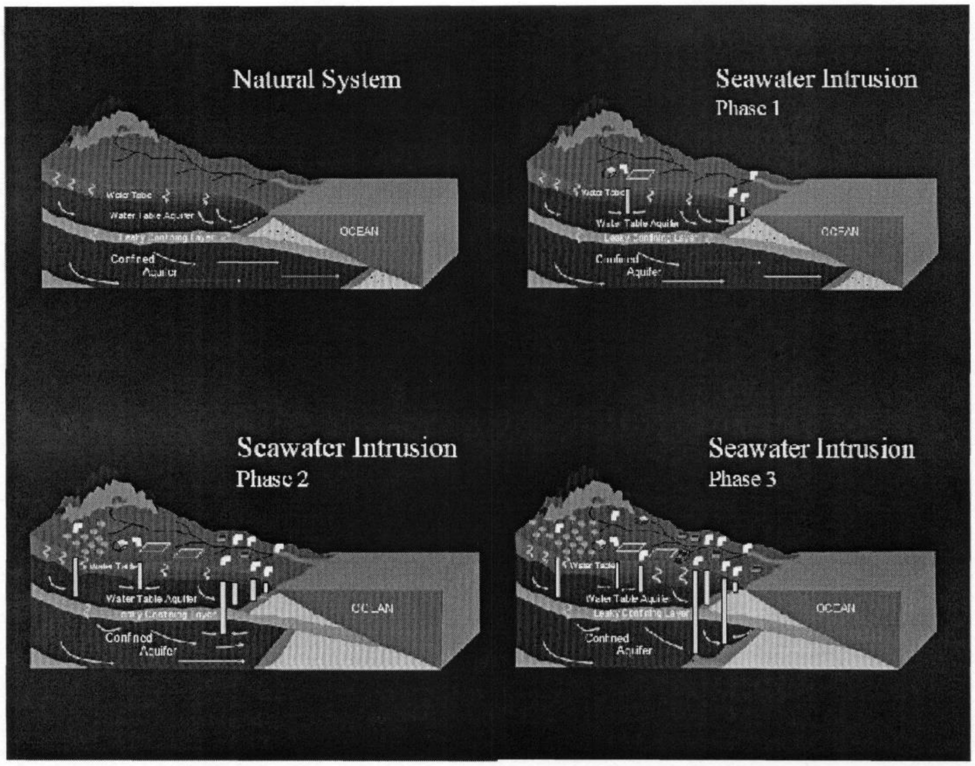


http://83.241.146.15/Heurika/Projekt/Neapel/Napoli04/essays/baltic.htm





Effects of Osmosis and Diffusion on Coastal Wetlands



http://kanat.jsc.vsc.edu/student/spatafora/setup.htm

Forum Assessment Student Responses

My [redacted] *2148_GBIO106_01* [redacted] Forums with [redacted]

Search forums

Forum 2

File download ▾ Display replies in nested form ▾

Export whole discussion to portfolio

[redacted] Forum 2 post
Sunday, September 28, 2014, 3:19 PM

[redacted] Forum 2 post

Cells:

The two posts fit into what we are studying in that they deal with energy, internal constancy, and mutation. The obese children's metabolism affects the drug that goes into their bodies differently than children who are of healthy weight. The second article deals with protein in the body, more specifically, the negative transformations a protein can undergo.

Cell Phone:

I now know never to share my cell phone with a stranger. I did not know that Herpes could be spread via cell phone. Hopefully, I will clean my cell phone regularly.

Osmosis/Diffusion:

Osmosis affects fish constantly by forcing out water through their gills to maintain internal constancy. Diffusion works the same way by maintaining internal constancy through urinating. The abundance or lack of salt in the water can affect the ecosystem by killing off a population and disturbing the food chain. This does not help me understand local environmental issues. I do not know how this even relates to environmental issues in Louisiana.

Conservation:

The video was terrible. Words cannot express my disdain for that video. Since I live in the West, I am always going to be accused of wasting and consuming. There is nothing I can do to change the way the 'cycle' operates. Nobody has taught me how to make renewable energy, so how am I supposed to 'change the world'? The local environment can always be affected by anything, but in St. Tammany parish, which is the wealthiest parish in the state, money can afford any repair in the environment.

[redacted]

Edit | Delete | Reply | Export to portfolio

My [redacted] *2148_GBIO106_01* [redacted] Forums with [redacted]

Search forums

Forum 2

File download ▼

Display replies in nested form ▼

Export whole discussion to portfolio

Forum 2- 9:30-10:45 [redacted]
by [redacted] - Tuesday, September 30, 2014, 11:05 PM

Cells:
Energy and mutation is the combination of the 2 post and what we are studying.Based on metabolism the drug will affect fat kids more than in shape kids. Negative process of protein is what the second article has to deal with.

Cell Phones:
Im going to start being careful with whoever touches my phone from now on. Herpes can spread through cell phone contact. I will keep a bottle of germ-x on me from now on.

Osmosis and Diffusion:
Fish are affected directly by osmosis by forcing water through their gills. Diffusion works the same way but remains constant by the urination. The salt in water keeps the population afloat, with out it everything can change by killing some animals. Since i fish a lot i know the importance of water.

Conservation:
I didn't really like the video. Im guilty of doing this. Noone is going to do anything about it either until its to late or something has to be done. Thats just the way society is.

[redacted]

Edit | Delete | Reply | Export to portfolio

My [redacted] *2148_GBIO106_01* [redacted] Forums with [redacted]

Search forums

Forum 2

File download ▼ Display replies in nested form ▼

Export whole discussion to portfolio

[redacted] Forum 2
by [redacted] - Tuesday, September 30, 2014, 2:19 AM

Cells:
We learning about cell growth and metabolism. The first article shows how drugs affect the metabolisms of a healthy child and obese child differently. The second article shows how a cell recycles themselves to grow and develop more.
Cell Phone:
I wasn't really surprised because germs are everywhere but i didnt what could be passed by letting someone use my phone. I regularly clean my phone since the touch screen wont work correctly if it too dirty but ill make sure to disinfect it more often.
Osmosis/Diffusion:
Osmosis is used by the gills the filter water in and out of their body. Diffusion helps keep the fish's salt concentration greater on the outside of their body. This does help me understand about osmosis and diffusion and how they wetlands are not very healthy areas for fish to live in.
Conservation:
Its something I've heard thousand times but I don't one video will change anything. I am guilty of buying and dumping bu everyone is and its hard to stop habits especially if its a habit a majority of people take part in. I care but then again I don't because i wont go out of my way to recycle of re use something but if i see the chance infront of i will. Yes then can effect local environment because our natural resources are being used up faster then they can replenish and that mean we are running the earth dry of materials we need for everyday life.

[redacted]

Edit | Delete | Reply | Export to portfolio

My [redacted] *2148_GBIO106_02* [redacted] Forums with [redacted]

Search forums

Forum 2

File download ▼ | Display replies in nested form ▼

Export whole discussion to portfolio

Forum 2
by [redacted] - Wednesday, October 1, 2014, 9:20 AM

Cells- Both articles deal with some form of cell growth whether it is metabolism rate in 16 obese children versus 9 normal weight children and that how protein and amino acids in cells affect one's metabolism and how a cell functions properly.

Cell Phone- I am not as surprised as I should since most everyday items has just as much germs and bacteria as the next, but it is informative enough for me to at least clean my phone on the regular.

Osmosis is the primary means of how much water passes through a fish; similar to how osmosis works with cells. A fish absorbs or lose water depending on its surroundings. Diffusion affect fish due to how much of salt is passed through a fish in salt water. The water in the LA wetlands have a lower concentration of salt in the water than inside a fish causing water to enter the fish to equalize the amount of salt in the fish and surrounding water. This cause the fish kidneys to work overtime to get rid of excess water. Yes because the more people destroy the wetlands chemically, it can alter the chemical compounds of fresh water causing defects in osmosis in fish.

Conservation- That our days are numbered here on earth due to unnecessary extraction of resources, increase of air and consuming toxins; pollution, unnecessary buying, increase in cancer, and changing of the climate. I am guilty of dumping because I can not physically make garbage disappear into thin air or take it somewhere in driving distance to dispose of properly and there is not a proper way to even dump trash. I can't do anything about dumping until technology allows me to shoot trash out into space but I can buy less than I already do now and be more of a person to recycle. Yes this affect our local environment because of the papermill in Bogulusas and Exxon in Baton Rouge releasing dangerous toxins in the air.

Edit | Delete | Reply | Export to portfolio

In-class Assessment Student Responses

<u>Senario</u>: Bubba and his best friend Duffy like to collect fish for their aquariums (fish tanks). Bubba went to the Amite River, a freshwater system, to collect his fish and Duffy went to Grand Isle, a saltwater system on the coast, to collect his fish. The two friends meet up at their favorite pub to show off their catch. When they left, each accidentally took each other's fish home.

Hint: focus on the effects of osmosis; draw the scenario with the fish tanks and fish to guide you

What happened to the fish Bubba put into his freshwater tank? ________________________
(died, expanded)

What is the term used for the environment (tonicity) of the fish tank? ________________________
(hypotonic)

What is the term used for the environment (tonicity) inside the fish? ________________________
(hypertonic

In which direction does the water move (in or out)? ________________________
(in)

What happened to the fish Duffy put into his saltwater tank? ________________________
(died, dehydrated)

What is the term used for the environment (tonicity) of the fish tank? ________________________
(hypertonic)

What is the term used for the environment (tonicity) inside the fish? ________________________
(hypotonic

In which direction does the water move (in or out)? ________________________
(out)

Describe the effects of tonicity on the fish and why the water was moving.
(answer should include concentration gradient, passive transport, tonicity)

Full

0

Name: [redacted] **Class Day & Time:** Tues Thurs 9:30-10:45
(Print Clearly)

AFFECTS OF OSMOSIS ON FISH

Scenario: Bubba and his best friend Duffy like to collect fish for their aquariums (fish tanks). Bubba went to the Amite River, a freshwater system, to collect his fish and Duffy went to Grand Isle, a saltwater system on the coast, to collect his fish. The two friends meet up at their favorite pub to show off their catch. When they left, each accidentally took each other's fish home.

Hint: focus on the effects of osmosis; draw the scenario with the fish tanks and fish to guide you

I don't know how to do this.

What happened to the fish Bubba put into his freshwater tank? ____________________

What is the term used for the environment (tonicity) of the fish tank? ____________________

What is the term used for the environment (tonicity) inside the fish? ____________________

In which direction does the water move (in or out)? ____________________

What happened to the fish Duffy put into his saltwater tank? ____________________

What is the term used for the environment (tonicity) of the fish tank? ____________________

What is the term used for the environment (tonicity) inside the fish? ____________________

In which direction does the water move (in or out)? ____________________

Describe the effects of tonicity on the fish and why the water was moving.

Full

0

Name: [redacted]
(Print Clearly)

Class Day & Time: 11/19/14 11:00

AFFECTS OF OSMOSIS ON FISH

Scenario: Bubba and his best friend Duffy like to collect fish for their aquariums (fish tanks). Bubba went to the Amite River, a freshwater system, to collect his fish and Duffy went to Grand Isle, a saltwater system on the coast, to collect his fish. The two friends meet up at their favorite pub to show off their catch. When they left, each accidentally took each other's fish home.

Hint: focus on the effects of osmosis; draw the scenario with the fish tanks and fish to guide you

What happened to the fish Bubba put into his freshwater tank? His friend took it.

What is the term used for the environment (tonicity) of the fish tank? IDK

What is the term used for the environment (tonicity) inside the fish? IDK

In which direction does the water move (in or out)? Out

What happened to the fish Duffy put into his saltwater tank? Bubba took it

What is the term used for the environment (tonicity) of the fish tank? IDK

What is the term used for the environment (tonicity) inside the fish? IDK

In which direction does the water move (in or out)? in

Describe the effects of tonicity on the fish and why the water was moving.

IDK

Full

0

Name: [redacted]______________ **Class Day & Time:** GB106 12:30 pm
(Print Clearly)

AFFECTS OF OSMOSIS ON FISH

Scenario: Bubba and his best friend Duffy like to collect fish for their aquariums (fish tanks). Bubba went to the Amite River, a freshwater system, to collect his fish and Duffy went to Grand Isle, a saltwater system on the coast, to collect his fish. The two friends meet up at their favorite pub to show off their catch. When they left, each accidentally took each other's fish home.

Hint: focus on the effects of osmosis; draw the scenario with the fish tanks and fish to guide you

What happened to the fish Bubba put into his freshwater tank? Lived

What is the term used for the environment (tonicity) of the fish tank? Fresh?

What is the term used for the environment (tonicity) inside the fish? Salty?

In which direction does the water move (in or out)? Out

What happened to the fish Duffy put into his saltwater tank? Died

What is the term used for the environment (tonicity) of the fish tank? Salty?

What is the term used for the environment (tonicity) inside the fish? Fresh?

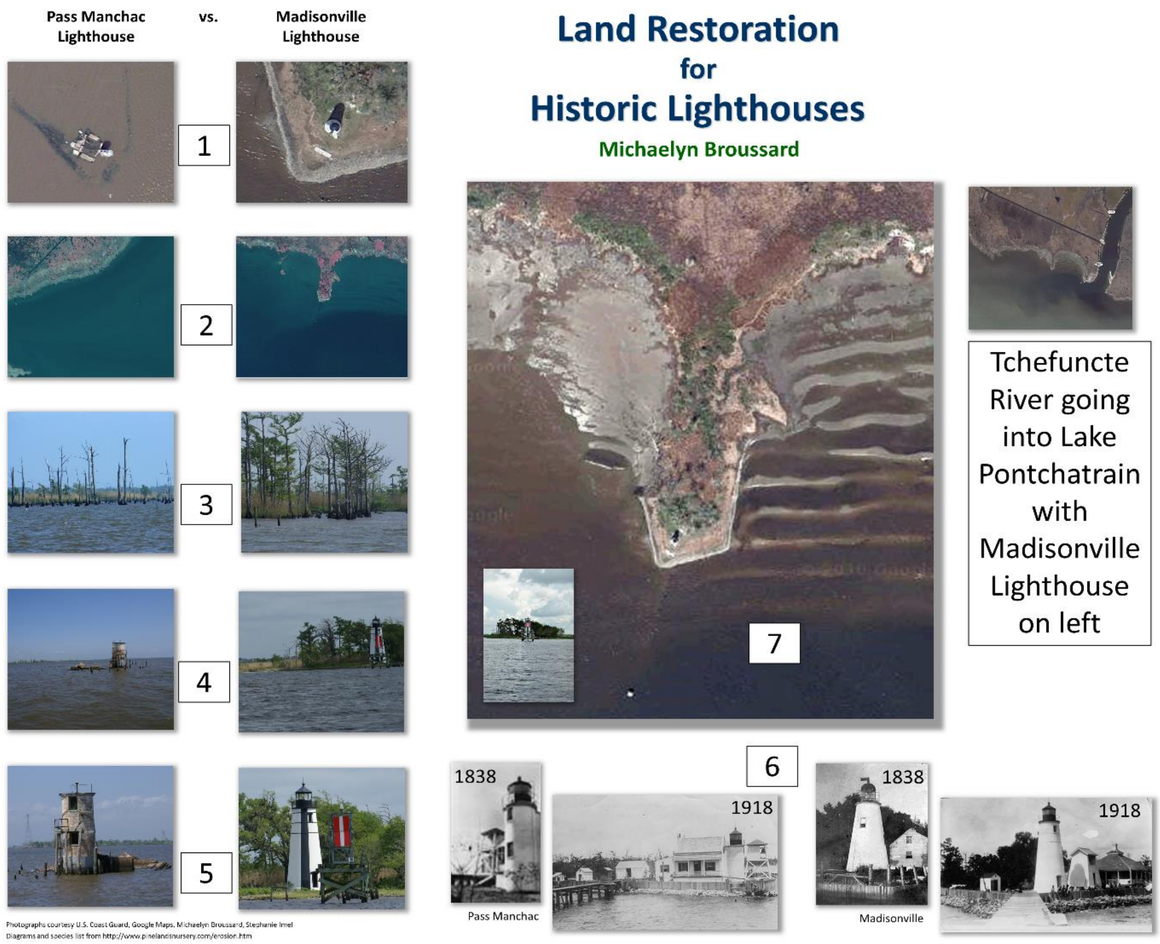
In which direction does the water move (in or out)? In

Describe the effects of tonicity on the fish and why the water was moving.

The salt inside the salt water fish moved out into the actual fresh water.

The fresh water fish absorbed the salt from the salt water.

APPENDIX C: FORUMS AND IN-CLASS ASSESSMENTS OF EFFECTS OF OSMOSIS ON LAND EROSION



Overview of Images: The Manchac and Madisonville Lighthouses were built between 1837-1838 on the Lake Pontchartrain Lake front (northshore) with land access to surrounding communities. Both lighthouses had attendants and their families residing there. Today, saltwater intrusion and other factors have eroded away the lakefront leaving the Manchac Lighthouse far from shore and in disarray. The Madisonville Lighthouse is still functional and only accessible by boat, but in time will have its land eroded away.

1) Google Map aerial view of both lighthouses
2) Google Map aerial view of lighthouses from main shoreline.
3) Photograph of flora remains of both locations.
4) Photograph of condition of both lighthouses.
5) Photograph of condition of both lighthouses.
6) Historic images from the Maritime Museum of both lighthouses in 1838.
7) Google Map aerial view of the remaining land with the Madisonville lighthouse.

Name: ______________________________ Class Day & Time: ______________________
(Print Clearly)

EFFECTS OF OSMOSIS IN LAKE PONTCHARTRAIN

The following questions focus on osmosis (tonicity) and its effects on Louisiana shorelines. Use the images of the Manchac and Madisonville Lighthouses to assist in answering the following questions. Apply what has been addressed in class as well as forums to answer the following questions:

1. Typically, plants prefer what type of environment (tonicity). ____________________
(hypotonic)

2. When hurricanes push Gulf waters into Lake Pontchartrain, what environment (tonicity) is the water (tonicity) compared to the plants themselves?

____
(hypertonic)

3. Although cypress trees can handle brackish water systems, what happens to the cypress trees when there is an increase in concentration gradients between the cypress trees themselves and the environment (tonicity) with hurricanes?

____
(dehydrate by releasing their water)

4. If cypress trees die, what happens to the land around them? ____________________
(coastal erosion)

5. With the land surrounding the Madisonville Lighthouse, what is occurring?

____
(erosion)

6. Describe the difference between the impact of a brackish lake ecosystem (Lake Pontchartrain) vs. the impact of a coastal ecosystem (Gulf) on local flora (plants) and fauna (animals). (Answers should refer to concentration gradient, osmosis, and its effects on the flora and fauna)

In-class Assessment Student Responses

Name: [redacted] ______ Class Day & Time: ______________
(Print Clearly)

AFFECTS OF OSMOSIS IN LAKE PONTCHATRAIN

The following questions focus on osmosis and its effects on Louisiana shorelines. Use the images of the Manchac and Madisonville Lighthouses to assist in answering the following questions. Apply what has been addressed in class as well as forums to answer the following questions:

1. Typically, plants prefer what type of environment (tonicity). Moist

2. When hurricanes push Gulf waters into Lake Pontchartrain, what environment is the water (tonicity) compared to the plants themselves?
Marsh

3. Although cypress trees can handle brackish water systems, what happens to the cypress trees when there is an increase in concentration gradients between the cypress trees themselves and the environment (tonicity) with hurricanes?
They fall more

4. If cypress trees die, what happens to the land around them? It becomes moist

5. With the land surrounding the Madisonville Lighthouse, what is occurring?
erosion

6. Describe the difference between the impact of a brackish lake ecosystem (Lake Pontchartrain) vs. the impact of a coastal ecosystem (Gulf) on local flora and fauna.
Brackish ecosystems are more stable than costal ecosystems.

Name: [redacted] **Class Day & Time:** Mon/Wed 9:30-10:45
(Print Clearly)

AFFECTS OF OSMOSIS IN LAKE PONTCHATRAIN

The following questions focus on osmosis (tonicity) and its effects on Louisiana shorelines. Use the images of the Manchac and Madisonville Lighthouses to assist in answering the following questions. Apply what has been addressed in class as well as forums to answer the following questions:

1. Typically, plants prefer what type of environment (tonicity). balanced environment

2. When hurricanes push Gulf waters into Lake Pontchartrain, what environment (tonicity) is the water (tonicity) compared to the plants themselves?

Aquatic

3. Although cypress trees can handle brackish water systems, what happens to the cypress trees when there is an increase in concentration gradients between the cypress trees themselves and the environment (tonicity) with hurricanes?

They begin to die.

4. If cypress trees die, what happens to the land around them? The land would go bad.

5. With the land surrounding the Madisonville Lighthouse, what is occurring?

the plants is growing up the lighhouse.

6. Describe the difference between the impact of a brackish lake ecosystem (Lake Pontchartrain) vs. the impact of a coastal ecosystem (Gulf) on local flora (plants) and fauna (animals).

the lake ecosystem has biotic plants, ~~and~~ animals and micro-organism.

0

Name: [redacted] **Class Day & Time:** 11/12/14 11am
(Print Clearly)

AFFECTS OF OSMOSIS IN LAKE PONTCHATRAIN

The following questions focus on osmosis (tonicity) and its effects on Louisiana shorelines. Use the images of the Manchac and Madisonville Lighthouses to assist in answering the following questions. Apply what has been addressed in class as well as forums to answer the following questions:

1. Typically, plants prefer what type of environment (tonicity). wetlands

2. When hurricanes push Gulf waters into Lake Pontchartrain, what environment (tonicity) is the water (tonicity) compared to the plants themselves? Salt waters

3. Although cypress trees can handle brackish water systems, what happens to the cypress trees when there is an increase in concentration gradients between the cypress trees themselves and the environment (tonicity) with hurricanes? ____________________

4. If cypress trees die, what happens to the land around them? ____________________

5. With the land surrounding the Madisonville Lighthouse, what is occurring? osmosis

6. Describe the difference between the impact of a brackish lake ecosystem (Lake Pontchartrain) vs. the impact of a coastal ecosystem (Gulf) on local flora (plants) and fauna (animals).

Name: [redacted] **Class Day & Time:** Mon 12:30 D

(Print Clearly)

AFFECTS OF OSMOSIS IN LAKE PONTCHATRAIN

The following questions focus on osmosis (tonicity) and its effects on Louisiana shorelines. Use the images of the Manchac and Madisonville Lighthouses to assist in answering the following questions. Apply what has been addressed in class as well as forums to answer the following questions:

1. Typically, plants prefer what type of environment (tonicity). I Dont Know

2. When hurricanes push Gulf waters into Lake Pontchartrain, what environment (tonicity) is the water (tonicity) compared to the plants themselves? I Don't Know

3. Although cypress trees can handle brackish water systems, what happens to the cypress trees when there is an increase in concentration gradients between the cypress trees themselves and the environment (tonicity) with hurricanes? I Don't Know

4. If cypress trees die, what happens to the land around them? I Don't Know

5. With the land surrounding the Madisonville Lighthouse, what is occurring? I Don't Know

6. Describe the difference between the impact of a brackish lake ecosystem (Lake Pontchartrain) vs. the impact of a coastal ecosystem (Gulf) on local flora (plants) and fauna (animals).

I Don't Know

APPENDIX D: FORUMS AND IN-CLASS ASSESSMENTS OF PHOTOSYNTHESIS, CELLULAR RESPIRATION AND HYPOXIA

My ▶ 2148_GBIO106_01 ▶ Forums with ▶

Search forums

Forum 3

Photosynthesis:

http://www.sciencedaily.com/releases/2010/02/100218092846.htm

http://phys.org/news/2013-10-crop-productivity.html

http://www.nanowerk.com/news2/biotech/newsid=32540.php new pathway

http://water.epa.gov/type/wetlands/outreach/fact26.cfm
http://www.takepart.com/article/2013/10/14/protecting-beer-climate-change?cmpid=foodinc-fb

- What do you think about photosynthesis and it's role in global warming?
- How can biofuel research help with energy sources?
- Why study about photosynthesis?

Cellular Respiration:

http://www.sciencedaily.com/releases/2010/06/100630101020.htm

Hypoxia:

http://www.sciencedaily.com/releases/2010/03/100311141213.htm

http://www.ncddc.noaa.gov/hypoxia/

http://www.gulfhypoxia.net/overview/
http://www.youtube.com/watch?v=AVxF074FpqU video 2003
http://www.youtube.com/watch?v=I8r83FROBjI - news video may 2012
http://www.nola.com/environment/index.ssf/2011/06/algae_blooms_reported_in_lake.html - lake pont - chlorophyll
http://www.bing.com/videos/watch/video/water-experts-monitor-lake-pontchartrain-for-algae-blooms/1d0yqdjw0?cpkey=02c0332b-0f7c-4c33-bf65-c52de053088a%257c%257c%257c%257c - news on algae blooms

- Did you know about the dead zone?
- What is hypoxia bad for Louisiana?
- Why do Louisiana lakes get algae blooms?
- What does cellular respiration have to do with hypoxia?
- What are some causes of hypoxia?
- How can it be fixed?
-

Add a new discussion topic

Discussion	Started by	Replies	Unread	Last post
forum 3		0	0	Wed, Nov 19, 2014, 9:55 AM
		0	0	Wed, Nov 19, 2014, 6:07 AM
Forum 3		0	0	Wed, Nov 19, 2014, 1:12 AM

Forum Assessment Student Responses

My [redacted] *2148_GBIO106_01* [redacted] Forums with [redacted]

Search forums

Forum 3

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Forum 2
- Sunday, October 26, 2014, 8:56 PM

Forum 3 post

Photosynthesis:

Photosynthesis and its role in global warming does not spark any interest or care from me. I am more concerned with making something out of my life and do not care about global warming or climate change, or whatever hogwash people are saying these days. Photosynthesis does play a role in global warming, but I do not concern myself with that stuff.

Biofuel will reduce or eliminate fossil fuel consumption and hopefully the cost of transport will drastically be reduced. Biofuels will help save the environment, at least in the US, but probably not in Brazil.

If you are interested in Photosynthesis you should study it, otherwise it is useless to learn anything about it. Since we only learn about it from a textbook, its uselessness is exponentially multiplied because there are no applications for it. Maybe one day it will be worth studying, but not this day.

Cellular Respiration:

Viewed

Hypoxia:

I did not know about the dead zone in Louisiana. I know about other rivers connecting with the Mississippi river. It surprises me that Hypoxia is prevalent in the southern United States, as I imagine water issues would be more prevalent in the 3rd world.

Hypoxia has a negative impact on the gulf region as a whole. Since Hypoxia can drive out aquatic organisms from the local are, the local economy and ecosystem are at risk. Even though the economy and ecosystem would not completely collapse, many of the results that come from Hypoxia can have a large effect on the economy.

The reason that the lake gets algae blooms is because of chlorophyll concentration. Hypoxia may be related to the blooms, as the site says that Mississippi river water is causing the development of the algae blooms.

Cellular respiration is involved in Hypoxia because of what is released through the use of Oxygen: carbon dioxide and water.

One cause of Hypoxia is low oxygen, because without it, survival of organisms is impossible. Another reason could be the pollutants that make their way down the Mississippi river. And on last reason could be the tropical storms and the hurricanes. Since they cause salt water intrusion on section of water may be chemically imbalanced.

Hypoxia can be fixed through creating more land barriers in the Gulf of Mexico. Reducing the amount of pollutants in the area can also help reduce the dearth. When more organisms are living in the gulf, you would be able to measure the amount of success.

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Forum 3

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Forum 3
by - Monday, October 27, 2014, 9:27 AM

Photosynthesis

Photosynthesis plays a vital role in Global an has both good and bad effects on global warming. Biofeul research can help with energy sources because its system could ultimately form the basis for a new strategy for the enviromentally-friendly and renewable transformation of solar energy into electrical energy. Studying about photosynthesis is important because it is a main part of everyday life that will never go away and will always have advances.

Cellular Respiration

This article is about how there will be a reduction in the amount of CO2 absorbed by the ecosystems.

Hypoxia

No, I did not know about the dead-zones. Now I know that "dead-zones" means oxygen deprived places along the worlds coast. Hypoxia is bad for louisiana because hypoxia affects many organisms. Louisiana is home to many seafood dishes and is hypoxia continues that will greatly effect the prices of seafood, etc. Louisiana lakes get Algae blooms because, algae blooms comes from high concetration of chlorophyll. The blooms occur from the Bonne Carre spillway being opened which allows for Mississippi water to mix with lake Ponchatrain water(Fresh Water). Cellular Respiration has a lot to do with hypoxia because hypoxia means "deprived of oxygen", and without oxygen cellular respiration can not occur. Some causes of Hypoxia are: Depletion of oxygen due to stratification, fresh water discharge and nutrient loading of the Mississippi river, etc. Hypoxia can be fixed by not mixing waters and allowing our waters to get more nutrients.

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My [redacted] *2148_GBIO106_01* [redacted] Forums with [redacted]

Search forums

Forum 3

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Forum 3
by - Tuesday, November 18, 2014, 8:41 PM

Photosynthesis:

I think that photosynthesis plays a major role in global warming. The oxygen it produces builds up our atmosphere, and creates greenhouse effect.

Biofuel research can help replace our energy sources. Eventually, we will run out of our fossil fuels which we have become reliant upon. These new biofules can replace them and make our enviorment cleaner in the process.

You should study photosynthesis, because it is the reason we are alive. This one process has major effects over all living organisms. Being able to understand how it works, can allow us to create energy like the fake leaf.

Hypoxia:

I did not know about the dead zone until we discussed it in class.

Hypoxia is bad or Louisiana because it kills the wildlife. It doesn't necessarly kill the wildlife, but it causes them to leave. Louisiana is a sportsman's paradise, we need out marine life to stay where they are!

Louisiana lakes get algae blooms because of increases in chemical nutrients.

Cellular resperiation is blocked for organisiams in hypoxia areas. The organism is nolonger ale to breath, and will die.

Try to fix the runoff problem "upstream" from phosphorous rich fertlizers. Focus on what humans are putting in the water from begining to end, and the hypoxia problem should be fixed.

Edit | Delete | Reply | Export to portfolio

APPENDIX E: STUDENT OPINION OF TEACHING

SOUTHEASTERN
LOUISIANA UNIVERSITY

Student Opinion of Teaching -- Narrative Response Form

Computer Number:	Name of Instructor:	Course:	Section Number:	Semester/Year:
0173	Michaelyn Brassard	GB10	106-02	Fall 2014

	STRENGTHS	SUGGESTIONS FOR IMPROVEMENT
The Instructor	Jewish	Be more jewish. I am also Jewish! :)
The Activities and Tests	Too much abat global Warmiy.	Less abat global warmiy.
The Books and Materials	Ive never looked at the book so I wouldn't know.	N/A
The Classroom (i.e., temperature, acoustics, etc.)	N/A	I think the chairs were designed for midgets. My binder is always in my lap which is uncomfortable

White copy – Faculty Member   Pink copy – Dept. Head

SOUTHEASTERN
LOUISIANA UNIVERSITY

Student Opinion of Teaching -- Narrative Response Form

Computer Number:	Name of Instructor:	Course:	Section Number:	Semester/Year:
0173	Michaelyn Broussard	GBio	106 - 02	fall 2014

	STRENGTHS	SUGGESTIONS FOR IMPROVEMENT
The Instructor	Good info	don't make it so boring - and make it more understandable for the non science majors
The Activities and Tests	A good length	too hard and difficult for no reason
The Books and Materials		just isn't comprehendable to a person that isn't good in science
The Classroom (i.e., temperature, acoustics, etc.)		atmosphere is boring

White copy – Faculty Member Pink copy – Dept. Head

SOUTHEASTERN
LOUISIANA UNIVERSITY

Student Opinion of Teaching -- Narrative Response Form

Computer Number:	Name of Instructor:	Course:	Section Number:	Semester/Year:
0173	Michaelyn Broussard	GBIO 106	02	Fall 2014

	STRENGTHS	SUGGESTIONS FOR IMPROVEMENT
The Instructor	She is enthusiastic about material and is helpful to students	Could not talk about wetlands as much
The Activities and Tests	Are all online	Tests sometimes have questions that don't pertain to material
The Books and Materials	Lecture notes are helpful	Could designate what chapter they're for
The Classroom (i.e., temperature, acoustics, etc.)	Is pretty open	She turns the lights off or puts them on dim so I get sleepy

White copy – Faculty Member Pink copy – Dept. Head

SOUTHEASTERN

LOUISIANA UNIVERSITY

Student Opinion of Teaching -- Narrative Response Form

Computer Number:	Name of Instructor:	Course:	Section Number:	Semester/Year:
0172	Michaelyn Broussard	GBIO 106	01	Fall 2014

	STRENGTHS	SUGGESTIONS FOR IMPROVEMENT
The Instructor	Relates material to current events, passionate and knowledgable about material she teaches	None. sat in the front of her class every day and did well in the course. Only felt sorry she had to deal with people being rude on phones or sleeping. She gives you a lot of opportunities to learn in her class.
The Activities and Tests	Test are truly information from lecture and book. Quizes definitely help w/ test in class. assignments not difficult, but are informative	
The Books and Materials	Material in class that was in original syllabus was covered completely	
The Classroom (i.e., temperature, acoustics, etc.)	spacious, bright enough, not too cold, no complaints	

White copy – Faculty Member   Pink copy – Dept. Head

SOUTHEASTERN
LOUISIANA UNIVERSITY

Student Opinion of Teaching -- Narrative Response Form

Computer Number:	Name of Instructor:	Course:	Section Number:	Semester/Year:
	Broussard, Michaelyn	BIOL GBIO 106-02	0454	Spring 2014

	STRENGTHS	SUGGESTIONS FOR IMPROVEMENT
The Instructor	Instructor is great; uses local occurences to teach points.	
The Activities and Tests	Tests are very clear + straight forward.	Test questions are worded very diff. from notes.
The Books and Materials	Books + Notes are very relevant to course + tests,	N/A
The Classroom (i.e., temperature, acoustics, etc.)	Classroom is fine.	N/A

White copy – Faculty Member Pink copy – Dept. Head

APPENDIX F: BASIC TERMS ASSESSMENT

[redacted]

9:30 9/25/14

0

① Invasive - tactic, plan

② Hypnoxia - disease

③ Cellular Respiration - cell system

④ Photosynthesis - a plants life

⑤ Diffusion - I dont know

[redacted]

11:00

0

Invasive - I forgot what it mean, IDK

Hypoxia - I forgot what it mean

Cellular Respiration - I remember the words but I forgot what it mean.

Photosynthesis - I forgot what it mean

Diffusion - I forgot what it mean

[redacted]

1.) Invasive -

2.) Hypoxia -

3.) Cellular Respiration -

4.) photosynthesis - when

5.) Diffusion -

9:30

0

Invasive - Plants or animals that are destructive towards an environment or ecosystem.

Hypoxia - I don't know

Cellular Respiration - I can't remember

Photosynthesis - A plants digestive cycle.

Diffusion - I can't remember.

APPENDIX G: LOUISIANA STATE UNIVERSITY – INSTITUTIONAL REVIEW BOARD APPROVAL

Application for Exemption from Institutional Oversight

Institutional Review Board
Dr. Robert Mathews, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu | lsu.edu/irb

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/projects using living humans as subjects, or samples, or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

– Applicant, Please fill out the application in its entirety and include the completed application as well as parts A-F, listed below, when submitting to the IRB. Once the application is completed, please the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at http://sites01.lsu.edu/wp/ored/human-subjects-screening-committee-members/

– A Complete Application Includes All of the Following:

(A) A copy of this completed form and a copy of parts B thru F.
(B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1&2)
(C) Copies of all instruments to be used.
*If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.
(D) The consent form that you will use in the study (see part 3 for more information.)
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB. Training link: (http://phrp.nihtraining.com/users/login.php)
(F) IRB Security of Data Agreement: (https://sites01.lsu.edu/wp/ored/files/2013/07/Security-of-Data-Agreement.pdf)

1) Principal Investigator: Michaelyn Broussard **Rank:** PhD graduate student

Dept: LSU School of Education **Ph:** 504-236-9687 **E-mail:** mbroussard@selu.edu

2) Co Investigator(s): please include department, rank, phone and e-mail for each
*If student, please identify and name supervising professor in this space

Dr. Pam Blanchard (PhD supervisor)
LSU School of Education
225-578-2297
PamB@lsu.edu

IRB# E8567 LSU Proposal #
✓ Complete Application
✓ Human Subjects Training
✓ IRB Security of Data Agreement

3) Project Title: A study of environmental literacy of non-major biology undergraduate college students

STUDY EXEMPTED BY:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
130 David Boyd Hall
225-578-8692 / www.lsu.edu/irb
Exemption Expires: 11/18/2016

4) Proposal? (yes or no) NO **If Yes, LSU Proposal Number**

Also, if YES, either ◯ **This application completely matches the scope of work in the grant**
OR ◯ **More IRB Applications will be filed later**

5) Subject pool (e.g. Psychology students) non-major biology undergraduate college students

*Circle any **"vulnerable populations" to be used**: (children <18; the mentally impaired, pregnant women, the ages, other). Projects with incarcerated persons cannot be exempted.

6) PI Signature Michaelyn [signature] **Date** 11/11/13 (no per signatures)

**** I certify my responses are accurate and complete.** If the project scope or design is later changes, I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted ✓ Not Exempted ____ Category/Paragraph 1

Signed Consent Waived?: Yes / No

Reviewer Mathews **Signature** Robt C Mathews **Date** 11/19/13

APPENDIX H: SOUTHEASTERN LOUISIANA UNIVERSITY – INSTITUTIONAL REVIEW BOARD APPROVAL

SOUTHEASTERN
LOUISIANA UNIVERSITY

Institutional Review Board
Box 11851
Phone: 549-2077

Campus Correspondence
www.selu.edu/irb
Fax: 549-3640

DATE: November 25, 2013

TO: Michaelyn Broussard
Biological Sciences

FROM: Dr. Michelle Hall, Chair

RE: IRB Action on Proposed Project

This memo is to inform you of the IRB action with regard to your proposal:

Title: A study of environmental literacy in non-biology major college classes

This proposal was given: Expedited Review:_____

Full Committee Review: X

Exempt:_____

The result was: Full Approval: X

Denied Approval:_____

If anything other than Full Approval is recommended, it is your responsibility, as investigator, to submit changes/corrections or plans to accommodate conditions listed below to the Institutional Review Board prior to initiating the project. This approval is valid for one year from the date above, if data is to be collected after that time frame, the PI must submit a Continuation of Research Form.

Failure to acquire full approval by IRB before implementation for any project which involves humans means that the PI is not acting in "good faith" with university policy and is not, therefore, guaranteed the protection of the university.

Committee Comments:

IRB Number:2014-091

APPENDIX I: HUMAN SUBJECTS CERTIFICATION

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Michaelyn Broussard** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 10/11/2013

Certification Number: 1300945

VITA

Michaelyn Broussard spent her childhood living in the country in Alexandria, Louisiana. She spent most of her time climbing trees, chasing snakes, swimming in ponds, and jumping on the trampoline. She always envisioned herself in the great outdoors being a champion for nature and wildlife and a voice for the voiceless. She idolized Jane Goodall and Joy Adamson, both pioneering women in the field of wildlife conservation.

As she progressed in school, she was diagnosed with dyslexia. She struggled with pronunciation and had a stutter. Because of this, she pursued a Sociology degree at Centenary College in Shreveport, since this major did not require a heavy foreign language component. This path discouraged her from entering a scientific career. After college, she went to work in retail, but continued to dream of being outdoors.

In 1994, she accepted a job opportunity at Global Wildlife Center, in Folsom, Louisiana, as a tour guide, which was the start of a career path she always desired – working with wildlife. She overcame her stutter and learned to speak to large groups of people. She also entered a Master's program at Southeastern Louisiana University to start her career in a scientific field, wetland ecology.

Today, she is a full time faculty member in the Department of Biological Sciences at Southeastern Louisiana University, the Director of the Region VIII Science Fair, and volunteers her time working with environmental and animal groups while pursuing a doctorate degree in Curriculum and Instruction from Louisiana State University.

Although she is not in the jungles of Bora Bora or the African savannas, she does speak for the environment and wildlife with her aim to continue to be of service to Mother Earth.