ANALYSIS OF AN INFORMAL

WATER EDUCATION

PROGRAM

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by

Andrew Sansom, B.S.

San Marcos, Texas
May 2013

ANALYSIS OF AN INFORMAL

WATER EDUCATION

PROGRAM

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Dedication

This dissertation is dedicated to students and staff of the

Meadows Center for Water and the Environment

at

Texas State University-San Marcos

They are leading the way in educating our children

About Water and Their Future

ACKNOWLEDGEMENTS

There are many friends, colleagues, professors, and relatives without whom this work would never have occurred. There are so many, in fact, that it is possible that I may have forgotten one or two. Hopefully, I did not but if so, they must know how grateful I am to have had their assistance and that it helped make it possible for me to do this at all.

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ANALYSIS OF AN INFORMAL

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The availability of sufficient water to provide for economic growth, population, and the environment is the most critical natural resource issue facing Texas in the coming generation. Recent studies indicate that the State's population will nearly double in the next fifty years and yet we have already allocated more water for use from many of our rivers than is actually in them. Additional research has shown that achieving resource sustainability in society will require a greater understanding of the interconnections between the environment, economy and society that is present in an increasingly urban

population today. An important delivery system for the education necessary to achieve such understanding can be found in informal educational programs offered at venues including outdoor nature centers, parks and other natural settings. One such program has been conducted for a number of years at Aquarena Center located at the Headwaters of the San Marcos River on the Campus of Texas State University – San Marcos. At Aquarena Center, as elsewhere, little research has been conducted to reveal the impact of water education programs, both in terms of the transfer of content knowledge and the impact of such programs on the participants. A mixed methods study approach was used to attempt to measure the impact upon middle and high school students attending informal water education programs at Aquarena Center. Data were gathered using surveys and interviews with teachers accompanying students to the site. Significant results were discovered in measuring content knowledge among students before and after the informal educational experience and important insights were gained from in-depth interviews with teachers as to the effectiveness and relevance of the program itself. These findings will help strengthen the informal educational offering at Aquarena Center and contribute to continuing efforts among educators as to the delivery of active and experiential learning to inspire students to connect with their environment, particularly in the face of looming water scarcity.

CHAPTER I

INTRODUCTION

An Urgent Issue

No natural resource has greater significance for the future of Texas than *water* and our willingness and ability to address issues related to its use and management is tied directly to formal and non-formal education (TWDB n.d.). In Texas, the population is expected to essentially double in the next generation and yet we have already given permission for more water to be drawn from many of our rivers than is actually in them (Sansom 2008) (Figures 1 and 2). Against this specter, most citizens, but especially our young children, have no clue that a crisis is looming as long as water flows when they turn on the tap (Henry 2011). Although there are many proposed strategies designed to meet our future water needs, none is more urgent than educating the coming generation of the value of sustaining water resources and its crucial impact on both economic prosperity and the environment in the years ahead.

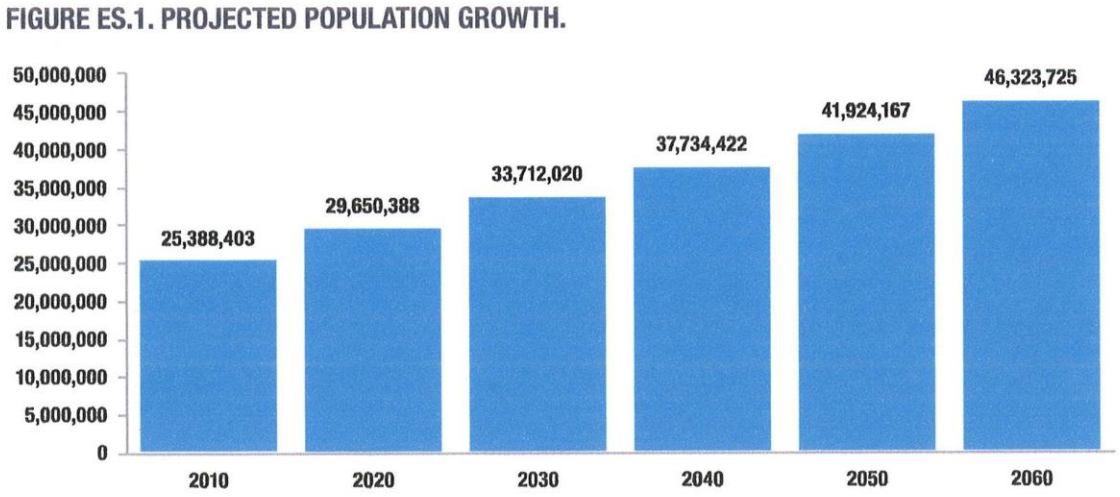


Figure 1. Texas Anticipated Population Growth. (Courtesy of Texas Water Development Board [TWDB] 2012).

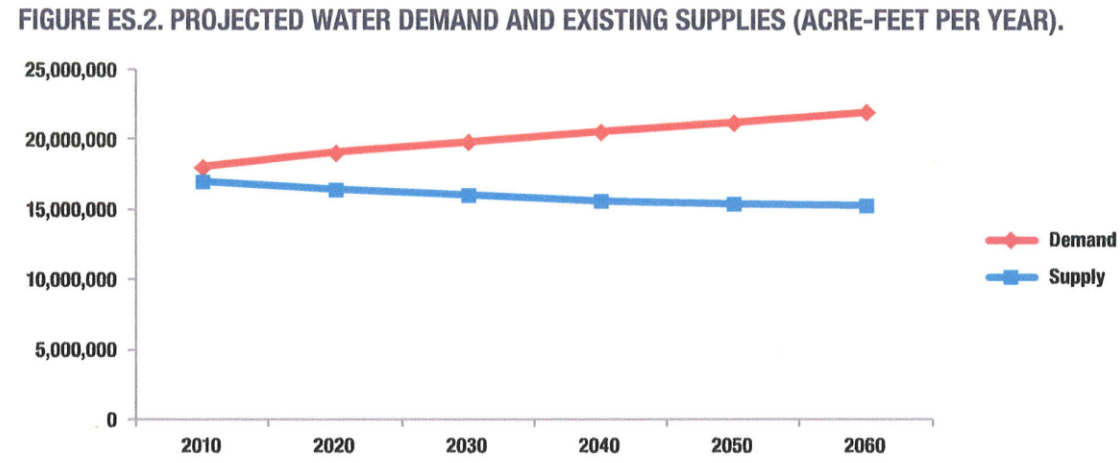


Figure 2. Projected Water Needs for Texas. (Courtesy of TWDB 2012).

Though serious droughts in the first decade of the 21st Century have brought greater attention to Texas' daunting water problems, these issues, in fact, have been developing over many years, as evidenced by the State's impressive system of reservoirs, built in the years following what is officially known as the "Drought of Record" in the l940s and 1950s. In those years, most Texans lived in small communities with comprised mainly of an agricultural or ranch economy. In this mostly rural environment; the drought was felt directly and personally by most of the State's inhabitants (Kelton 1973). In response to such a direct impact, Texas leaders launched an extensive water infrastructure development program and water planning system that we still rely on. Today, the Texas economy is complex and diverse with most of its residents living in large urban areas, where the effects of drought are not as painful or immediate (Figures 3 and 4).

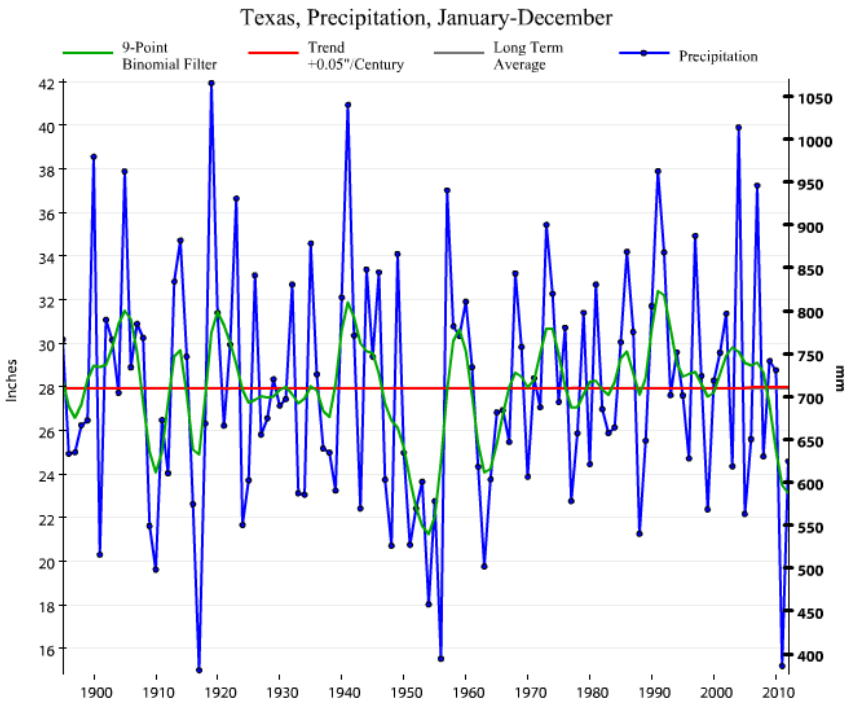


Figure 3. Texas statewide precipitation (year to date accumulation) from 1895 -2012. (Courtesy of National Oceanic and Atmospheric Administration [NOAA] 2013).

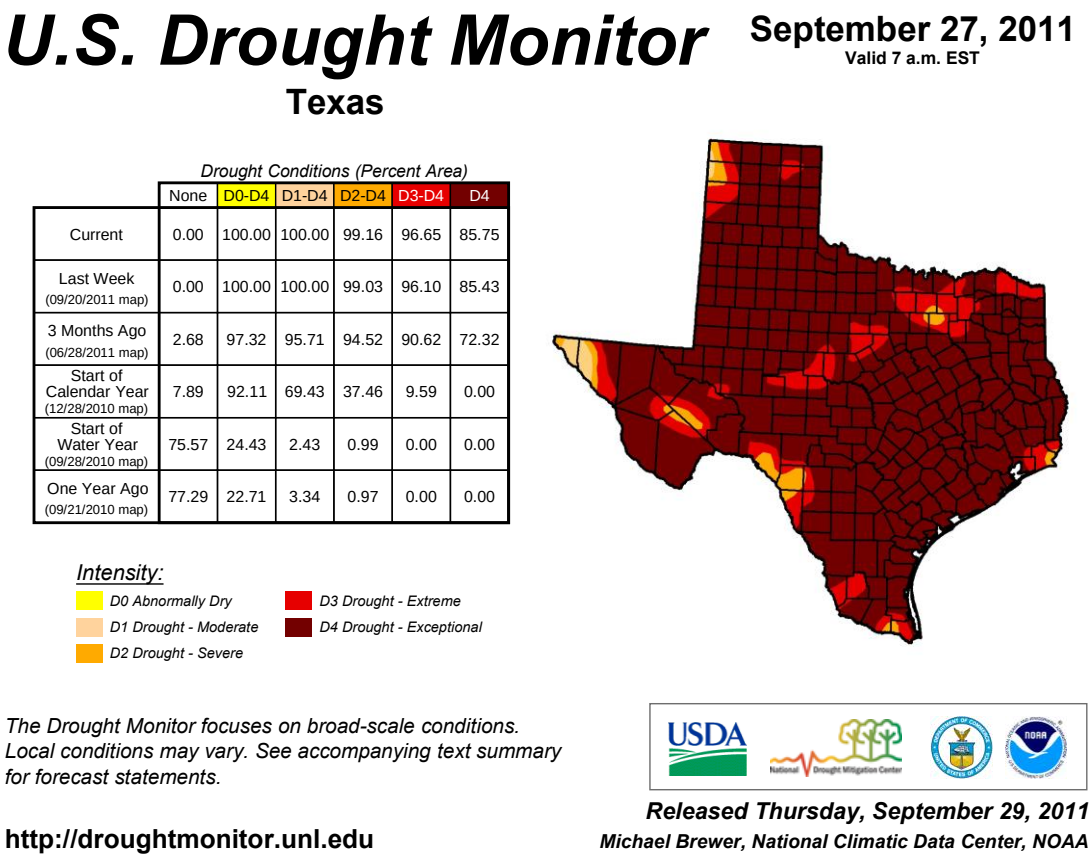


Figure 4. 2011 Texas Drought. (Courtesy of Drought Monitor 2011).

To compound the difficulty presented by the lack of public awareness of the seriousness of the water dilemma in modern Texas society, planning and management of water resources has become much more complex. The "Texas Water Plan" issued in 2012 by the Texas Water Development Board was created in a "bottom-up" process involving 16 regional planning groups and is largely a wish list of proposed construction projects designed to create additional water supply. The estimated cost of the plan is $53 billion. The facts are that even if State leaders could find a way to generate that amount of financing, the reality of other water challenges including protection of our watersheds; ensuring continuing supplies of freshwater to our bays and estuaries; and improving

groundwater management is such that we cannot simply build our way out of them (Sansom 2012).

A Record of Achievement

Ironically, against this backdrop, we have been very successful in managing our natural resources in Texas, including water, over the past century. According to Dr. David Schmidly, President of the University of New Mexico and author of *Texas Natural History: A Century of Change*, our landscape, including our watersheds, is in much better condition today than it was prior to the turn of the 20th century (Schmidly 2002). Barely 50 years after European settlement began in earnest with the arrival of Anglo colonists and sodbusters, most of the native grasslands in what was to become Texas had been plowed under and overgrazed, as well as, complete deforestation of the vast virgin timberlands of the Piney Woods (Figure 5). Great quantities of soil had washed off the land, especially in the Hill Country and the Rolling Plains severely impacting critical watershed functions, including aquifer recharge and catchment (Schmidly 2002).

Figure 5. Texas Gould Ecoregions. (Courtesy of Texas Parks and Wildlife Department [TPWD] 2004).

In the latter half of the 20th century, following the Great Dust Bowl of the 1930s, an entire generation of landowners received formal and non-formal education and instruction which inspired them to become more enlightened stewards of the land, thanks to the efforts of government agencies such as the Agricultural Extension Service, now known as The Agrilife Extension Service, and the Soil Conservation Service, now known as the Natural Resource Conservation Service. In Texas, approximately 95 percent of the

landscape is privately owned and, thanks to the efforts of these private land stewards, the condition of that landscape and thus, our watersheds and recharge areas, has greatly improved (Francell 2003). Partially as a result, our water quality has improved as well. Significantly, the passage and implementation of pollution control legislation has dramatically improved the water quality in our rivers and streams, which, until the late 1960s were often contaminated with poorly treated or completely untreated industrial and municipal waste (Clean Water Act 1972).

At the same time, our aquatic and terrestrial flora and fauna are generally in better condition that they were early in the last century. At one time, for example, white tailed deer (*Odocolilus virginanus*) were largely extinct in parts of the state (Schmidely 2002). Today, in some areas, their numbers have increased to such an extent that they present a serious ecological problem (Armstrong and Young 2000). Again, thanks to sound wildlife management, Texans harvest more wild turkeys (*Meleagris gallopavo*) each year than existed in the entire state prior to World War II (Texas Agrilife Extension 2007). And finally, we have stocked billions of fish in our waters (TPWD n.d.) and have substantially eliminated, or fundamentally limited, commercial harvest of marine and freshwater species (Heffernan and Kemp 1978).

As a result, Texas is the number one hunting and fishing state in the nation (U.S. Fish and Wildlife Service, 2006). It is among the foremost destinations for birdwatchers in the world (Bartlett 1995). Texas possesses system of state parks and wildlife management areas that is the envy of other states and it is home to some of the nation's most important national parks and wildlife refuges. The vast system of reservoirs built in Texas since the 1950s not only has provided vital water supplies for industry, agriculture,

residential and municipal use but also has generated an incredible opportunity for fishing and boating.

A Time of Challenges

In spite of these successes, though, Texas must be prepared to confront very serious challenges, particularly related to water provision, and public and institutional education will, out of necessity, be a key strategy for doing so.

With respect to the landscape, the most important fact and insight is that the State is almost entirely owned by private citizens; thus virtually all of our watersheds, recharge areas and habitat are on private property. Although experts argue about the exact percentage of land in private ownership, it is indisputable that somewhere between 94% and 97% of the Texas landscape is privately held (Francell, 2003). The implications for the environment and water resource management in particular, are profound. Texas has become one of the most urbanized states in the country and, as a result, loses increasing amounts of rural and agricultural land each year; faster, in fact than any other state (Wilkins et al. 2003). This accelerating urban encroachment, combined with the pressure on heirs who are often left by their parents with as much tax burden as land, contributes to an inexorable process of land fragmentation (Figures 6 and 7). Fragmentation is the single greatest terrestrial environmental problem Texas faces today and it is directly related to the State's water problems as well (Wilkins et al. 2003).

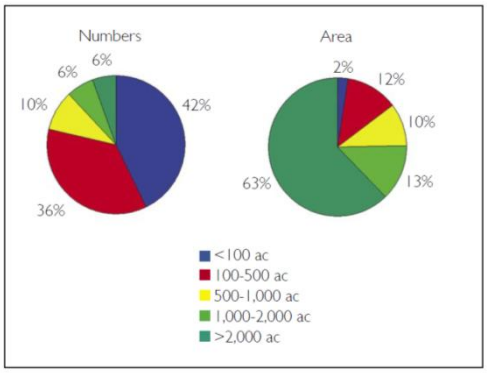


Figure 1. Farms and ranches by ownership size, statewide.

Figure 6. Loss of farms and ranches by ownership size, statewide. (Courtesy of Wilkins et al. 2003).

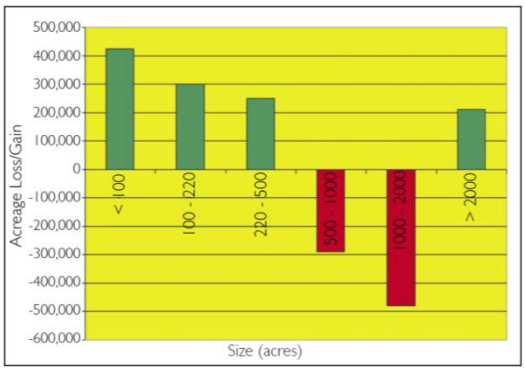


Figure 2. Statewide change in acreage by ownership size (1992-97).

Figure 7. Statewide change in acreage by ownership size 1992-1997. (Courtesy of Wilkins et al. 2003).

As the average size of tracts of land in Texas continues to diminish, wildlife habitat disappears and open space is lost along with much of the outdoor recreation opportunities we have come to enjoy. Most noteworthy for both the economic and environmental future of the State, the function of our watersheds is being irrevocably impaired.

In fact, the issues associated with ensuring sufficient clean water for economic growth and the environment is the most significant and urgent environmental concern facing Texans in the next generation and there are several very significant insights, which we must find a way to convey to them (Meadows Foundation 2011).

Most of the available water in Texas is located in the eastern part of the state where rainfall is upwards of 60 inches per year and growth is essentially flat (Figure 8). Conversely, most of the current and expected economic growth is along the Interstate 35 and Interstate 45 corridors where the rainfall can be as low as 25 inches per year. (Estaville and Earl 2008).

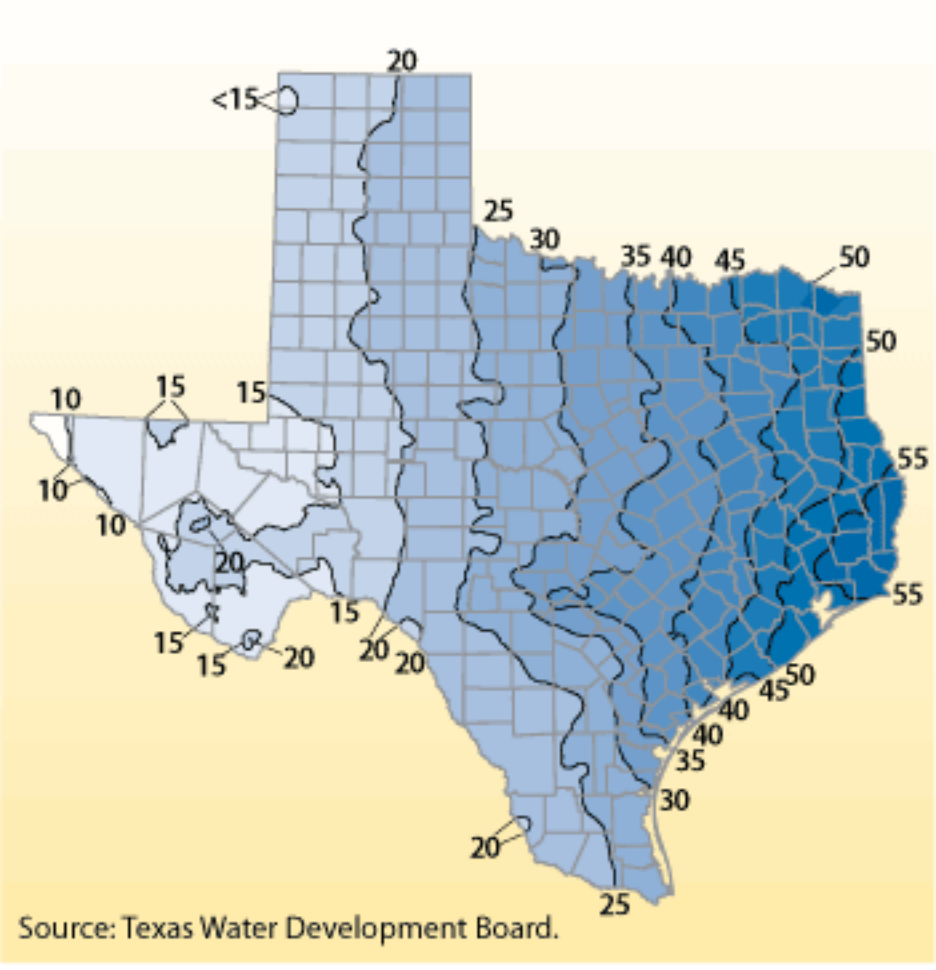


Figure 8. Rainfall Patterns in Texas. (Courtesy of TWDB n.d.)

Over the years there has been much talk of moving large amounts of water westward from eastern rivers to thirsty cities, farms and industries. However, regional competition, environmental objections and very substantial legal impediments have thus far kept this from happening on a major scale (Webb 1954). Nevertheless, water planners, policy makers and utility managers will continue to attempt to find ways to move water westward in the years ahead and decisions related to these attempts will require an informed and engaged citizenry.

Such enormous and far-reaching projects have their origin in the fact that historically we have largely depended on surface water for human uses, including agriculture, industry, municipal consumption and recreation. Surface water occurs naturally in rivers and streams and is now stored in 188 major reservoirs that comprise one of the most extensive systems of impoundments in the United States (Figure 9) (TWDB 2012). According to the 2012 Texas Water Plan, a major reservoir is one that has at least 5000 acre-feet of storage capacity as its normal operating level. An acre-foot is the amount of water required to cover one acre of land with 12 inches of water (TWDB 2012).

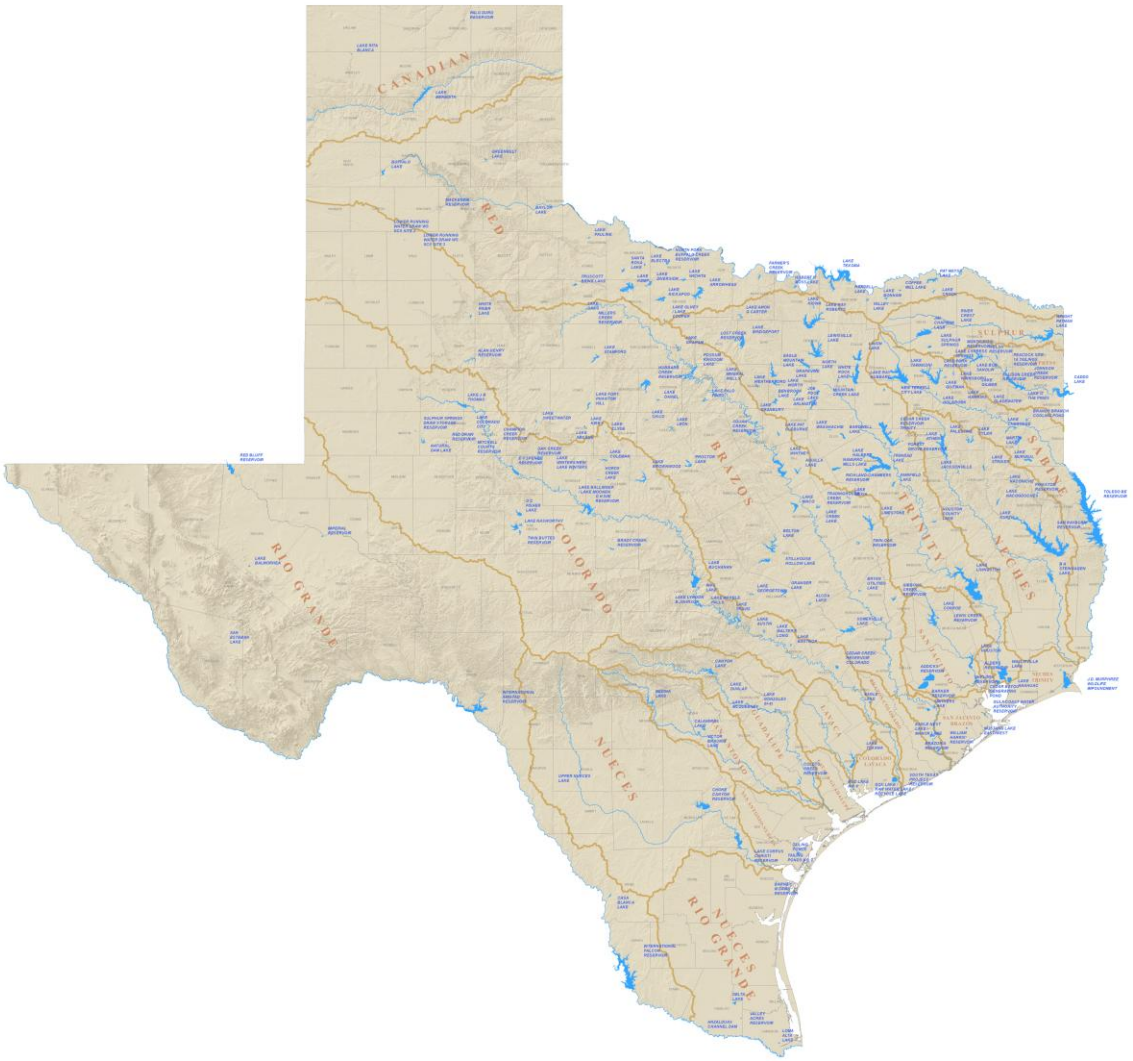


Figure 9. Texas Lakes and Reservoirs. (Courtesy of TWDB n.d.).

By law, the water in our rivers is considered the property of the people of the State of Texas. Today, most of that water has already been spoken for through a system of water rights allocation that has its origin when Texas was a colony of Spain. In fact, some of our rivers have actually been over-appropriated in the course of this long history. That is, if all of the water permitted to be used from them were actually withdrawn, they would dry up (Lee 2012). A vivid example of this frightening possibility was made all

too clear in the first decade of the new century when, for a time, the Rio Grande River no longer reached its mouth on the Gulf of Mexico. The majority of the water in our rivers and streams has been allocated to agriculture, as much as 85%, thereby rendering its availability very difficult for purposes such as urban development, industry, and the environment (TWDB 2012).

Compounding this problem is the fact that the state has not constructed a new reservoir in more than 20 years. The most recent is Jim Chapman Reservoir on the Suphur River, which was dedicated in 1991 (TWDB 2012). There are not many sites left in Texas where reservoirs can be built and those that do exist often contain important biological resources that would be destroyed by reservoir construction including much of the State's remaining bottomland hardwood forests and other very significant fish and wildlife habitat. A prominent example was the proposed Fastrill Reservoir on the Neches River, the site for which was identified by the U.S. Fish and Wildlife Service as a Priority One Conservation Area in 1985. The latest State Water Plan (Water Plans are issued every five years) envisions 26 new major impoundments and there are significant environmental concerns about many of these projects (TWDB 2012). Finally, private landowners in Texas have become increasingly politically aggressive in resisting the taking of private property for reservoir construction through eminent domain (Southwest Farm Press 2007). In sum, all of these factors make the process for approval, financing and construction of reservoirs a challenge that can take many years to complete.

Another important factor constraining the use of surface water is that the State has provided very little protection historically for what are called "environmental flows." These are the quantities of water deemed necessary to sustain aquatic life in the rivers

and the bays and estuaries into which they flow. "Instream flows" are essential to support freshwater aquatic life in the upper reaches of river systems and "freshwater inflows" help maintain the health of our bays and estuarine systems (Hess 2005). The Texas Legislature did not officially recognize that protecting the aquatic environment was a beneficial use of water until 1985 when fairly modest provisions were included in water rights permits for the first time to protect environmental flows. By that time, unfortunately, the vast majority of Texas' surface water had already been permitted for use, therefore not available for environmental purposes (Lee 2012).

Signs of Hope, Scenes of Conflict

Recognizing both the environmental and political consequences of this dire situation, a major educational effort, known as the Texas Living Waters Project, was launched in the 1990s to educate decision makers and the general public about the environmental and economic impacts of wasteful water development as well as the availability of cost-effective, environmentally sound alternatives (Texas Water Matters 2011). This initiative was ultimately successful in 2007 in encouraging the Texas Legislature to lay the groundwork for protecting environmental flows. From an ecological standpoint, if we are not able to sustain the flow of freshwater to our bays and estuaries, their biological productivity can decline substantially. These areas provide not only the best coastal sport fishery in the country but also billions of dollars of annual economic benefit to the state through waterfowl hunting, bird watching and commercial harvest of oysters and shrimp.

In a discouraging decision, the Texas Commission on Environmental Quality recently declined to seize the opportunity provided by the Legislature by promulgating a very weak set of environmental flow standards for the first two rivers to go through the process, the Sabine and the Trinity (Kramer 2011).

Largely as a result of these daunting challenges to Texas' limited surface water supply, the State is increasingly looking at groundwater as its principal water source (TWDB 2012). Groundwater use in Texas is not a new concept. San Antonio, for example, has historically been 100% dependent on groundwater from the Edwards Aquifer for both industrial and municipal use. A primary reason for this situation is that for nearly one hundred years Texas did not regulate groundwater use in any way.

A Texas Supreme Court decision in the early 20th Century declared that groundwater was too "mysterious and occult" to understand and thus to regulate (Houston and Texas Central Railway Co. v. East 1904). Since then the rule for groundwater use in the State has been the "rule of capture" meaning that anyone owning land above a subterranean water source could pump an unlimited amount of water for any purpose. This total lack of regulation for groundwater is in stark contrast to the very heavy regulation of surface water and is the primary reason that "Texas aquifers have been subject to uncontrolled and harmful pumping." Despite the creation in recent years of Groundwater Conservation Districts in Texas, "Critics suggest that problems of self-interest, limited funding, local politics and the self-limiting nature of these districts prevent meaningful management and protection of groundwater resources" (Kaiser 2001).

Another complicating factor is that Texas' nine major aquifers and twenty-one minor aquifers are very different hydro-geologically. Some underground reservoirs, including the Edwards Aquifer which lies in very porous limestone, recharge themselves fairly regularly, while others were charged as long ago as the Ice Age and do not replenish (George and Mace. 2011). In recent years, the Texas Legislature has enabled the establishment of local groundwater conservation districts to begin bringing some semblance of order to groundwater use in the state (Figure 10). However, many of these districts are organized along county lines rather than the natural boundaries of the aquifers, are very poorly funded, and lack either the fundamental science or expertise to successfully do their jobs. Complicating these impediments is the fact that citizens who are affected by the actions of these districts are often uninformed as to their activities and unlikely to participate in elections for their leaders.

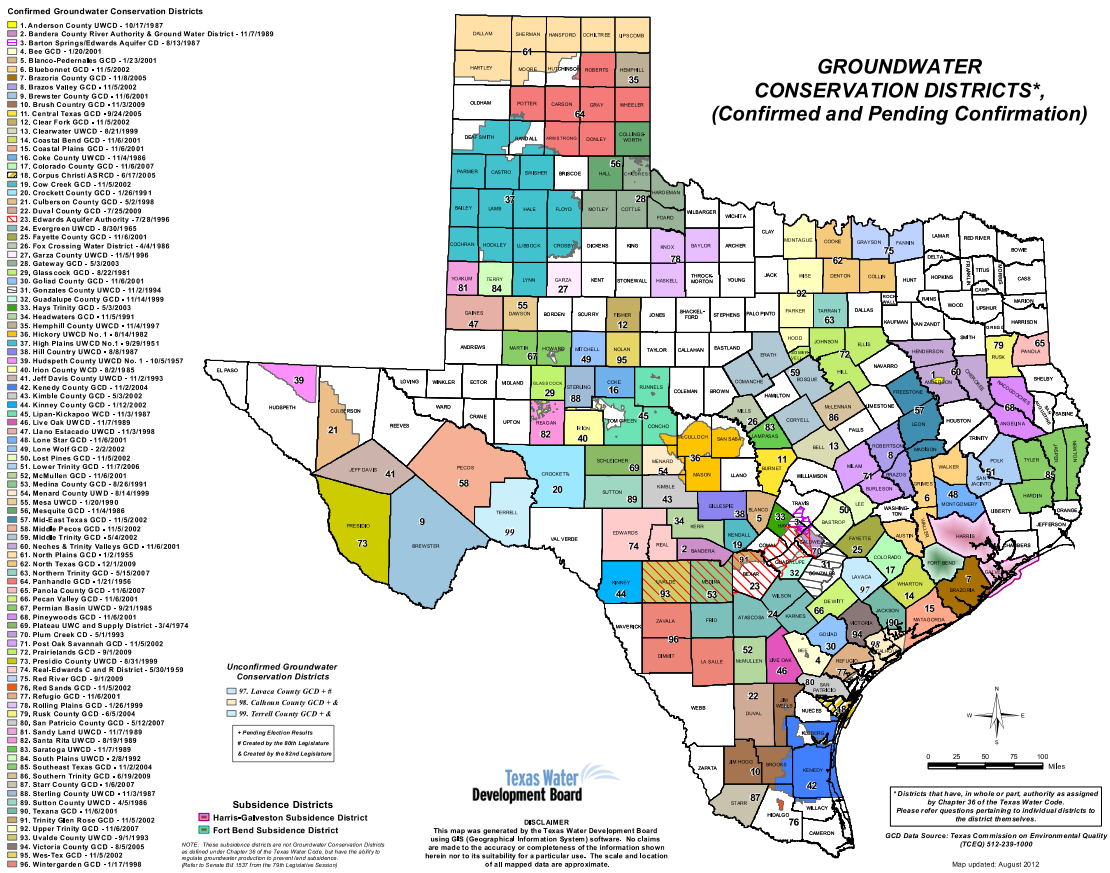


Figure 10. Texas Groundwater Conservation Districts. (Courtesy of TWDB n.d.).

Most scientists concur that there are substantial groundwater reserves available that directly affect, and even maintain, our surface waters through spring flows. Without greater capacity on the part of the groundwater conservation districts, greater public education, and without laws and policies linking groundwater and surface water, sustainable management of these resources will be ineffective.

Traditionally, it has taken a crisis to spur Texas politicians to address the State's water problems. Much of the existing water infrastructure and the planning process on which the future of the State depends developed in the wake of the drought of the 1950s, the so-called "drought of record" (TWDB 2012). Currently, Texas is experiencing potentially just as serious a drought which has caused wells to go dry, wildfires to break

out across the state and reservoirs to decline. In fact, the month of July 2011 was the warmest month ever recorded statewide in Texas. Still, according to the Texas State Climatologist, the most severe drought overall is still the period from 1950 to 1957 (Nielson-Gammon 2011). More ominous, climate experts now suspect that the geographic area we now call Texas may have experienced far more serious conditions than in the "drought of record" in previous centuries (Miao et al. 2007). By the end of the 20th Century, however, most Texans had migrated to urban areas where the effects of drought are not so obviously felt as long as water flows from the tap, compared to earlier times when most lived on farms or ranches or in small towns.

Nevertheless, a drought in the 1990s sparked a new spate of water related laws that provide the context for addressing Texas's future water needs in the new century. Senate Bill 1, passed in 1997, is considered a landmark piece of legislation (Senate Bill 1 1997). Its centerpiece is the creation of a "bottom-up" planning process that involves local interests and stakeholders in regional committees replacing the old centralized planning system that came into being after the drought of record which is defined as "the period of time during recorded history when natural hydrological conditions provided the least amount of water supply" (TWDB 2012). Unfortunately, many of our river basins were divided when these regional planning groups were established, making system-wide planning very difficult. In addition, some of the groups considered environmental issues important, while others ignored them completely, rendering their decisions ineffective at best and destructive at worst. Clearly, the "bottom-up" process, to function effectively, is dependent on participants who are informed and motivated.

As Texas has continued to urbanize, another disturbing trend in recent years is the increasing lack of consideration for issues of concern to rural areas and small towns. Dallas, for example, seeks to impose unwanted reservoirs on East Texans, while San Antonio continues its reliance on the Edwards Aquifer, threatening spring flows in New Braunfels and San Marcos and the water supplies of downstream communities, including Seguin and Victoria.

The planning system put in place through Senate Bill 1 demonstrated that groundwater would have to play a much bigger role in the future and, as a result, its management became the basis for Senate Bill 2. This second major piece of legislation, enacted in 2001, enabled the creation of groundwater conservation districts throughout the State, thus amending the rule of capture for the first time in a century (Texas Water Matters 2001).

Finally, in 2007, the Texas Legislature took another bold step and established for the first time, a process for protection of environmental flows in the State's rivers and streams with Senate Bill 3.

Today, thanks to the increased public participation mandated by the new laws, continued population growth, persistent drought and the obvious fact that some of our most important sources of water are increasingly limited, water remains in the forefront of public policy in Texas. Unfortunately, for most of our citizens, especially Texas children who will be the leaders of tomorrow, as long as water continues to flow from the tap, the erroneous perception is that there is no problem.

In this context, water education is absolutely essential.

Pathways to Sustainability

One of the most promising ways to extend our supplies of water is through increased efficiency and conservation in both agricultural and municipal use. The City of San Antonio has made major strides in water conservation, decreasing per capita water consumption by as much as 40% while consumption in other Texas communities has continued to grow (Jervis 2011). Certain agricultural sectors, particularly in the High Plains, have dramatically improved the efficiency of irrigation practices, while consumption in other farm communities, particularly citrus, is way behind (Sauls 2008). Many cities and water authorities are looking closely at re-use of treated wastewater, which, while intuitively logical, may cause problems for communities and interests downstream depending on return flows.

Finally, looming over all these issues is the fact that all modern water planning in Texas for the past half century has been based on the notion that the drought of the 1950s is as bad as our water situation is going to get. Today, with the widespread consensus that the climate is indeed changing as a result of both natural and human-induced phenomena, such thinking is outdated and unhelpful. Examination of fossil records, studies of tree rings and ice cores from the poles demonstrates that climatic extremes far greater than previously envisioned may well be experienced by humanity in the coming decades (Fowler et al. 2012).

Accordingly, educated consideration of climate change is essential to discussions of future water resource planning and management in the State, despite the fact that recent state water planning has minimized or ignored it. Anticipating the uncertainties of climate change will help us prepare more thoughtfully for the future (Dawson 2011).

Ensuring there are water resources in Texas that can help meet our needs requires that we plan wisely and we now have a process in place that is transparent and dependent on public participation (TWDB 2012). It is up to us to be educated, informed, and engaged. Indeed, the future of our children may depend in large measure on their water literacy.

Lighting the Way

The purpose of this research was to assess the effectiveness of one of the most extensive efforts to educate school children about water resources in the United States at what is known as Aquarena Center on the Texas State University-San Marcos campus. Although the University has been at the forefront of efforts to increase water literacy, little evaluation has been done to measure program effectiveness.

Using a mixed methods research design, in particular, the questions that guided this research were as follows:

1. How well does the informal education program at Aquarena Center convey water education to students and teachers?
2. How did students and teachers rate the experience at Aquarena Center and what environmental activities followed their visit.

In addition to these questions, this researcher explored the following: 1) did the experience at Aquarena Center result in a deeper understanding by students and teachers of water issues; 2) did the field trip experience result in a strengthened belief in the importance of water; 3) what particular issues and experiences from the field trip significantly contributed to the experience; 4) were insights from the experience at Aquarena Center incorporated into lessons back at school; 5) as a result of the field trip,

have teachers incorporated technology in the classroom or other venues to teach about water; and 6) as a result of the field trip, have teachers attempted to involve their students in service learning or experiential activities? The first three questions focused on the short-term aspects of the field trip experience, while the last three addressed longer-term post activities on water education after returning to the classroom.

In 1994, Texas State, then Southwest Texas State University purchased Aquarena Springs Resort, transforming the mission of the former amusement park from entertainment to preservation and education (Kleiner n.d.). In 2005, responsibility for stewardship and operation of the site was assigned to the River Systems Institute, now known as the Meadows Center for Water and the Environment (Haurwitz 2012).

This historic renaming signifies a transformational gift to Texas State from the Meadows Foundation. For many years, the Meadows Foundation, located in Dallas, Texas, has been a leading philanthropic institution for support of the Environment, being one of the original funders of the River Systems Institute. In August of 2012, Ms. Linda Evans, President of the Meadows Foundation announced a gift of $1 million to the University, to be followed with an expected additional $1 million annually for a period of four years. These funds are expected to be matched by the University from other sources for a total of $10 million to be used to endow a series of chairs, professorships, and graduate fellowships devoted to the study of water and the environment (University News Service 2012).

With the benefit of these new resources, The Meadows Center for Water and the Environment will first establish an endowment for the Center Director and an Endowed Professorship in Environmental Flows. To follow will be additional Endowed Chairs for

Watershed Research and Environmental Education, and an additional Endowed Professorship in Water Conservation. A prestigious series of scholarships will be established for highly competitive graduate students to be known as Meadows Fellows.

Headquartered in the restored Aquarena Springs Resort Hotel, the Center is ideally situated for its mission of studying and safeguarding river systems and monitoring crucial issues concerning freshwater resources in Texas and beyond. Its offices overlook the San Marcos Springs and Spring Lake, making up the hydrologically-linked headwaters of the San Marcos River, which winds its way through the University campus (Figure 11). In addition to the Meadows Center Senior Staff, the venerable old building is also home to all of the scientists from the Texas Parks and Wildlife Department (TPWD n.d.) who study rivers and streams. Their presence creates a powerful synergy for collaboration and is a direct result of the Department's financial contribution to the restoration of the building itself.

Figure 11. The Meadows Center for Water and the Environment n.d.

The Meadows Center for Water and the Environment was established to study, protect, and interpret the remarkable aquatic system that surrounds it. The San Marcos Springs are a living metaphor and inspiration that extends to freshwater systems and issues across the state, the nation, and the world. The Center's home at Texas State University-San Marcos is close to the State Capitol in Austin, affording its leadership access to policymakers and administrators working to find solutions to ever more urgent water issues (Figure 12).

The Meadows Center's mission is to research, develop, and promote holistic approaches to the management of freshwater systems which include aquifers, springs, streams and the watersheds that feed them, as well as the lakes and estuarine systems into which they flow. The scientists, faculty, graduate students, and interpreters who make up The Meadows Center Team accept as core values the principles of sustainability and

equitable use for water policy and strategy at the local, state, national, and global level (Meadows Center, n.d.).

The Meadows Center for Water and the Environment is a unique institution established in January of 2002 as an integrating mechanism to coordinate and encourage interdisciplinary and campus-wide efforts in freshwater research, education, service, and stewardship. As a funder and strategist, it provides opportunities for faculty and graduate students from a range of disciplines to engage in scientific research and gain invaluable experience in freshwater conservation and management activities. Staff of the Center is distinguished and includes a former Interim President of the University, the former Executive Director of Texas Parks and Wildlife, the former Deputy Director of the Water Branch of the United Nations Environment Programme, the former Director of the Oregon Department of Fish and Game, and a former Associate Director of the Water Lab at Utah State University who serves as Chief Science Officer. The former Director of Fish and Wildlife in both Oregon and Texas, who also served as President of Safari Club International, rounds out a team that includes underwater archaeologists, geographers, planners, biologists, and educators who have worked together to create the Center's impressive record of accomplishment. Finally, The Center Leadership has initiated a significant initiative in Conservation Leadership which has mentored and trained some of the brightest young natural resource professionals in Texas (Meadows Center n.d.)

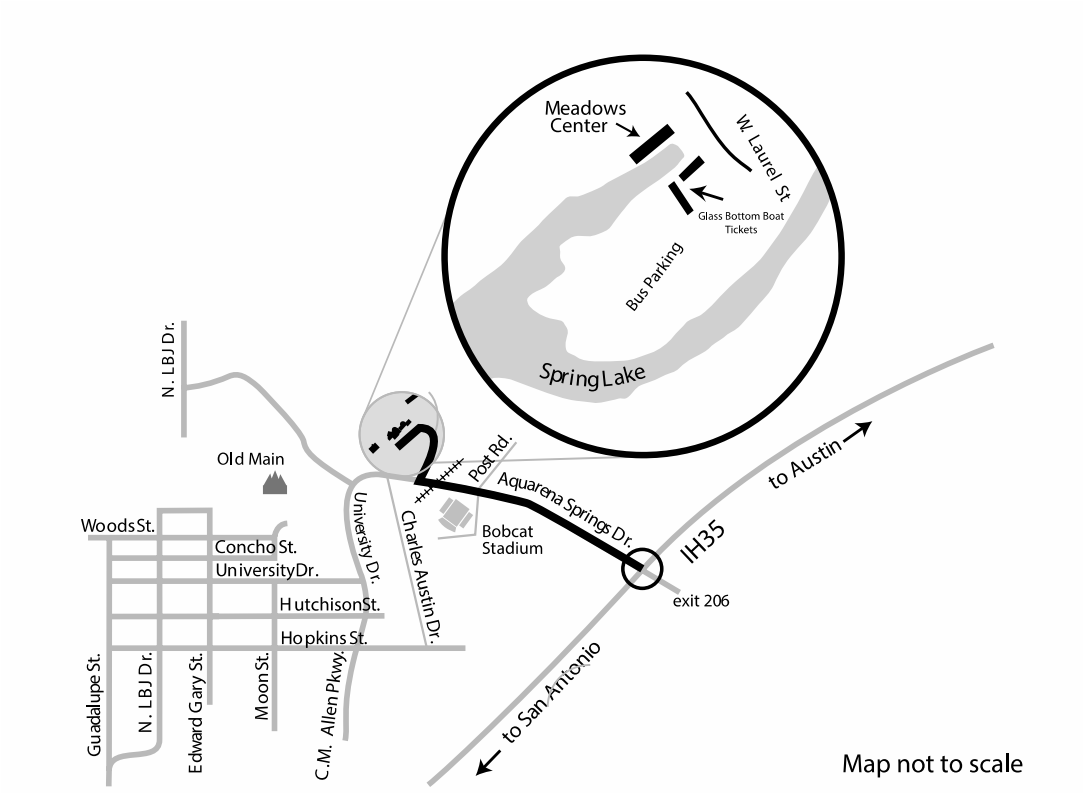


Figure 12. Location of Meadows Center for Water and the Environment. Meadows Center n.d.

The Meadows Center for Water and the Environment is also the home of Texas Stream Team, formerly Texas Watch, which coordinates the work of trained volunteers in collecting information about the quality of the State's water resources. Texas Stream Team is a volunteer network funded through collaboration between Texas State, The Texas Commission on Environmental Quality, and the Environmental Protection Agency (EPA) (Texas Stream Team n.d.). The Stream Team leads the Center's efforts in watershed protection, research, and planning, specifically in supporting processes that blend stakeholder training, education, and engagement with science based data collection and information dissemination.

The four main functions of the Center include research, environmental education, stewardship, and service. These key functions are manifest through the following goals:

- Advancing the educational and research mission of Texas State University-San Marcos.
- Ensuring protection of the unique cultural and natural resources at the San Marcos Springs.
- Instilling in all who participate in its informal educational programs and its research an understanding and appreciation of the springs and the role of water in their origin and connection to the region (Meadows Center n.d.).

CHAPTER II

WATER EDUCATION AT THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT

A Unique Educational Opportunity

The centerpiece of the informal education function is Aquarena Center, which manages an extensive informal environmental education program on the site of the former amusement park. The educational program is an operating division of the Meadows Center for Water and the Environment and has established as its mission *"to provide people of all ages with the ability to recognize Spring Lake as a unique freshwater ecosystem through interpretive experiences that engage the audience in an exploration of interconnections between all living things and water."* (Meadows Center n.d.).

To fulfill its mission, Aquarena Center offers a variety of informal educational opportunities for all ages and types of groups. The interpretive staff specializes in experiential learning programs, which are customized to meet specific grade levels and classroom learning goals including those of the Texas Essential Knowledge and Skills (TEKS), which are the state standards for what students should know and be able to do (TEKS n.d.).

These programs now reach an impressive number of visitors. Nearly 125,000 people come to Aquarena Center every year to participate in its programs. Of these, approximately 25,000 are teachers and school children who arrive in buses on pre-

arranged field trips tailored to their needs, including specialized content focused on particular units of study (for example, food chains).

This effort is particularly crucial at a time when the water resources of Texas are under increasing stress from the dual pressures of climate change and an exploding population, while there is little understanding of the direct connection between the viability of resources such as San Marcos Springs with the health of the aquifer itself, the Guadalupe River Basin, and the bays and estuaries on the Gulf of Mexico into which it ultimately drains.

This setting is a metaphor for river systems around the world. In order to maximize its contribution to the informal education of school children in Central Texas, interpretive programs presented to them are designed to be informative, exciting and fun. Research has shown that children who are exposed to extraordinary natural experiences at an early age not only do better in the classroom but also are often motivated to pursue further studies and career choices related to the environment as adults (Wells 2006). To this end, the staff of Aquarena Center communicates with teachers in advance of field trips to the springs and can often tailor their visit to help meet the requirements of various standards and achievement tests.

The normal field trip experience at Aquarena Center consists of three primary components. First, with support from the Meadows Foundation, the Shell Companies and others, the University has constructed an extensive system of boardwalks through freshwater wetlands on the perimeter of the lake itself (Figure 13). The wetlands walk allows teachers and students to be guided through one of the most important elements of the aquatic ecosystem and to be led to understand the contributions wetlands make to the

environment, including providing habitat for numerous species of birds, helping to remove pollutants from the water itself, and providing protection for the landscape from the effects of flooding and other natural hazards.

Figure 13. On the Wetlands Boardwalk, (Courtesy of the Meadows Center n.d.).

To complement the wetlands experience, an indoor system of aquaria and other exhibits provide the opportunity for children to better understand the subterranean ecosystem, including actually viewing live specimens of some of the creatures that inhabit it, and to engage in interactive experiences that help prepare them to make informed choices with respect to water conservation and management.

Finally, the *tour de force* for students of all ages is a ride on a glass bottom boat, with origins in the earliest days of the amusement park following World War II (Figure 14). There is no experience short of scuba diving that provides such a vivid opportunity to view the aquatic ecosystem of Spring Lake. For up to an hour, students are captivated

by the opportunity to see water actually emerging from the Edwards Aquifer from low and high pressure springs, to observe the aquatic fauna of the lake directly including turtles, birds and numerous species of fish, and to actually look down on an archaeological excavation which has produced over 100,000 stone tools and paleological artifacts, including the bones of mastodons and the teeth of ice age horses (Shiner 1983).

Figure 14. On the Glass Bottom Boat. (Courtesy of Meadows Center n.d.).

Barriers to Understanding

With respect to more formal education, the logical place for water education for middle and high school students is in either geography or environmental science classes. Unfortunately, due to geography's placement within the social studies, many geography teachers have completed little, if any geography coursework as part of their certification program. Instead, preservice education generally consists of content coursework spread over multiple social studies fields, including history, economics, and political science. Of the 48 colleges and universities offering secondary social studies teacher certification, 79 percent require six or fewer credit hours of geography, while 36 percent require three or fewer, and 15 percent do not require a single geography course (Frazier 2010). Yet the teachers completing these varied requirements are certified to teach world geography. As a result, many teachers lack even a basic knowledge of physical geography, much less specialized knowledge in water.

This problem may be compounded by what University of Northern Colorado Geography Professor Karen S. Barton speculates is an "outdoor to indoor" migration similar to the urban-rural movement of Americans alluded to earlier in this document. Writing in the Journal of Geography, Barton suggests that dwindling exposure to nature may impact conservation efforts and understanding this dynamic is therefore important for geographic educators in both the classroom and the field (Barton 2012).

Not surprisingly, this lack of exposure to nature extends to the general public as well and, in turn, contributes to the difficulty of obtaining consensus or even support for controversial or expensive measures needed to address pressing water and other environmental problems. All of these issues suggest that an effort to enhance the appeal

and impact of informal outdoor education is important and potentially very significant to the geographic education community.

In 2004, The Texas Water Development Board, through the firm EnviroMedia, commissioned Baselice and Associates to conduct a statewide telephone poll to attempt to measure water literacy among the general public in the State (EnviroMedia 2004). A random sample was drawn of 1,228 respondents during the first week of August 2004. The principle objective of this study was to explore attitudes and perceptions about water conservation.

The researchers concluded in this study that timing was right to launch an aggressive statewide water conservation campaign. In fact, a full 98% of the study's respondents indicated a belief that water conservation was important. On the other hand, just as striking was the finding that only 28% of Texans know where their water comes from. Further, only 17% of Texans have any knowledge of what plans the State has for addressing future water needs. The study additionally exposed a striking lack of knowledge as to how water is used in Texas and by which economic sector, i.e., agriculture, municipalities, industry, etc. Finally, although water is generally thought to be the most significant natural resource issue facing the coming generation in Texas, only 18% of Texans believe it is the biggest environmental problem (EnviroMedia 2004).

In focus groups conducted as a follow up to the quantitative survey, these findings were strengthened as awareness among participants of water resources generally proved to be very low. Most telling, researchers concluded that the possibility of the State of Texas running out of water "has not crossed people's minds and is generally thought to be unbelievable" (EnviroMedia 2004).

Finally, a third component of this research was composed of an intensive series of interviews among 100 stakeholders actively involved in Texas water issues, including municipal officials, agriculturalists, industry leaders, environmentalists, and others. Among this group, water was clearly identified as the most critical environmental issue in Texas, and public education and outreach was determined to be the most effective strategy for achieving statewide water conservation goals (EnviroMedia 2004).

Water is one of the most, if not the most critical environmental or natural resource issue facing Texas today, with public education and outreach seen to be the most effective means of addressing it. Unfortunately, water knowledge among the public is not substantial, and this lack of knowledge is a serious concern. Further, knowledge concerning the efficacy of informal education programs designed to convey water information is not great. Therefore the underlying objective of this research project is to examine the efficacy of the informal water education program at the Meadows Center for Water and the Environment.

A Natural Classroom

The water education programs examined in this research are informal in nature and presented at the Aquarena Center, a division of the Meadows Center for Water and the Environment at Texas State University-San Marcos. The water education programs of Aquarena Center are conducted on a site, which for many years was the location of Texas' first and most successful amusement park. Its centerpiece is the San Marcos Springs, an exceptional setting for place-based informal environmental education.

The San Marcos Springs are the second largest artesian springs in Texas and regularly produce flows that often exceed 100 million gallons per day (Musgrove and Crow 2012; Brune 1981). The springs emerge from the southern or San Antonio segment of the Edwards Aquifer which stretches 170 miles from Brackettville, Texas in the West to Kyle, Texas, located north of the City of San Marcos on Interstate 35. The Springs are located in the artesian zone of the aquifer that was formed by a series of earthquakes 15 to 27 million years ago. This tumultuous geologic history resulted in formation of the Balcones Fault along the aquifer's eastern perimeter, creating immense pressure that causes the springs to burst to the surface with significant force (Musgrove and Crow 2012; Brune 1981).

The unique natural hydrogeological conditions of the San Marcos Springs have created an environment over millennia that provides habitat for an extraordinary endemic community of flora and fauna, some of which occur nowhere else in the world. There are eight federally listed endangered and threatened species that inhabit the site, including San Marcos Salamander (*Eurycea nana*), Texas Blind Salamander (*Eurycea rathbuni*), Texas Wild Rice (*Zizania texana*), San Marcos Gambusia (*Gambusia georgei*), Fountain Darter (*Etheostoma fonicola*), Comal Springs Riffle Beetle (*Heterelmis comalensis*), Comal Springs Dyropid Beetle (*Strygoparhus comalensis*), and Peck's Cave Amphipod (*Stygobromus pecki*) (Meadows Center, n.d. [b]). The United States Fish and Wildlife Service (USFWS) has designated the Springs and 4.5 miles of the San Marcos River headwaters which flow from them as critical habitat for these creatures. Critical habitat is defined as a particular geographic area containing all of the physical, chemical and biological components necessary for the survival of an endangered plant or animal,

(Endangered Species Act 1973). The presence of this habitat and the unique species it supports make the site extremely significant biologically and requires rigorous attention to its stewardship in accordance with both State and Federal law.

To the best of human knowledge, the San Marcos Springs have never stopped flowing, with the steady supply of freshwater resulting in their being considered one of the oldest, if not the oldest continuously inhabited places by human beings on the North American continent (Van Oudekerke 2011). Stone tools crafted by indigenous peoples in prehistoric times have been found along the ancient riverbed that are at least 11,500 years old, indicating that humanity has been present on the site in every known period of human habitation in Central Texas. Even more evidence of habitation during the archaic period has been found indicating extensive use of the site from about 7000 BC to 500 AD (Kimmel 2006). Much later, the first indications of visitation by Spanish explorers are notes from an expedition led by Alonzo De Leon who arrived at the Springs on Saint Mark's Day in 1689, appropriately naming them the San Marcos Springs (Brune 1981). This was De Leon's third expedition in response to word that the Frenchman, La Salle, had reached the region and claimed it for his nation, a fierce rival of Spain.

In the 18th Century, the Springs became a popular stopover on the El Camino Real de los Tejas, the principle route used by the Spanish travelling from Mexico City to the Northeastern extremity of their colonial empire in Louisiana. In 1845, General Edward Burleson, a soldier and Indian fighter who was a veteran of the battle of San Jacinto that resulted in Texas' independence from Mexico, acquired the land around the springs from the original Spanish land grantee, Juan Veramundi. Burleson, who served as the first

Vice President of Texas, built a cabin on the hillside overlooking the springs and dammed them up a year later; creating what is now Spring Lake to power a gristmill. In 1851, Burleson, by then a state senator, founded the City of San Marcos (Bousman and Nickels 2003).

A half century later, just prior to the turn of the 20th century in the late 1890's, a mortician named A.B. Rogers purchased the property and, in 1929 built the Rogers Spring Lake Park Hotel. At the grand opening in April of that year, guests dined and danced on the hotel roof, played golf, and swam in the springs, but the nation was plunged into depression that same year and the grand old building was ultimately converted to a rehabilitation facility and operated as such until 1960. That year, Rogers' son Paul took the building through its first restoration, returning it to its original glory as a fine resort hotel. Paul Rogers had purchased the property from his parents in 1949, one hundred years after the erection of the dam. Shortly thereafter, he launched the first glass bottom boats on the lake accompanied by the announcement that a ride on the boats would provide visitors with the opportunity to "explore a veritable fairyland and see aquatic life undisturbed in its natural habitat" and experience a "restful, relaxing, and educational trip over the headwaters of the picturesque San Marcos River," providing a glimpse of "the widest variety of freshwater life in the nation" (Weber 2009).

In the years that followed, Paul Rogers established what came to be known as Aquarena Springs Resort, ultimately to become one of the largest commercial tourist destinations in Texas. With the rise of other, more elaborate amusement parks in the state, the aging family-owned resort entered a long decline, and the site was subsequently rescued from adverse development when purchased in 1994 by Southwest Texas State

University, now Texas State University-San Marcos. Today, as part of the Meadows Center for Water and the Environment, which is housed in the newly restored hotel building, it is one of the foremost freshwater environmental education centers in the nation, with over 100,000 annual visitors, including approximately 25,000 school children who come to the Center on organized field trips each year.

Aquarena Center's mission is: *to enhance Texas State University's educational, research, service and leisure activities; to promote the protection and preservation of the San Marcos Springs and related ecosystems; and to foster an appreciation and stewardship of natural and cultural resources.* Specifically, Aquarena Center's educational mission is to provide people of all ages with the ability to recognize Spring Lake as a unique freshwater ecosystem through interpretive and interactive experiences that engage the audience in an exploration of interconnections between all living things and water (Aquarena Center n.d.).

In fulfilling its mission, Aquarena Center has created a well-organized and widely known venue that features environmental education themed tours of the site. Arriving in school buses from locations throughout Central Texas and beyond, students are led on organized field trips that range in length from 3 or 4 hours to a full day. The students and their teachers are given basic instruction and hands-on experience aimed at instilling in them a greater appreciation of water conservation, pollution prevention, endangered species conservation and protection of threatened habitats. In consultation with teachers well in advance of field trips, programs are customized for each group. Tours include some or all of a wide range of activities led by trained interpreters, including tours of the lake on glass-bottom boats; a visit to aquaria displaying specimens of some of the

springs' endangered species; and a walking tour through the lake's freshwater wetlands (Figure 15). Students may also participate in various interactive exercises including sampling of invertebrates from the lake (bug picking) and other fun and experiential learning activities (Aquarena Center n.d.).

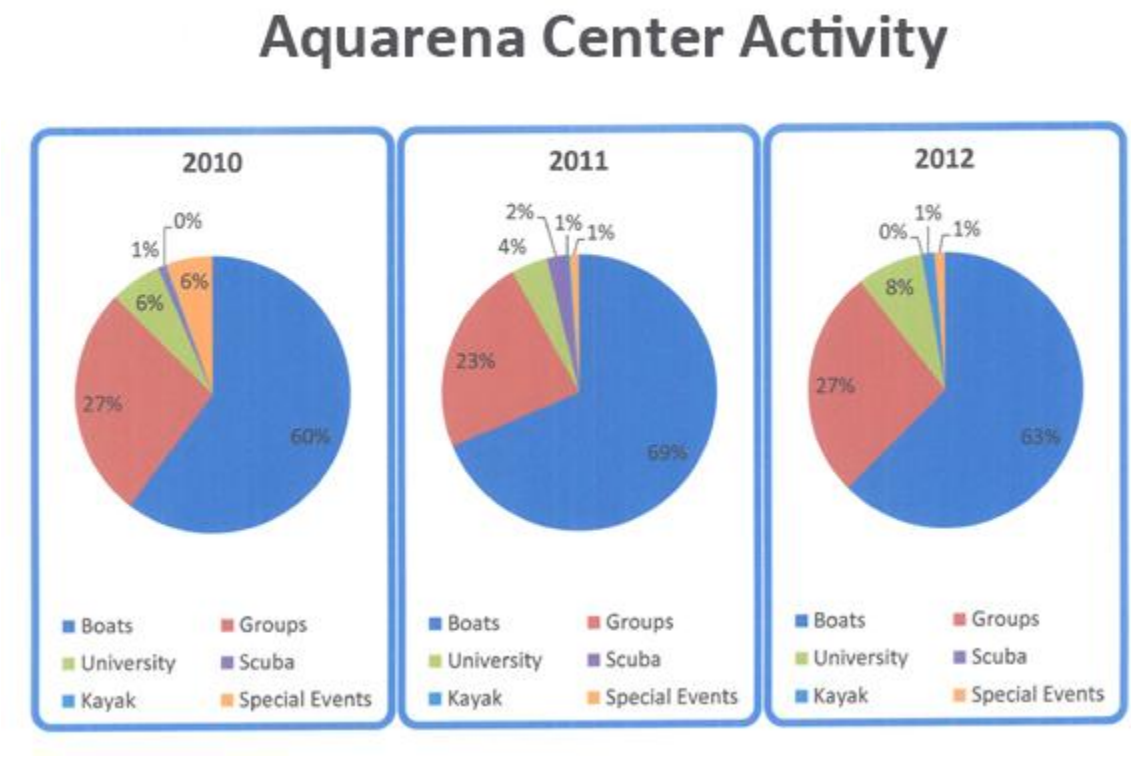


Figure 15. Aquarena Center Activity, (Courtesy of Aquarena Center 2012).

As referred to earlier, learning goals include providing people of all ages with an understanding of the following themes: Ecosystems and how they work; Water, the Lifeblood of the Earth; Interconnections, the Delicate Balance of Sustainability; Uniqueness of Spring Lake; History, Geography, and the importance of place; and Human Environmental Impact and Stewardship (Aquarena Center n.d.).

At Aquarena Center, the Curriculum Coordinator is responsible for developing and implementing all educational programming. It is the responsibility of the

Coordinator to ensure that educational offerings meet various local, state and national educational goals as well as the specialized needs of the individual groups. The Coordinator maintains professional affiliations with environmental, scientific, experiential and cultural educators and associations. The Coordinator works closely on a daily basis with the Boat and Interpretive Tour Supervisor and the Aquarium Supervisor.

The Aquarium Supervisor manages all exhibits containing living specimens of both endangered species that inhabit the lake, and more common native species as well. The aquaria are specifically designed to display the unique habitats of the Edwards Aquifer and its spring systems as well as the individual organisms. The Boat and Interpretive Tour Supervisor manages a fleet of custom-built, wooden, electrically powered glass-bottom boats and the staff that maintains and operates them. The primary goal of the Boat and Interpretive Tour Supervisor is to ensure that the boat operators or interpreters are properly trained to deliver accurate, engaging and informative information, and that the boats are maintained to such a standard that all visitors, including school children, leave with a positive experience.

For purposes of this study, the educational program for high school students entitled *On the Water's Edge* was examined. This presentation provides students with a comprehensive background in understanding aquatic trophic levels, the impact of exotic species on diverse ecosystems, an introduction to endangered plants and animals and rudimentary water quality testing and invertebrate collection and identification. It is specifically designed for students in biology, science and environmental science. The program generally lasts 3 to 4 hours and includes physically getting into the water for insect collecting and water testing activities.

These activities and more constitute learning experiences outside the classroom. Such experiences lend themselves well to geographic education according to Professor Amy Richmond Krakowa at the United States Military Academy at West Point (Krakowa 2012). It is critical, however that we determine the efficacy of such programs in order to ensure that they are actually accomplishing their objectives. One reason informal educational field trips are effective is that the students enjoy being outside the classroom. This dimension requires that evaluation of such programs be both quantitative and qualitative in order to measure both the actual transfer of knowledge but also the perceptions and impact on students of the experience itself.

Therefore, both qualitative and quantitative methods were used in this research, including test instruments and interviews. The mixed methods design enabled the researcher to gain a more complete understanding of both the quality and the pedagogical efficacy of the experience.

CHAPTER III

REVIEW OF THE LITERATURE

Organization of the Literature Review

The following literature review addresses the state of Environmental Education in America with emphasis on sustainability and quality resource management. The review examines the theory and practice of informal outdoor education as practiced in the United States, including consideration of the differences between "formal" and "informal" education. It concludes with an emphasis on water education and the application of these educational delivery systems to Education Standards in Texas.

Environmental Education in the United States

Environmental education has been practiced in the United States for many years in various venues across the country, including summer camps, urban nature centers and through programs designed to interest young people in "consumptive" outdoor recreation pursuits, primarily hunting and fishing. There is much in the literature on the subject. The movement and practice of informal nature related education, however, catapulted to the front page in recent years with the publication of Last Child in the Woods: Saving Our Children from Nature Deficit Disorder by Richard Louv (Berns 2009). In this work, which has become a modern classic in the environmental movement, Louv takes what has been understood through common sense that is that being outdoors is good for children,

to a new level by providing empirical evidence that outdoor learning and play contribute directly to alleviating some of the most daunting pathologies affecting children today including obesity, attention deficit disorder and depression (Louv 2006). Children are increasingly deprived of direct contact with nature and are experiencing negative consequences as a result. Today, research has shown that young people between the ages of 8 and 18 spent an average of 6.5 hours a day in front of one kind of electronic screen or another (Roberts, Foehr, and Rideout 2005). Another recent study demonstrated that a group of 8 year olds had greater success identifying animated characters from the Japanese electronic game, *Pokemon,* than common plants such as oak trees in their own back yards (Balmford et al. 2002). Last Child in the Woods: Saving Our Children from Nature Deficit Disorder has served as much as anything else to bring together a modern and expanding body of research leading to the conclusion that experience in nature is essential for wholesome child development. His findings, although sometimes criticized as simplistic, have been verified by other researchers in direct relevance to this study (Driessnack 2009). Louv cites other work indicating that students who participate in healthy outdoor play and informal nature related education outperform their peers in traditional classrooms.

Other researchers have demonstrated that, beyond such healthy outcomes resulting from experiential learning in the outdoors, children who participate in such activities are much more likely to develop pro-environmental views and a higher level of understanding of environmental issues than children who do not (Cachelin, Paisley and Blanchard 2009). This finding strengthens the theory that instilling in students an appreciation of nature, particularly water, will serve to prepare them to be more

responsible citizens and decision makers as adults. Further, "place-based" informal outdoor education can help develop practical wisdom and useful problem-solving skills essential to development of environmentally responsible citizens (Havlick 2005).

Much appears in the literature related to the life skills that are developed in informal outdoor experiences which then transferred to daily existence. Outcomes most often mentioned include: enhanced relationships with others, greater self-awareness, greater understanding and appreciation of the environment and new skills (Holman 2005). In addition, there are strong indications that outdoor adventure or wilderness programs contribute to the development of self-efficacy among participants (Jones 2007). Self-efficacy is generally understood to be a belief in one's ability to organize and execute a course of action required to attain a given outcome (Weiner, Schimitt and Highhouse 2012).

These findings suggest that practioners in many diverse institutions across the United States, including K-12 teachers, are showing a growing interest in providing informal outdoor experiences for their students and engaging them with nature. In addition, government agencies at all levels engaged in the environment have developed various initiatives to encourage environmental education and strengthen teachers' ability to deliver it (Earl et al. 2009). Most state natural resource agencies are connected to national outdoor education efforts including Project Wild and Project Wet. Many also provide resources such as field trip opportunities, workshops for teachers and more. In a 2009 article in the *Journal of Geography,* Earl and others state that much of the content of these programs and initiatives "contributes to

fundamental geographic education themes as specified in the 1983 *Guidelines in Geographic Education K-12* and *Geography for Life: National Geography Standards 1994* (Earl et al. 2009). This interest is evidenced by supportive legislation in a number of states, by increased emphasis on children and nature among conservation organizations and educational institutions and by initiatives in the for-profit sector as well (Louv 2008).

Education for Sustainability

Today it is very clear that achieving sustainability in society will necessitate changes in lifestyles of all people, particularly those in developed countries (Martins, Mata and Costa 2006). Although the definition of sustainability continues to evolve in the literature and in practice, the term is commonly characterized as dealing with the ideas of "living with the limits;" understanding the interconnections between the environment, economy and society;" and "equitable distribution of resources and opportunities." (Mebratu 1998; Mitchell 2000; Ferreira, Alexandre and Miranda 2003). Thus, the connection between the goal of sustainability and education is apparent.

The need for educators to give attention to sustainability is not new. For more than twenty years, practitioners of outdoor and adventure education particularly have argued for their inclusion in informal education programs (Hill 2012).

Among the problems identified with successfully integrating sustainability into both formal and informal educational systems is the lack of a coherent approach to education for sustainability (Martins, Mata and Costa 2006). These authors found that introducing a multidisciplinary and interdisciplinary approach to both teaching

and research is essential. In addition, students need to have a working knowledge concerning the environment, as well as a positive attitude and favorable values (Birdsall 2010). Of equal significance in successfully educating for sustainability are teachers' philosophies, values, understandings and skills (Earl 2007).

It is obvious that complex and difficult pedagogical change will be necessary to seriously address environmental sustainability issues. This pedagogical change must occur at three levels: philosophy, values, and understandings; programming and resource use; and teaching and learning strategy (Hill 2012). Environmental educators must also place increased emphasis on relationships, from coaching to networking and collaboration. Working with colleagues and community groups is particularly important in creating direct experience for students in the outdoors and in conducting such experiences (Riordan and Klein 2010). Interestingly, storytelling can become an appropriate and effective pedagogical tool for sustainability education in forming conceptions, values and attitudes that favor a more positive relationship between humans and the environment (Agelidou 2010).

A frequently mentioned barrier to providing students with experiences that inspire and inform them about sustainability is the time and energy necessary to implement them in the field (Ernst 2009). Nevertheless, sustaining the environment will depend on developing student's problem-solving skills and critical thinking. Sustaining the Earth will require educational reform that builds values into the system and inspires students to become change-makers (Riordan and Klein 2010).

Toward Quality Resource Management

A significant challenge facing society today is the fact that natural resource management has become extremely complex, due to the increased involvement of diverse stakeholders, the growth of both scientific understanding and regulation and increased litigation. These changes in the resource management landscape will increasingly require professionals comfortable and skilled in public involvement and conflict resolution (Sample et al. 1999). In addition, communication, outreach and leadership are identified as key skills for navigating the increasingly troubled waters of quality resource management (Smith 1990; Baughman et al. 1999; Guldin 2003; Machlis and Nyambe 2003; Gordon and Berry 2006). Gill (2004) has written that the coming generation of natural resource leaders will need to be able to combine an understanding and interpretation of science with stakeholder facilitation and leadership.

In this context, informal experiential learning offers great potential for teaching leadership skills (Myllykangas 2004). Most established outdoor education organizations such as Outward Bound and others have been founded on the theory that leadership can best be developed through extensive outdoor recreation and challenge programs (Newman, Bruyere and Beh 2007). Current pedagogical theory also focuses on such experiences for the development of "self-directed, resilient, optimistic, democratically participatory, life-long learners" who can thrive in a rapidly changing world (Falk and Kilpatrick 2000; Kilpatrick and Falk 2003).

Throughout the relevant literature, which is derived largely from publications related to rural life, extension and agriculture, it is clear that to prepare students for

engagement either as citizens or professionals in quality resource management, the most effective principles are to use active and experiential learning to contribute to the development of skills and motivation and to inspire students to connect with local interests, concerns, and places (Lane et al. 2005).

Formal and Informal Approaches

A basic difference between "formal" and "informal" environmental education is that formal approaches are resistant to change and when they do change, it takes a long time to measure results. Informal or non-formal approaches, on the other hand, are capable of changing rapidly, incorporating new information and methods more quickly and easily (Martins, Mata and Costa 2006). Sadly, despite the advantage of rapid adaption and innovation, most states have not consistently encouraged partnering with informal programs, particularly in the STEM agenda (Thomasian 2012).

Another difference is formal educational disciplines, whether science, social studies, or mathematics, have developed their bodies of knowledge over time and "deconceptualized" this knowledge by presenting it in repositories such as encyclopedias, textbooks and multimedia (Hung, Lee and Lim 2012). This tradition has assumed that, in the classroom, knowledge is best transferred through language directly, without full consideration of the belief that "knowing" transcends explicit knowledge (Brown 2002; Barron 2006). Thus, "formal" education may best be characterized as a learning delivery system where the teacher imparts knowledge explicitly through direct instruction (Nasir and Hand 2008). Research into the limitations of formal education has suggested that the rich authentic situations that

occur in communities of practice and experience cannot be simulated in the classroom setting (Boersma et al. 2010).

Informal Learning is less structured and even "messy" (Hung, Lee and Lim 2012). Studies of informal learning suggest that it is characterized by placing participants in settings where they can experiment, or tinker in an environment that is more relaxed than the classroom and where the stakes are low (Barron 2006; Nasir and Hand 2008). One study shedding a more nuanced light on the experience of informal educational activities such as field trips found that although teachers visiting a museum with their students provided structured engagement including workbook exercises and rotating stations, the students were additionally allowed to have brief play periods and free choices of exhibits for closer study (Kisiel 2006).

In this informal process, students actually find meaning in addition to facts. The literature suggests that a more structured understanding emerges from the experimentation and what children are absorbing through informal processes contributes significantly to their learning "to be" (Brown 2005). This form of learning does not often contain specific outcomes which are known or predicted at the outset. However, when opportunities for informal learning through field trips or outdoor experiences are provided for students to create authentic learning experiences, it enhances formal education by giving them greater context and meaning (Hung, Lee and Lim 2012).

Water Education - No Child Left Dry

Scholarly literature on the subject of water education is limited. Most sources are web-based training programs sponsored by government agencies and non-profit

institutions such as the Environmental Protection Agency, various state water resources and fish and game agencies and international organizations including the World Water Council. Some research exists concerning the preparation and presentation of instructional material about water (EPA 2009). A common theme is that in virtually every nation and culture of the world, water and education are closely related, based on the essential requirement for knowing how to deal with growing water issues (World Water Council, 2006).

There is evidence that suggests that collaborative strategies that utilize the skills, talents, and perspectives of diverse institutions in a team approach are effective and that water educational materials and programs developed by such collaborations work better when tailored to specific regions or locations (Cockerill 2010). Of particular pertinence to this research is that students relate closest to water when it is connected to everyday life including recreation and bathing (Aikenhead 1994).

Numerous studies indicate that water literacy is low among students of all ages (Ewing and Mills 1994; Dickerson et al. 2007; Shepardson et al 2007; Covitt, Gunckel, and Anderson 2009). Ironically, though water is generally included in most science education curricula around the world, students "do not understand water's significant role in life (Ben-Zvi-Assaraf and Orion 2005). Compounding the problem is the finding that some teachers feel inadequate in integrating water knowledge and education into classroom activities (Brody 2005; Coyle 2005). Nonetheless, a recent study of a community water education program concluded, "As the strain on water resources continues to grow throughout the world, educating people about how water works will become increasingly important." (Cockerill 2010). According to the

United States General Accounting Office (GAO), we need to inspire a new generation of water leaders because there is increasing competition across the country to meet the freshwater needs of growing cities, suburbs, farms, industries, recreation and wildlife. The report concludes that "Freshwater shortages are likely in the near future and their impact on the economy, environment, and communities may be severe" (GAO 2003).

Many water related institutions have expressed the urgent need for increased water education, particularly for children. The Texas Water Development Board has created a program entitled "TWDB Kids" and states on its web page: "Children today will face a daunting challenge when they are adults: managing and conserving Texas' dwindling water supplies. So that they are equipped for this challenge, these future decision makers will need to be educated about the scientific background and complex issues associated with this critical resource" (TWDB n.d.).

This commitment to educating our children about water is international in scope. One example is "Waterworks," a curriculum resource of the Australian Academy of Science whit the mission statement: "Water is essential to life. As humans, we not only drink water, we use it for cooking, hygiene, recreation and agriculture." Australia is a dry continent with an expanding population, and how we use water has become increasingly important. Water is a precious resource (Australian Academy of Science n.d.). Closer to home in Ontario, Canada, The Children's Water Education Council was created in 2001 with a mandate to "protect our water resources and preserve them for future generations through greater awareness and appreciation for this vital life force." The Council's mission is to

educate students about the importance of water conservation, protection, technology, and ecology (Children's Water Education Council n.d.).

In the United States, one of the best-known water education programs is Project WET. WET is an acronym for Water Education for Teachers. The mission of Project WET, which is an initiative of the Council for Environmental Education, is to "reach children, parents, educators, and communities of the world with water education." Project WET publishes, among other materials, WET in the City: Water Education for Teachers (Council for Environmental Education 2007).

These entities across the world agree with the contemporary research, which indicates strikingly low water literacy among students and adults of all ages (Ewing and Mills 1994; Dickerson et al. 2007; Shepardson et al. 2007; Covitt, Gunckel and Anderson 2009).

Water and the State Standards

Although much of the literature concerning Education Standards in Texas in recent years has reflected controversial debate among members of the State Board of Education concerning evolution and the political nature of the standards process, (Schafersman 2009; Stutz 2009), Texas students score about the same as students across the country in Science (National Center for Education Statistics 2013).

The importance of standards and testing today in the K-12 world necessitates an examination of the Texas Essential Knowledge and Skills (TEKS) to achieve some understanding of what level of water education is occurring in the classroom. The result is mixed. In the Social Studies, where Geography Standards are nested, content is significantly skewed toward History, Economics and Civics. However, given this

limitation, there appear in the standards for elementary, middle school, and high school, some references to water among the geography standards. In Grade 3, students are expected to describe the effects of human processes including conservation and pollution in shaping the landscape (TEKS 2010a). Fourth Grade Geography students must be able to explain the ways humans have modified the environment including wetlands alteration and the impact on water quality (TEKS 2010a). For Middle School Geography students in Grade 6, identification of natural processes, including ocean currents and erosion, is required, along with the location of renewable and nonrenewable resources such as fresh water (TEKS 2010b). Fourth Graders are expected to explain ways in which geographic factors including limited water resources have affected the political, social, and economic development of Texas (TEKS 2010b). The inclusion of water topics in Geography Standards for Texas High School students is much weaker and limited to the requirement that physical processes that affect the environments of regions including weather and erosion and those that affect the hydrosphere be examined (TEKS 2010c).

Thankfully, the topic of water appears much more frequently in the Texas Life Science, and Earth Science Standards. Kindergarteners are required to observe and describe physical properties of water including color and clarity in earth science and examine evidence that living things have basic needs that include water (TEKS 2010d). In the first grade, earth science students must become familiar with natural occurrences of water, such as rivers, lakes and oceans, understand the difference between fresh and saltwater and explore the components of the hydrologic cycle as connected to weather (TEKS 2010d). In life science, first graders are expected to

observe physical characteristics of plants such as the movement of water in their stems (TEKS 2010d).

In middle school, sixth grade earth science students are required to model the effects of human activity on groundwater and surface water in a watershed (TEKS 2010e). Eighth graders must be able to identify the role of the oceans in the formation of weather systems (TEKS 2010e) and, in life science, understand the dependence of humanity of ocean systems and the modification of these systems by human activity (TEKS 2010e).

At the high school level in Texas, the entire approach to water evolves and is strengthened by the inclusion of Aquatic Science in the standards (TEKS 2010f). In Aquatic Science, students are required to explore the elements of aquatic environments, both physical and biological. Emphasis may be placed on either fresh or saltwater, depending on the geographic location of the school. Students who complete study in Aquatic Science should understand an array of aquatic systems, observe and analyze various aquatic environments and work in teams to develop collaborative, critical-thinking, and problem-solving skills (TEKS 2010f).

Among the concepts, high school students are expected to understand in Aquatic Science are the sources and amounts of water in watersheds, how water moves through watersheds and identification of water quality and quantity in watersheds (TEKS 2010f). In high school Chemistry, students are required to explain the unique role water plays in chemical and biological systems (TEKS 2010f) and in Earth Science to understand the concept of fluid Earth including the hydrosphere, cryosphere and atmosphere (TEKS 2010f).

Finally, High School Environmental Science Students must examine environmental laws enacted at the local, state and national levels, including the Clean Water Act (TEKS 2010f).

CHAPTER IV

RESEARCH DESIGN

Research Questions

Although there are thousands of school children attending informal education programs at Aquarena Center each year, little is known as to whether the information being delivered to them is actually being retained or having any effect on their behavior and perspectives with respect to water. Measuring the success or failure of this program is important in that several hundred thousand dollars a year are being spent to conduct the program and, more importantly, the water issue is now of such critical importance in Texas that both informal and formal educators need to know whether their efforts are having any impact.

Secondly, and again due to the substantial effort going into conducting the informal education program at Aquarena Center, it is important to determine whether its participants, both students and teachers, consider the program of value to them and, even more critically, whether it has any impact on their behavior after experiencing it.

The purpose of this study is to examine the effectiveness of an informal education delivery system in conveying knowledge and understanding about water.

The study employed a multilevel mixed methods design in which both qualitative (QUAL) and quantitative (QUAN) data were collected at two levels (teachers and students). This approach yielded both empirical evidence of the effectiveness of the

program and perspective, with each being analyzed to form "global inferences" at the conclusion of the research. Data were collected from both students and teachers participating in the informal water education programs at Aquarena Center. As mentioned in the Introduction, the overarching research questions were:

1. **How well does the informal education program at Aquarena Center convey water education to students and teachers?**
2. **How did students and teachers rate their experience at Aquarena Center and what environmental activities followed their visit?**

In addressing the primary research questions utilizing a multilevel approach, other subsidiary but also interesting themes emerged including the effectiveness of exposing teachers to direct experiences in the environment through an outdoor informal venue. Thus the following questions were also explored: 1) did the experience at Aquarena Center result in a deeper understanding by students and teachers of water issues; 2) did the field trip experience result in a strengthened belief in the importance of water; 3) what particular issues and experiences from the field trip significantly contributed to the experience; 4) were insights from the experience at Aquarena Center incorporated into lessons back at school; 5) as a result of the field trip, have teachers incorporated technology in the classroom or other venues to teach about water; and 6) as a result of the field trip, have teachers attempted to involve their students in service learning or experiential activities? The first three questions focused on the short-term aspects of the field trip experience, while the last three addressed longer-term post activities on water education after returning to the classroom.

The qualitative phases of this study focused on assessing student and teacher satisfaction, involvement in extracurricular environmental activities, experiential preferences and application of content knowledge. Qualitative data collection focused directly on effectiveness of the program in transference of content knowledge.

Research Methods

This study was conducted using a mixed methods approach. This approach allowed the researcher to collect and analyze both qualitative and quantitative data, in order to more effectively extract meaning from the various sources and variables that were collected, examined and measured. By utilizing this methodology, the strengths of both qualitative and quantitative data collection and analysis were brought to bear on the principle research questions. Using either approach alone would not have yielded a complete picture necessary for adequately addressing the research questions and thus a mixed methods design was chosen this study.

Creswell and Plano Clark (2011) believe that a mixed methods approach should include diverse viewpoints and combine methods, a philosophy, and a research design orientation, as well as, highlighting key components. Thus, in mixed methods, the researcher:

- Collects and analyzes persuasively and rigorously both qualitative and quantitative data (based on research questions);
- Mixes, links, or integrates the two forms of data concurrently by combining or merging them, sequentially by having on build on the other, or embedding one within the other;

- Gives priority to one or both forms of data (in terms of what the research emphasizes);
- Uses these procedures in a single study or in multiple phases of a program of study;
- Frames these procedures within philosophical worldviews and theoretical lenses; and
- Combines the procedures into specific research designs that direct the plan for conducting the study.

Creswell and Plano Clark (2011) also emphasize that the complexity of today's research problems calls for answers beyond simple numbers in a quantitative sense, and that a combination of both forms of data provides the most complete analysis of problems.

Thus, by using a mixed methods approach, this research produced qualitative data allowing for the establishment of key themes and provided a lens for viewing quantitative results as the qualitative phases of this study focused on assessing student and teacher satisfaction, involvement in extracurricular environmental activities, experiential preferences, and application of content knowledge. In addition, qualitative data collection focused directly on the effectiveness of the program in transference of content knowledge. At the same time, gathering and analyzing the quantitative information allowed the researcher to determine whether or not the informal water education program at Aquarena Center was successful at delivering content knowledge to students. Further, results from quantitative data analysis verified insights gleaned from the qualitative process, which assisted at arriving at some general conclusions about the effectiveness of informal water education programs.

The overarching component of the mixed methods design for this research was *triangulation*, which can also be thought of as "cross examination" in that the confidence level is increased if different methods lead to the same results (Liying and Cheng 2005). At the same time, the unique assemblage of subjects and variables in this study required that different levels of analysis be performed and thus necessitated a variant of triangulation, the multilevel model. Different methods (Qualitative) and (Quantitative) were used to address both students and teachers and, therefore "different levels" within the study itself. The findings from both groups of subjects and both methodologies were merged together at the conclusion to form an overall interpretation, as defined by Creswell and Plano Clark (2011). Figure 16 illustrates the adapted model for this research design.

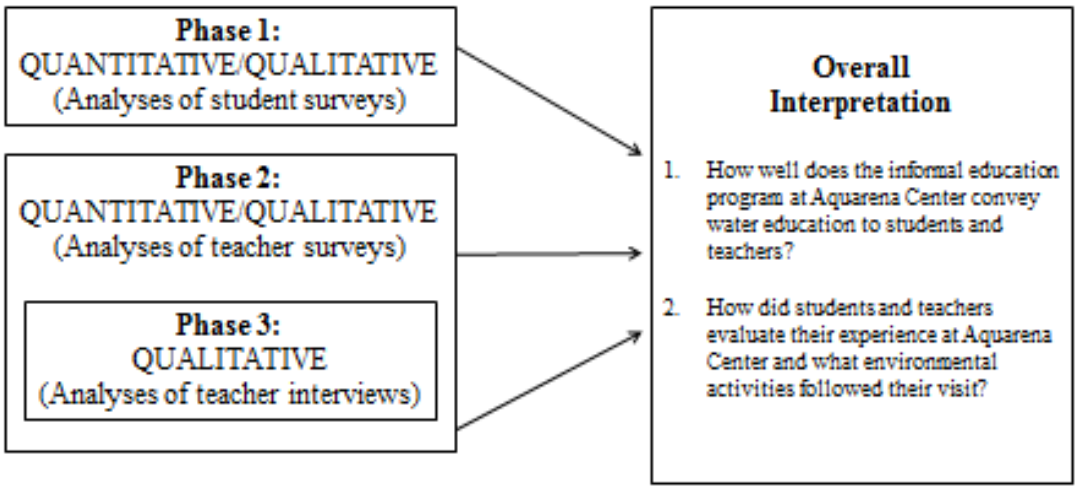


Figure 16. Multi-Level Triangulation Model adapted from Creswell and Plano Clark (2011).

PHASE I – Student Evaluation

In the first phase of the study, quantitative data were collected from middle and high school students participating in informal educational activities at Aquarena Center during the months of May to October 2011. The schools represented a broad geographic range within Central Texas.

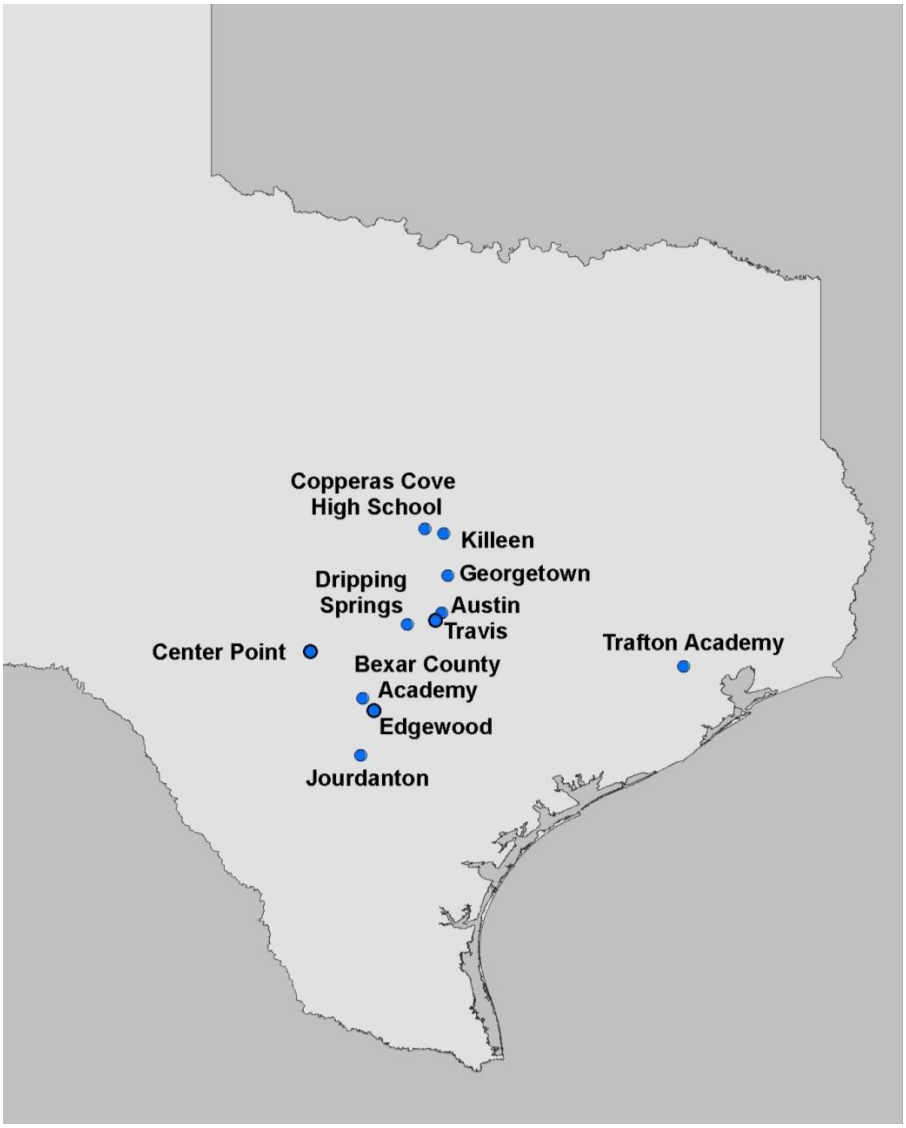


Figure 17. Communities and Schools Represented on Field Trips to Aquarena Center.

Teachers who made reservations for field trips to the Center were mailed pretest questionnaires (Appendix 1) for their students to complete before arrival. Immediately upon arriving at the site, Aquarena Center staff collected the completed pretest questionnaires that were coded and filed by date and school. At the conclusion of the field trip, teachers were handed posttest instruments (Appendix 2) along with self-addressed, stamped envelopes enabling students to complete the questionnaires on the trip back to their schools. Teachers were then asked to mail posttest responses back to Aquarena Center for collection, filing, and analysis. In all, 1096 questionnaires were administered (Table 1).

Table 1. Summary of Pre and Post Tests Administered to Students and Teachers at Aquarena Center May 2011-October 2011.

Summary of Pre and Post Tests Administered				
Date	School	Student/Teacher	Pretests	Posttests
5/4/11	Bexar	Student	45	
5/4/11	Bexar	Student		45
5/4/11	Travis-Austin	Student	47	
5/4/11	Travis-Austin	Student		43
5/5/11	Kerr-Center Point	Student	7	
5/5/11	Kerr-Center Point	Student		7
5/5/11	Kerr-Center Point	Teacher	1	
5/5/11	Kerr-Center Point	Teacher		1
5/9/11	Georgetown	Student	21	
5/9/11	Georgetown	Student		19
5/9/11	Georgetown	Teacher	2	
5/9/11	Georgetown	Teacher		1
5/11/11	Bexar-Edgewood	Student	51	
5/11/11	Bexar-Edgewood	Student		0
5/12/11	Bexar Edgewood	Student	0	
5/12/11	Bexar Edgewood	Student		62
5/12/11	Bexar Edgewood	Teacher	0	
5/12/11	Bexar Edgewood	Teacher		1
5/16/11	Atascosa-Jourdanton	Student	29	
5/16/11	Brackenridge	Student	16	
5/16/11	Brackenridge	Student		16
5/30/11	Travis (Austin ISD)	Student	38	

Table 1 continued.

5/30/11	Travis (Austin ISD)	Student		0
9/2/11	American	Student	10	
9/2/11	American	Student		5
9/29/11	Copperas Cove High	Student	23	
9/29/11	Copperas Cove High	Student	27	
9/29/11	Copperas Cove High	Student		26
9/29/11	Copperas Cove High	Teacher		23
10/18/11	Trafton Academy	Student	28	
10/18/11	Trafton Academy	Student	32	
10/18/11	Trafton Academy	Student	24	
10/18/11	Trafton Academy	Student	21	
10/18/11	Trafton Academy	Student	15	
10/18/11	Trafton Academy	Student		114
10/18/11	Trafton Academy	Teacher	16	
10/18/11	Trafton Academy	Teacher		7
11/7/11	Dripping Springs	Student	35	
11/7/11	Dripping Springs	Student		33
11/7/11	Dripping Springs	Teacher	3	
11/7/11	Killeen	Student	12	
11/7/11	Killeen	Student		20
11/7/11	Killeen	Student	12	
11/7/11	Killeen	Student		17
11/7/11	Killeen	Teacher	1	
11/7/11	Killeen	Teacher	1	
7/17/11	Killeen	Student	33	
7/17/11	Killeen	Teacher	10	
7/17/11	Killeen	Teacher		5
7/17/11	Killeen	Teacher		7
7/18/11	Killeen	Student		15
7/18/11	Killeen	Student		18
7/19/11	Geography Summer	Student		41
7/23/11	Summery Academy	Teacher		10

The researcher developed the questions following two pilot studies done with students and teachers participating in the Geography Summer Academy during the summer of 2011, and an inservice training session conducted at The Texas Education Agency Regional Offices in Austin, Texas. The session of the Academy, which has historically been conducted with geography teachers and students from the Central Texas

Area, each summer at Texas State, was specifically designed to incorporate water education and to be structured so that experimenting with pre and post testing of various water topics would be possible. At the in service workshop, pre and post test questions were administered in part to determine their validity for inclusion in the subsequent research with students and teachers who visited Aquarena Center. Ultimately, the questionnaires utilized at Aquarena Center were developed using insights gained from the pilot studies, being directly designed to reflect and measure information specifically from the curriculum used by instructors during the field trips. The test instruments were designed to gather the most direct information about the impact of the experience. Quantitative information sought in the test instruments was specific to the information presented during informal education programs at Aquarena Center, to ensure that the evaluation produced measurable and therefore useful results. The test instrument was designed specifically to avoid imposing any unreasonable or unnecessary burden on either the researcher or participants. Instructors at the Center consisted of both professional educators and graduate students at Texas State specifically trained to deliver water education content at the site. Care was taken in filing, tracking and organizing data collection so that the scores of both pre and post tests could be accurately matched.

PHASE II – Teacher Evaluation

The second level of the study consisted of three distinct inquiries involving teachers who brought their students to Aquarena Center to participate in informal environmental education programs. These inquiries collected both qualitative and quantitative information from participating teachers.

Inquiry I – Survey Monkey Tool

The first inquiry was an electronic survey of teachers visiting Aquarena Center during the years 2010-2011. The instrument was distributed using Survey Monkey (Appendix 3). Survey Monkey is an online research tool that makes it relatively simple for researchers to create, customize, and evaluate opinions in an effective and controlled manner. The test questions were pilot tested at the in service teacher training workshop held at Texas Education Agency Regional Headquarters in Austin as described in Phase I above. Teachers were shown a short video presentation on watersheds as part of the web-based teacher-training program developed by the Grosvenor Center for Geographic Education called "Teaching with the Stars." This researcher administered the questions and the results were documented (Frazier 2010). All recipients of the Survey Monkey questionnaire were informed that the researcher would place $5.00 in a pool for every returned survey, with this incentive resulting in a total of 108 returned surveys.

Inquiry II – Aquarena Center Field Trip Evaluation

The second inquiry was a survey of 236 teachers who accompanied students to Aquarena Center during 2011 (see Table 1 above). This survey was done using a small response device given to all visiting teachers upon completion of their experience at the Center. At the conclusion of their visit, teachers were asked to fill out a very short

questionnaire designed to elicit their evaluation of the informal education program (Appendix 4). This survey instrument was developed by Aquarena Center staff and had been historically administered to participating teachers prior to the initiation of this research. The brief instruments were designed to gather the most basic information about the impact of the experience on them and their students. As some of the data collected were relevant to this research, it was decided to take advantage of the fact that this information was already being collected and to include appropriate insights gained from it in the analysis. In addition, by utilizing an instrument already completed by participating teachers, there was no additional burden created for Aquarena Center staff or the teachers themselves.

Inquiry III – In-depth Interviews

Based on quantitative results from the two surveys, the researcher determined that a more in-depth inquiry was necessary regarding the potentially enhanced understanding of both themselves and the students and any changes in the perspective of the students following their experience at Aquarena Center. The goal of this research was primarily to gauge the impact of informal water education at Aquarena Center, meaning the mixed methods design required an additional dimension of information.

The third inquiry was a series of twelve telephone interviews conducted by this researcher with respondents to the Survey Monkey inquiry. Participants were informed that the first twelve teachers who indicated a willingness to participate in follow-up interviews would receive $100, resulting in twenty individuals responding. All interviewees were asked the same set of questions (Appendix 5), with this researcher asking follow-up questions based on varying perspectives and emphases expressed by the

individual teachers. All interviews were transcribed. Some recordings were of such poor quality that they could not be used. In another case, the respondent was not actually a teacher and in a few cases, there was some inconsistency in the questions. For these reasons, only twelve of the twenty transcriptions were selected for subsequent analysis.

CHAPTER V

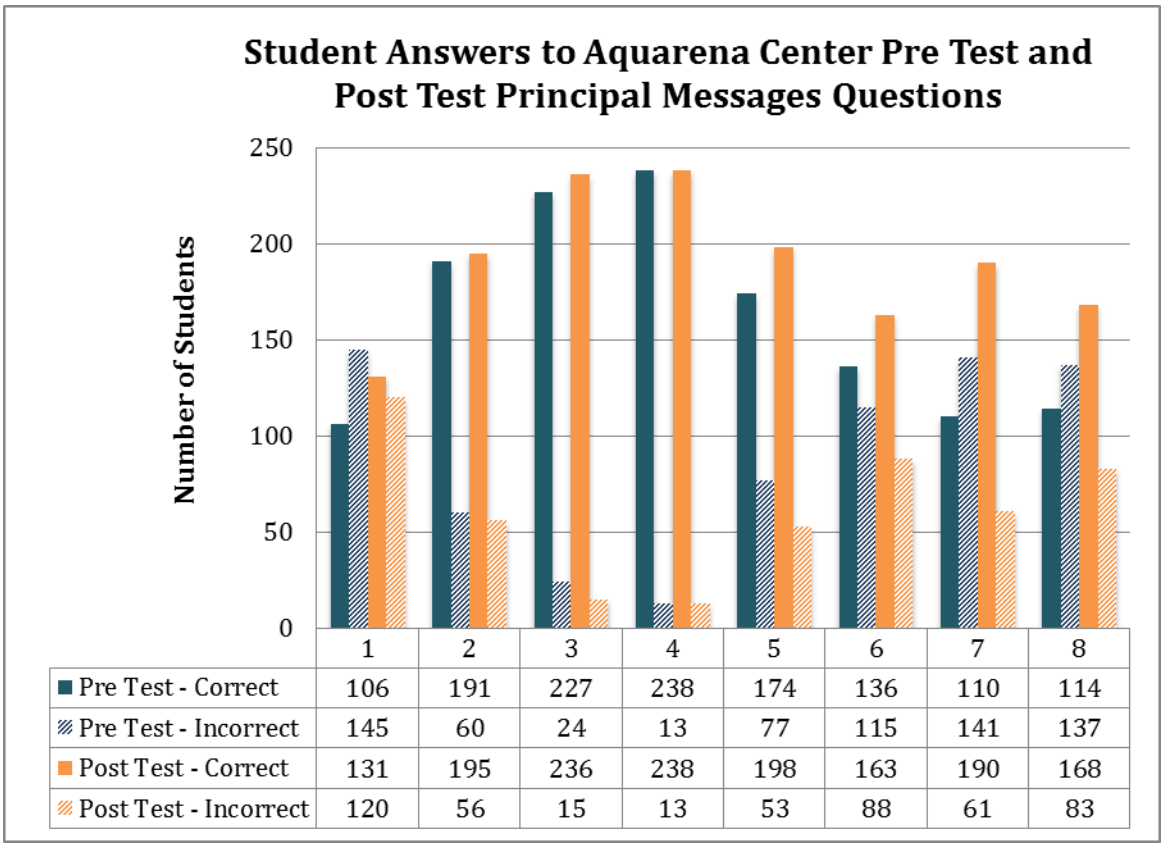
ANALYSIS AND RESULTS

PHASE I – Student Evaluations

In the first phase of data collection for this research, 252 middle and high school students visiting Aquarena Center on organized field trips in 2011 were asked to complete questionnaires regarding their knowledge of major water concepts both before and after their visit. A total of fourteen questions were prepared based on the educational curricula they would be receiving during their visit. Pre and post questions were divided into four groups: *Principal Messages, Connections, Perceptions, and Experience* (Appendix 1 and 2).

Principal Messages Questions

Principal messages questions were administered for both pre and post test questions. The data were entered and quantified using Excel. Students who did not return both a pre and posttest questionnaire were excluded from the sample. For questions 1-8 on the pre and posttests, answers were coded A=1, B=2, C=3, D=4, Blank=0. Correct answers were coded as 1, Incorrect as 0, and Blank as 0. In general, students' posttest scores were higher than their pre test scores, indicating that the educational curricula were effective. Figure 18 below summarizes the students' pre and posttest answers to questions 1-8.



	1	2	3	4	5	6	7	8
Pre Test - Correct	106	191	227	238	174	136	110	114
Pre Test - Incorrect	145	60	24	13	77	115	141	137
Post Test - Correct	131	195	236	238	198	163	190	168
Post Test - Incorrect	120	56	15	13	53	88	61	83

Figure 18. Student Answers to Test Questions.

A Paired T-Test of the data was then performed using SPSS. This test is used when the data consist of two related samples of measurements. It is used when there is one measurement measurable and two nominal variables. One of the nominal variables is different individuals (the students) and one nominal variable is a "before" and "after" (pre and posttests) influence. The null hypothesis is that the difference between the two variables is zero. For purposes of testing the validity of the null hypothesis, a *p-value* was established in the statistical analysis of each question. *P-value* is defined as "the probability of observing, when the null hypothesis is true, a value of the test statistic at least as extreme (in the appropriate direction) as the value actually observed." (Daniel 1990). A *p-value* of .05 or less is used as the basis for rejecting the null hypothesis.

The first question was designed to determine if students could correctly define a watershed. A watershed is defined as "a geographic area from which rainfall flows to a river or stream." Here, the H_o was rejected; significantly more students answered the multiple choice question correctly following the field trip on the posttest questionnaire (131 vs. 106), resulting in a *p-value* of .006.

1. A watershed is:
- a. A tank for storing water
- b. An ocean
- c. A spring at the headwaters (beginnings) of a river
- d. **A geographic area from which rainfall flows to a river or stream**

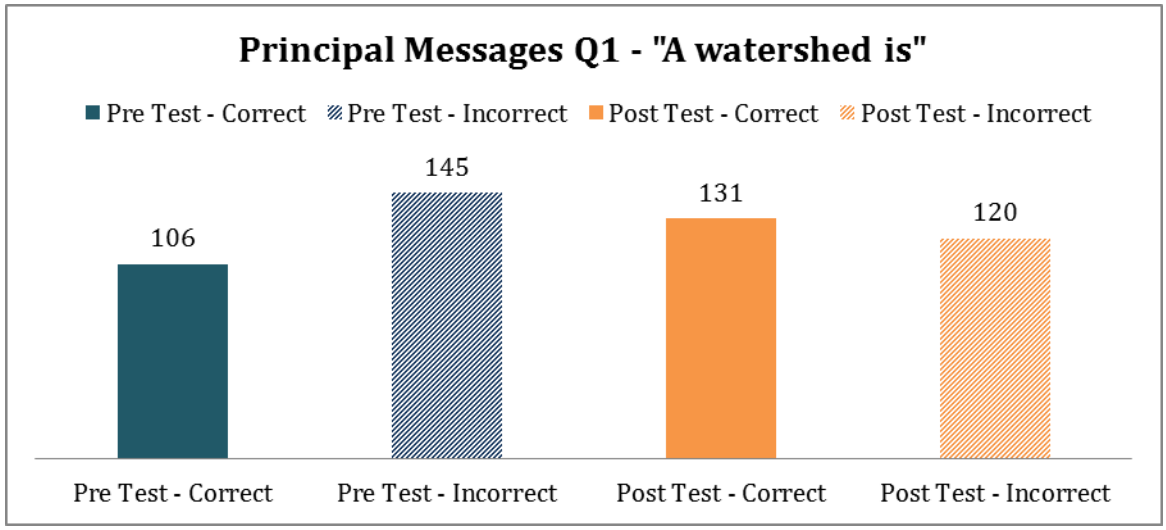


Figure 19. Principal Question 1.

On the second question in which students were asked to indicate why watersheds are important, the null hypothesis was not rejected. However, four students did answer the question correctly after receiving the educational curricula (195 correct posttest answers vs. 191 correct pretest responses). These results indicate that, although a few students improved their scores, this section of the educational curricula may require improvement. Such improvement is especially important with respect to this question, as

an understanding of watershed function is one of the most important concepts to be conveyed in a sound water education program.

2. Healthy watersheds are important because:

a. They are 100 gallon tanks used water for use during a drought
b. It is impossible to pollute a healthy watershed
c. They maintain water quality and quantity
d. They are a great storage facility for garbage

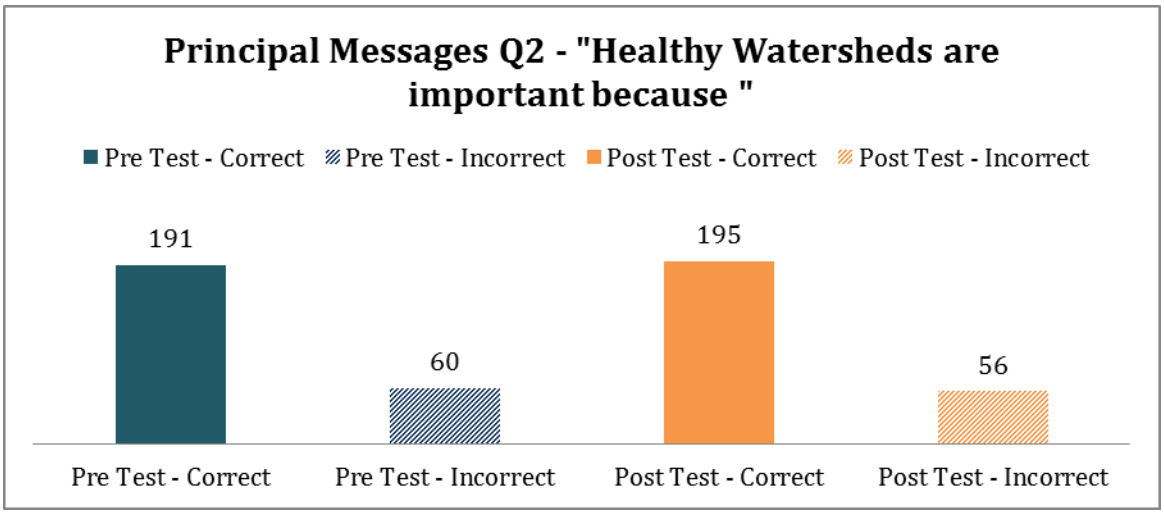


Figure 20. Principal Question 2.

Questions Three and Four, in which students were to define aquifers and the hydrologic cycle, produced the same results. An aquifer is correctly defined as "an underground formation containing and conducting water," while the correct definition for the water cycle is "Evaporation, condensation, precipitation, and collection." In responses to both questions, the null hypothesis was not rejected (Q3, P=0.072; Q4, P=1.000). In Question 3, 236 respondents answered the posttest correctly, compared with 227 pretest correct responses. Question 4 responses were exactly the same for the pre and posttest, but it is important to consider that both the questions had a very low number of incorrect responses in the pretest. Thus, students arrived at the Center with a basic

understanding which is enforced by the visual working of the aquifer and its role in conceptualizing the hydro cycle, as experienced during the field trip.

3. An aquifer is:

a. **An underground formation containing and conducting water**
b. A wild animal
c. A water treatment plant
d. A bay on the Gulf of Mexico

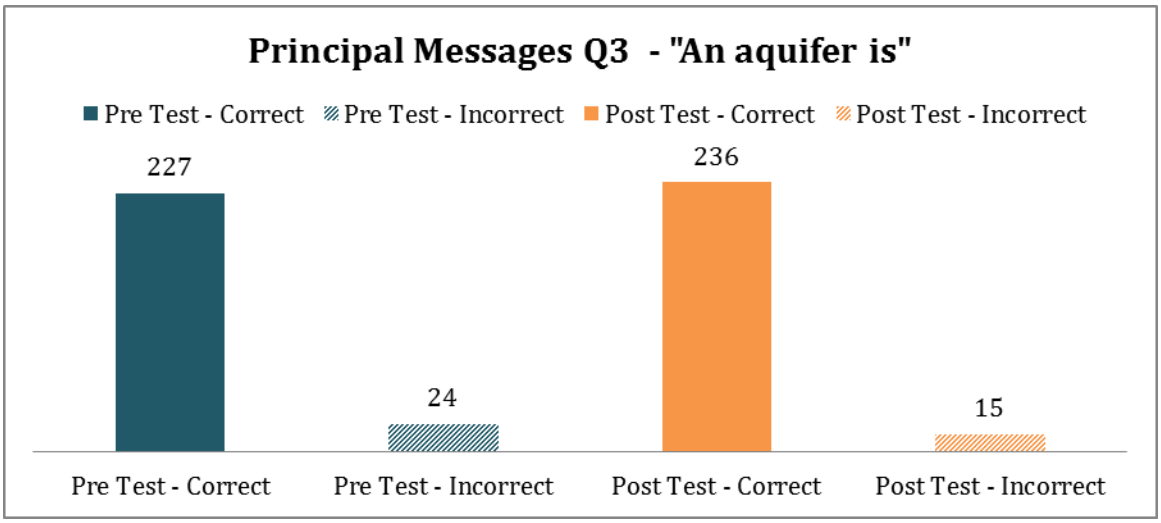


Figure 21. Principal Question 3.

4. The water cycle is:

a. A two wheeled device for carrying water
b. **Evaporation, condensation, precipitation, and collection**
c. A rain storm
d. The history of water on the earth

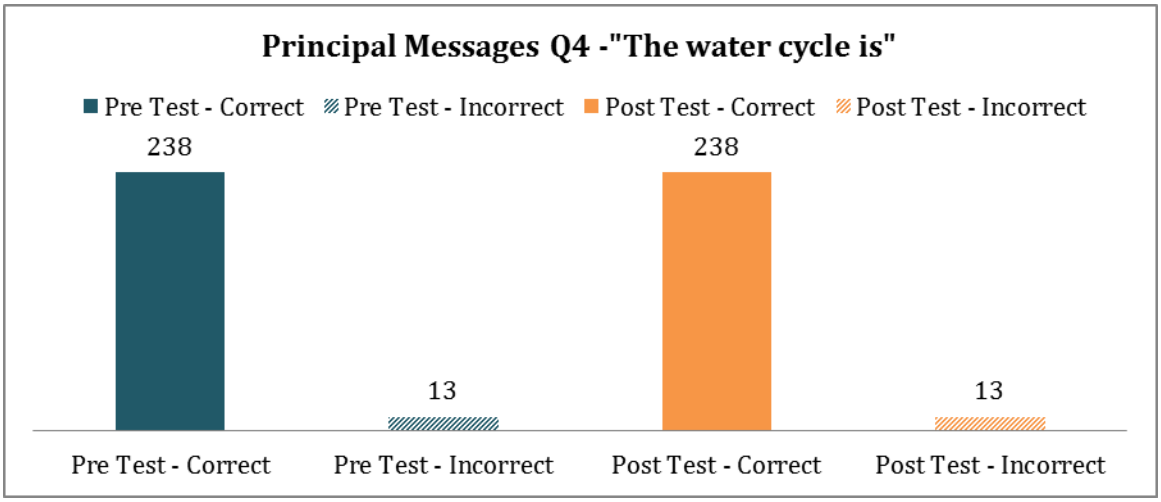


Figure 22. Principal Question 4.

Question Five asked students to define an estuary, the correct answer being "a geographic area on the coast where fresh and salt water mix." H_o was rejected (P=0.004). After receiving the educational curricula, 31% of students (24) improved their score between the pre and posttests. Here, the results are encouraging as this is one of the most important concepts to get across: that water emerging from the springs is directly connected to the health of the coast. The results were particularly encouraging as most of the students were from schools located well away from the coast and thus experience with bays, estuaries and marine issues are not part of their daily lives (Figure 17).

5. An estuary is:

a. A winding stream
b. A place where people are buried
c. **A geographic area on the coast where fresh and salt water mix**
d. A fish hatchery

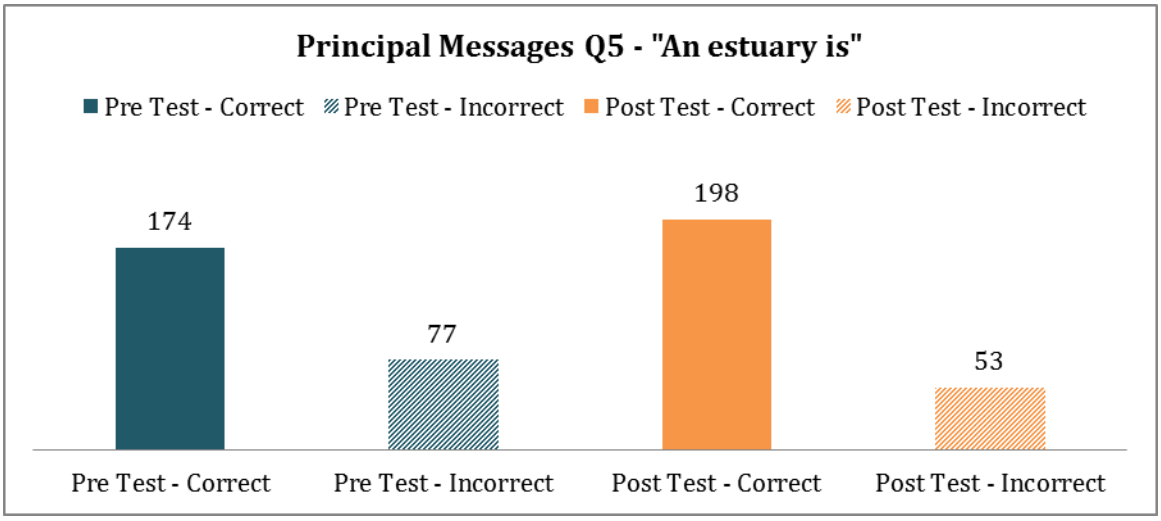


Figure 23. Principal Question 5.

Question Six was designed to determine if students could identify the river into which the San Marcos River, which arises from the springs at Aquarena Center, flows. The correct answer is "The Guadalupe River" and H_o was rejected (P=0.005). Nearly 24% of students improved their post score (115 incorrect and 136 correct in the pretest and 88 incorrect and 163 correct in the post test.) Here, the positive results as with Question 3 (above) the hands on experience with the river itself increased students' ability to comprehend the concept of a tributary and its connection to the larger river. This understanding is potentially very significant to the development of water literacy among students as it contributes to the overall all comprehension of river basins and the larger water system.

6. The San Marcos River flows into:

a. the Blanco River
b. **the Guadalupe River**
c. the Comal River
d. the Nueces River

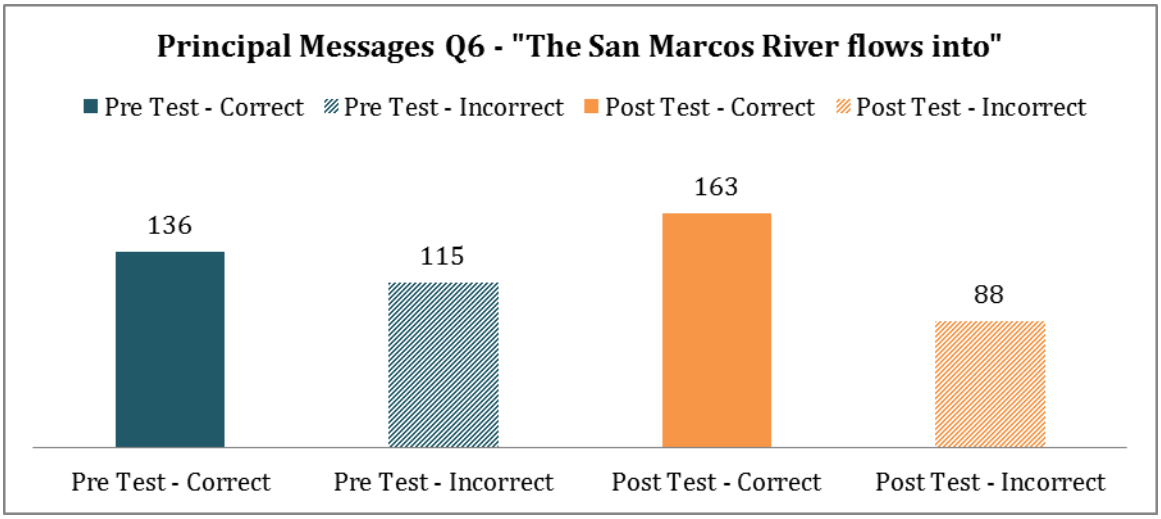


Figure 24. Principal Question 6.

Among the eight questions, the most striking difference between pre and posttest correct answers was response to Question Seven in which students were asked to identify the water temperature at Spring Lake. Fully 80 students who answered the question incorrectly on the pretest got it right on the post test, which allowed for the rejection of H_o ($P<0.001$). The correct answer is that the temperature in Spring Lake is "constant."

7. The water temperature of San Marcos Springs:

a. varies depending on the air temperature
b. **is constant**
c. varies depending on the season
d. is constantly changing from day to day

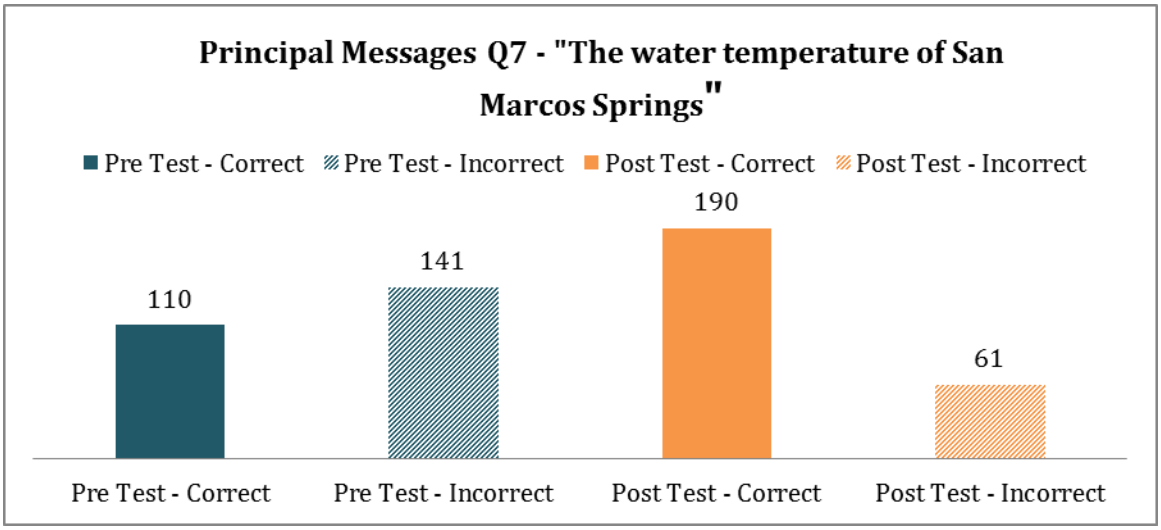


Figure 25. Principal Question 7.

Finally, and also very significantly, 54 students correctly identified the rivers that make up the San Marcos watershed on the posttest who were unable to do so on the pretest (Reject H_o, $P<0.001$). Those rivers are "the San Marcos River, the Blanco River, and the Guadalupe River."

8. The rivers that make-up the San Marcos watershed are:

a. **the San Marcos River, the Blanco River, the Guadalupe River**
b. the San Marcos River, the Blanco River, the Comal River
c. the San Marcos River, the Comal River, the Guadalupe
d. the San Marcos River, the Nueces River, the Trinity

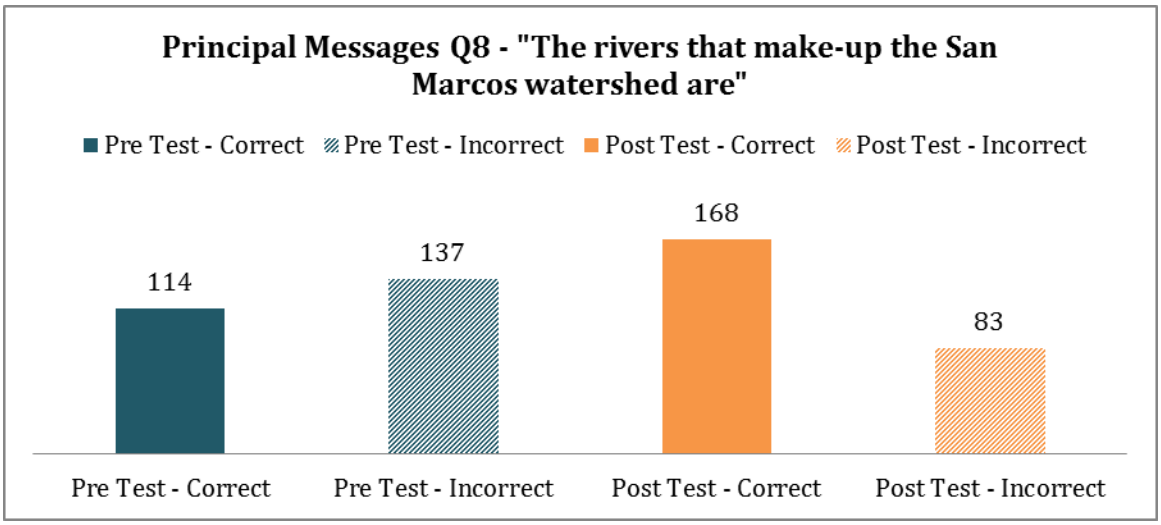


Figure 26. Principal Question 8.

In summary, of the eight questions regarding content knowledge presented in informal educational programs at Aquarena Center, responses by students to five of those questions indicated a statistically significant difference between pre and posttest answers, also indicates a need to strengthen education on the importance of watersheds in maintaining water quality and quantity; that transference of content knowledge in the program generally successful.

Table 2. Table of *P-values* for Students Pre/Post Questions.

Table of *P-values* for Students Pre/Post Questions			
Q	Content	Significance (2-tailed)	Comment
1	Define watershed	.006	Significantly more students correct on post
2	Importance of watersheds	.587	About the same number correct pre/post
3	Define aquifers	.072	About the same number correct pre/post
4	Define water cycle	1.00	Exactly the same number correct pre/post
5	Define estuary	.004	Significantly more students correct on post
6	Flow of San Marcos River	.005	Significantly more students correct on post
7	Temperature of San Marcos Springs	<.001	Significantly more students correct on post
8	San Marcos Watershed makeup	<.001	Significantly more students correct on post

Examining the data by grade level, the largest improvement in scores occurred among responding students in the 7^{th}, 9^{th} and 10^{th} grades.

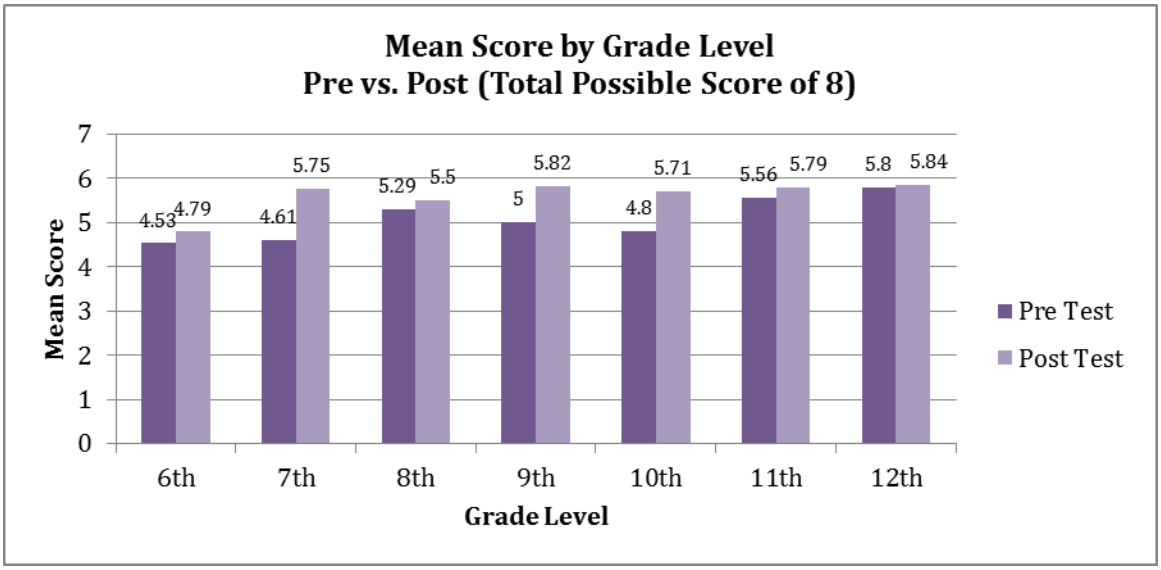


Figure 27. Mean Score by Grade Level.

Connections and Perceptions Questions

In student pretests, a set of qualitative questions aimed at gleaning insights into student connections and perceptions about water were included following initial questions designed to measure understanding of the principal messages or content knowledge conveyed through informal education at Aquarena Center. The first of the qualitative Connections Questions in the pretest asked if students belonged to an outdoor or environmental club in their school or hometown. A total of 455 students responded to this question. More than three-quarters of the student respondents (361) indicated that they did not belong to such an organization, 94 or 21% indicated that they did belong to some type of outdoor or environmental organization (Table 3). Here as in subsequent questions, qualitative data were collected in interviews with participating teachers to try and lend meaning to responses on surveys and questionnaires.

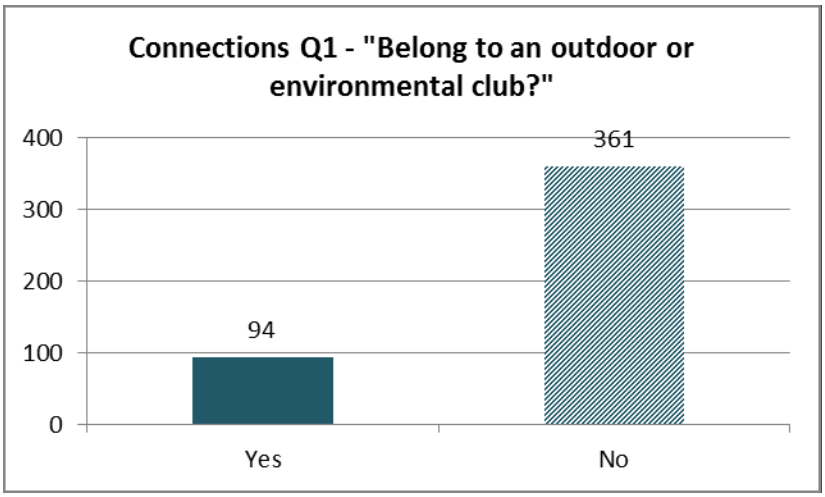


Figure 28. Connections Question 1.

Table 3. Connections Question1.

Connections Q 1. Belong to an outdoor or environmental club?		
	# Student Respondents	% of Students
Yes	94	21%
No	361	79%
Total responses	455	

The second question sought to determine students' connections to the outdoors by asking respondents to indicate their level of comfort in the outdoors and the importance to them of spending time in the outdoors. 456 students responded, with the majority reporting that "being outdoors in nature" is somewhat important (43%) or very important (34%). Table 4 below shows the respondents' results to question 2.

Being outdoors in nature is:

A. Uncomfortable for me
B. Not important to me
C. Neither important or not important
D. Somewhat Important to me
E. Very Important to me

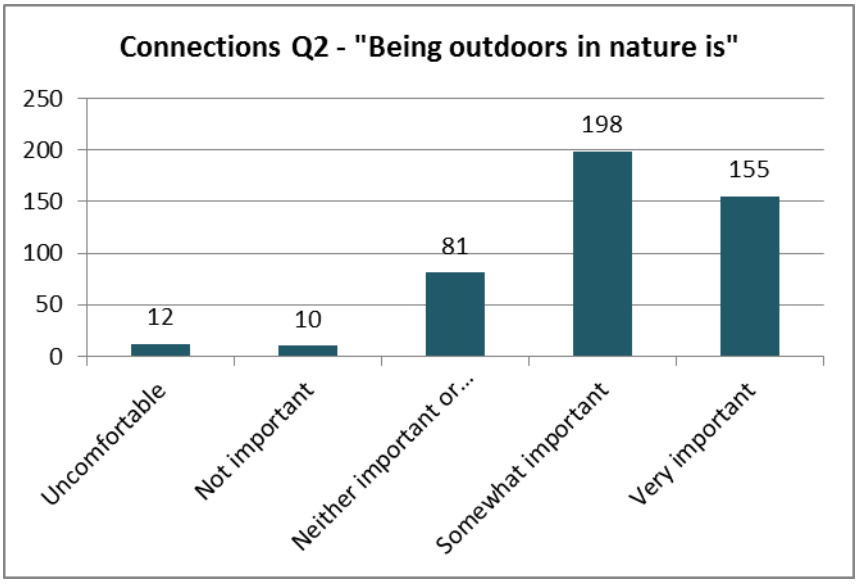


Figure 29. Connections Question 2.

Table 4. Connections Question 2.

Connections Q 2. Being outdoors in nature is:		
	# Student Responsents	% of Students
Uncomfortable	12	3%
Not important	10	2%
Neither important or not important	81	18%
Somewhat important	198	43%
Very important	155	34%
Total responses	456	

Question 3 of the Connections section of the pretest asked students to rate the presence in their lives of water sports such as swimming, fishing, and boating. Here, 36% of the 453 respondents reported that these activities were very important to them and 44% of the students indicated that these activities were somewhat important. Table 5 below shows students' responses. For both Questions 2 and 3, the fact that a majority of respondents indicated that "being outdoors in nature" was important to them is quite possibly an indicator of the demographic of the students. A topic for further study would be to test this same concept while classifying respondents by gender and race. Another useful inquiry would be to compare those students who indicated that being in the

outdoors was not important to posttesting designed to explore specific outdoor experiences.

Water sports or recreation such as swimming, fishing and boating are:

A. Things I don't like
B. Neither important nor not important
A. Somewhat important to me
B. Very important to me

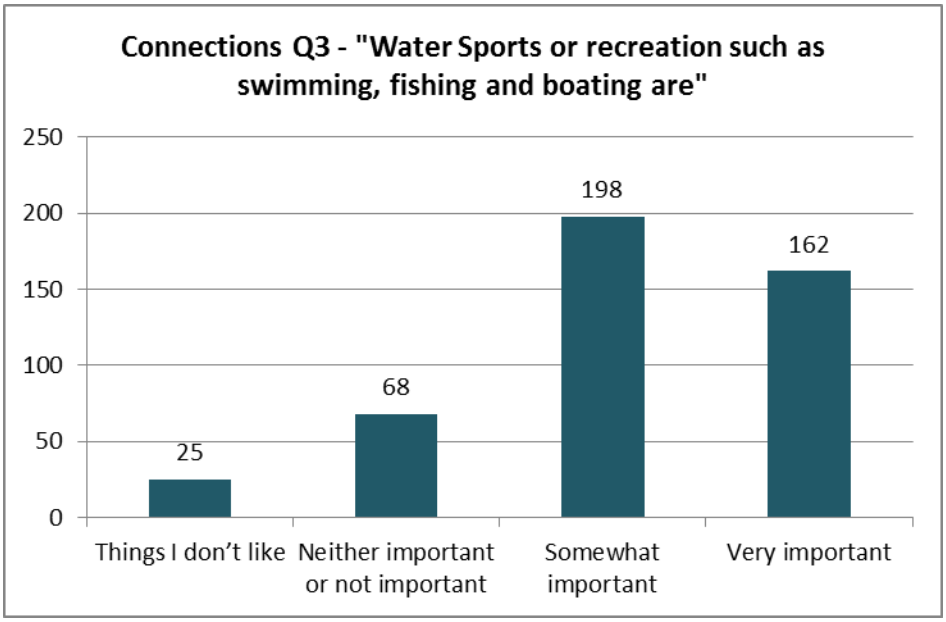


Figure 30. Connections Question 3.

Table 5. Connections Question 3.

Connections Q 3. Water Sports or recreation such as swimming, fishing and		
	# Student Responsents	% of Students
Things I don't like	25	6%
Neither important or not important	68	15%
Somewhat important	198	44%
Very important	162	36%
Total responses	453	

In the Perceptions portion of the pretest, the intent was to ascertain a sense of the importance of water in the lives of students responding to the survey. The first of these Perceptions questions asked that students rate the importance of water in their lives. A total of 459 students answered the question. In response to the statement, "Water is

important for all life" 75% of students (343) strongly agreed. These results indicate that the majority of students visiting Aquarena Center understand that water is important. It is likely that students are getting this information from school curricula, parents and media outlets. This is even more likely given the fact that during the period of this research, Texas experienced a record magnitude drought. On the other hand, it is disturbing that, in the face of such an extreme drought, a full 25% of respondents do not appreciate the importance of water, indicating that educators still have significant work remaining to ensure the message is being disseminated.

Water is important for all life:

a. Strongly disagree
b. Disagree
c. Neither agree or nor disagree
d. Agree
e. Strongly agree

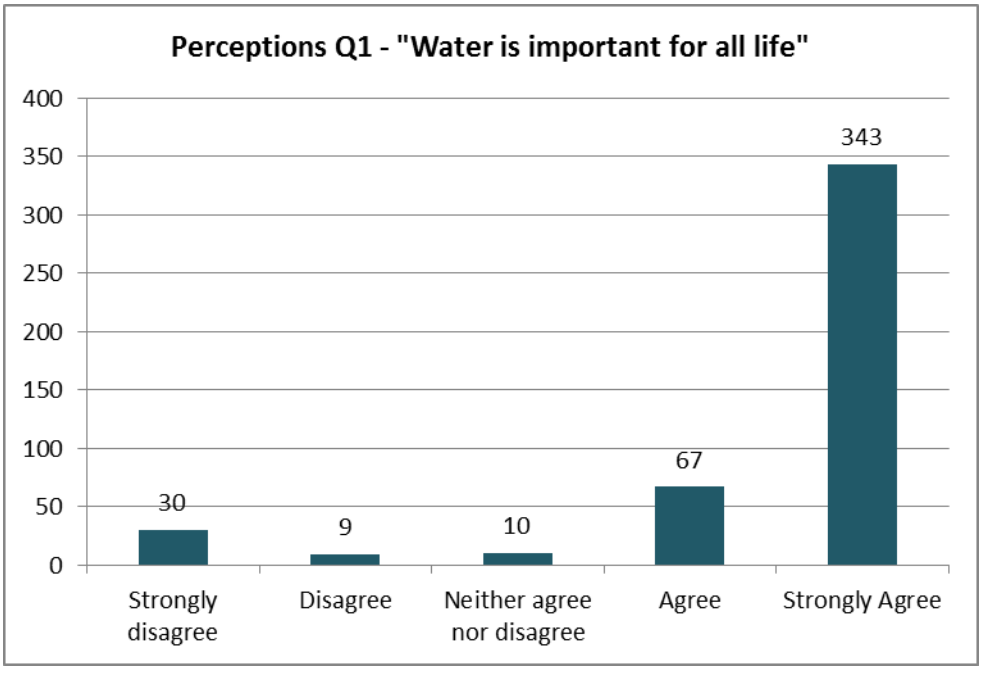


Figure 31. Perceptions Question 1.

Table 6. Perceptions Question 1.

Perceptions Q 1. Water is important for all life		
	# Student Responsents	% of Students
Strongly disagree	30	7%
Disagree	9	2%
Neither agree nor disagree	10	2%
Agree	67	15%
Strongly Agree	343	75%
Total responses	459	

The second Perceptions question asked students to indicate whether they and their families practiced water conservation in their homes. A total of 458 students responded. The responses were somewhat more ambiguous with 37% agreeing with the statement "In my home, we practice water conservation," 10% strongly agreeing, 36% neither agreeing nor disagreeing and 17% disagreeing or strongly disagreeing. Responses to this question may indicate that households and especially children in Central Texas are not being exposed to sufficient water conservation education. Here, the relatively weak indication of water conservation practices at home is striking given the severe drought and the urgency of conserving water. This may be the result of the urban demographics of the students (Figure 17), which tend to mask the direct impact of drought. This likely would not occur among students from more rural settings where the impact on agriculture and the landscape would be very apparent. This finding suggests at a minimum that continuous measurement of perceptions about water through extended periods of drought would yield useful information concerning the impact of increased media attention and educational focus on water.

In my home, we practice water conservation:

a. Strongly disagree
b. Disagree
c. Neither agree or nor disagree
d. Agree
e. Strongly agree

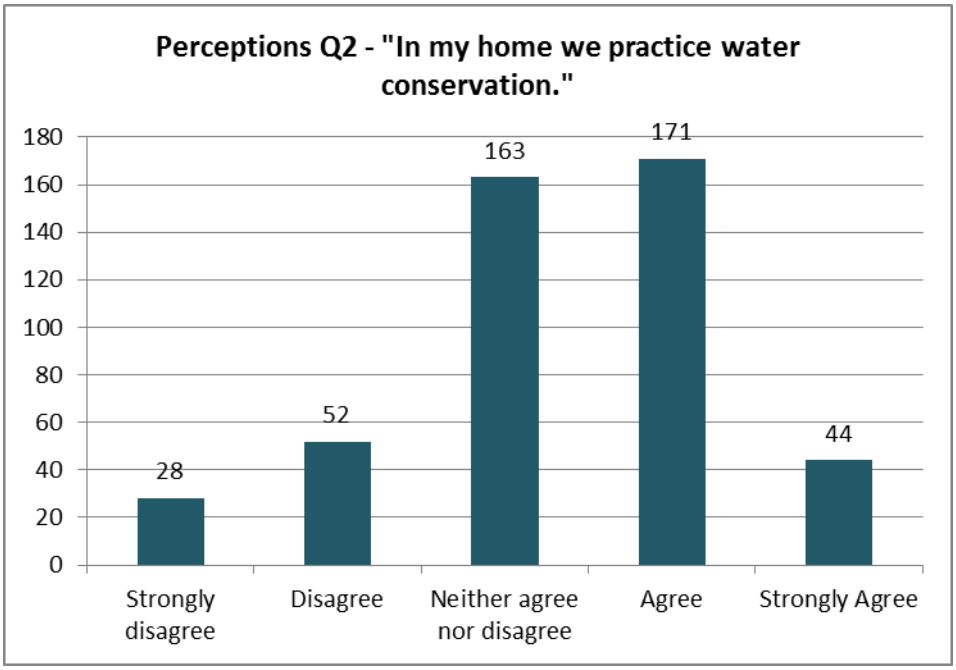


Figure 32. Perceptions Question 2.

Table 7. Perceptions Question 2.

Perceptions Q 2. In my home we practice water conservation.		
	# Student Responsents	% of Students
Strongly disagree	28	6%
Disagree	52	11%
Neither agree nor disagree	163	36%
Agree	171	37%
Strongly Agree	44	10%
Total responses	458	

The final pretest Perceptions question asked students to indicate the extent to which they agreed or disagreed with the statement that learning about water was important in their class. Of the 459 respondents, 61% (189 and 92 respectively) either agreed or strongly agreed. This response is certainly encouraging. Interestingly, most water professionals, policy makers and educators have called for increased water education. As described in Chapter 1, water education is actually required in Texas although, to date, there is a marked lack of curricula or other materials for teachers.

In my class, learning about water is important:

a. Strongly disagree
b. Disagree
c. Neither agree or nor disagree
d. Agree
e. Strongly agree

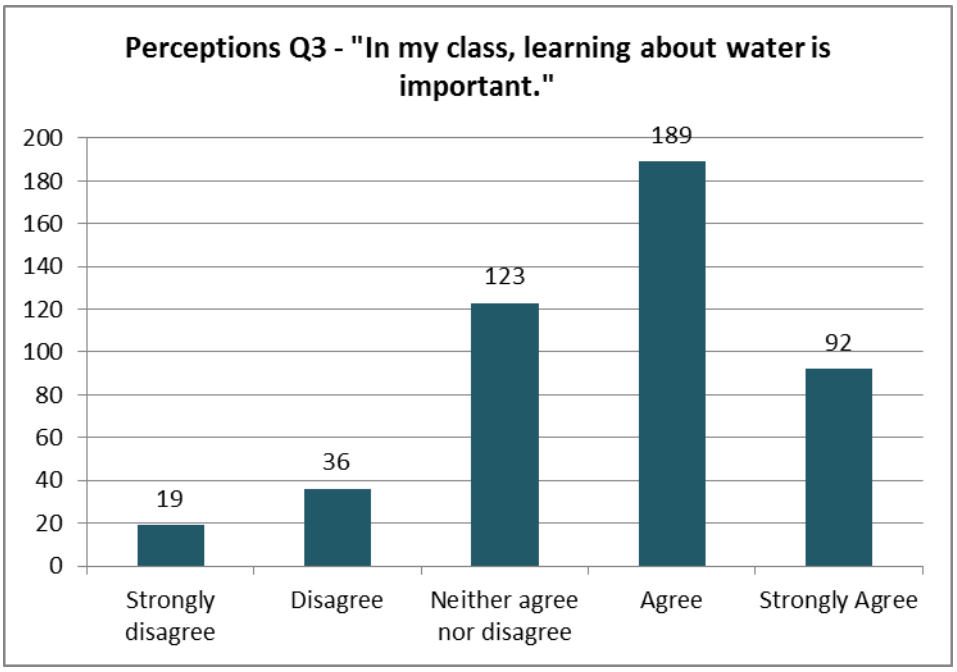


Figure 33. Perceptions Question 3.

Table 8. Perceptions Question 3.

Perceptions Q 3. In my class, learning about water is important.		
	# Student Responsents	% of Students
Strongly disagree	19	4%
Disagree	36	8%
Neither agree nor disagree	123	27%
Agree	189	41%
Strongly Agree	92	20%
Total responses	459	

Experience Questions

At the end of the students' posttest, five questions were asked related to the experience at Aquarena Center. The first of these Experience Questions asked students to identify their favorite activity. A total of 381 students responded, with 78% indicating that the glass bottom boats were their favorite, while 11% identified the wetlands boardwalk, 8% the Aquarium and 3% the cave exhibit. Here as in subsequent questions, qualitative data were collected in interviews with participating teachers to try and lend meaning to responses on surveys and questionnaires.

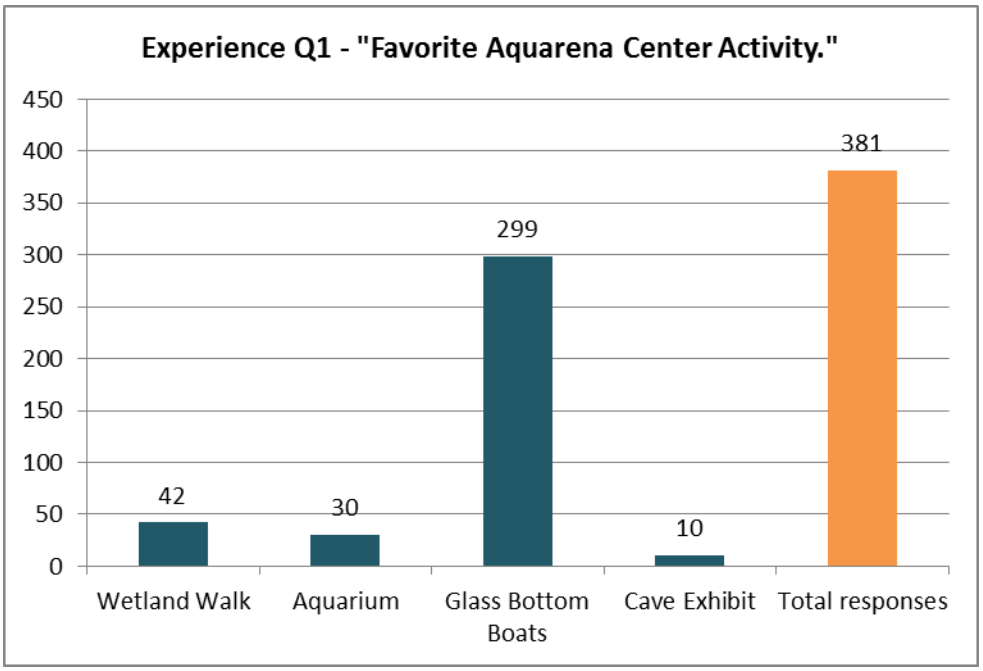


Figure 34. Experience Question 1.

Table 9. Experience Question 1.

Experience Q 1. Favorite Aquarena Center Activity.		
	# Student Responsents	% of Students
Wetland Walk	42	11%
Aquarium	30	8%
Glass Bottom Boats	299	78%
Cave Exhibit	10	3%
Total responses	381	

The second Experience question on the posttest asked students to rate their day at Aquarena Center on a scale ranging from "horrible" to "wonderful." A total of 382 responses were collected. After spending the day at the Center, 83% of responding students described their experience as either "Wonderful" or "Interesting" while 15% rated it as just "Okay" and only 2% gave the day a score of "Horrible."

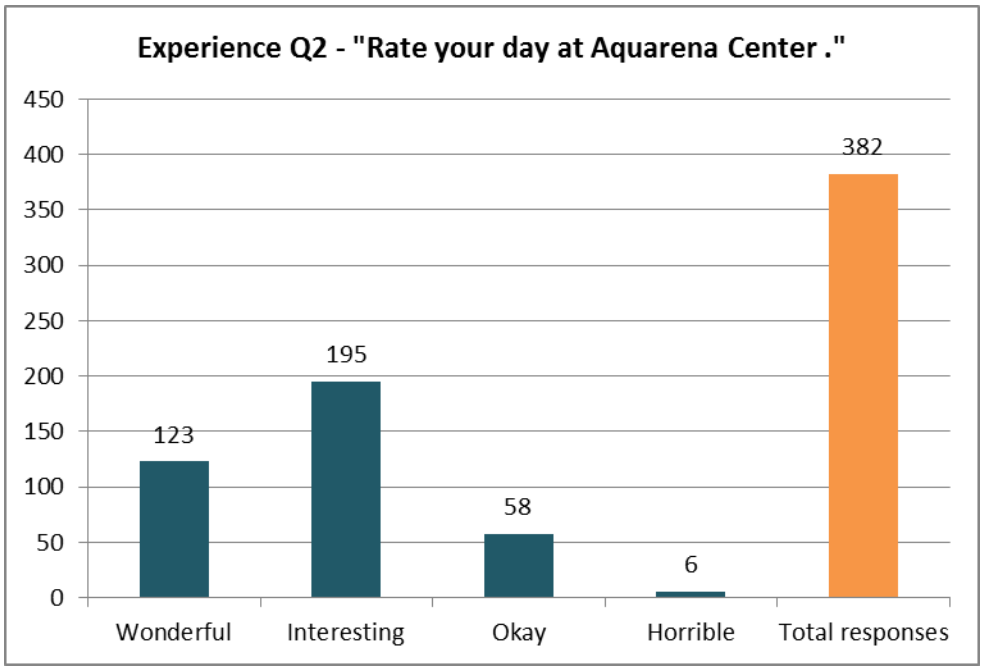


Figure 35. Experience Question 2.

Table 10. Experience Question 2.

Experience Q 2. Rate your day Aquarena Center .		
	# Student Responsents	% of Students
Wonderful	123	32%
Interesting	195	51%
Okay	58	15%
Horrible	6	2%
Total responses	382	

In response to the third Experience Question on the posttest based on their experience at Aquarena Center, students were asked to agree or disagree with the

statement that water is important. Of the 383 responses, 91% indicated that they either strongly agreed or agreed.

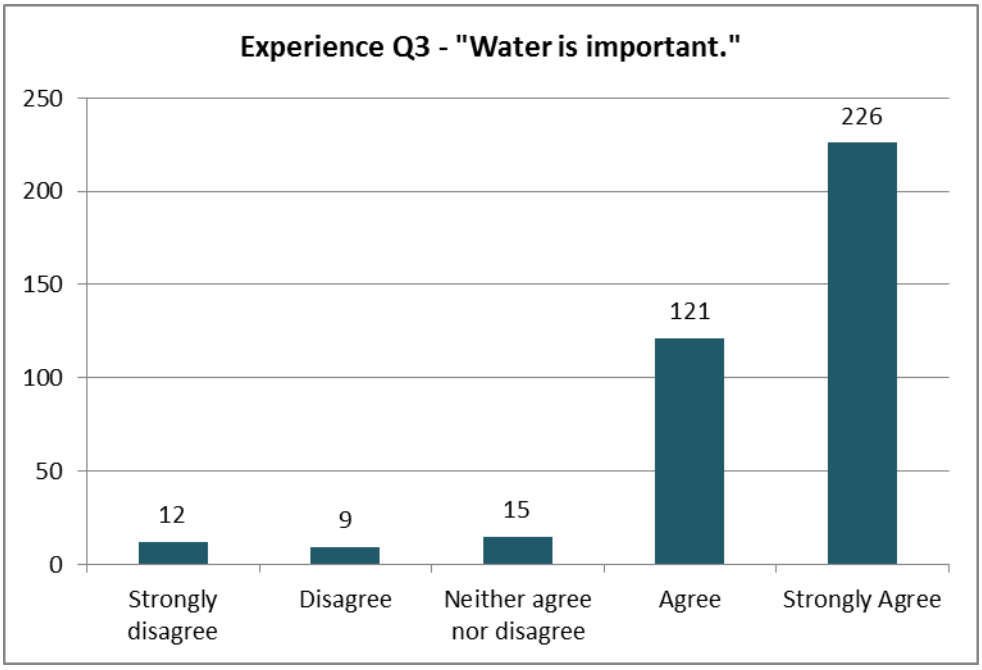


Figure 36. Experience Question 3.

Table 11. Experience Question 3.

Experience Q 3. Water is Important.		
	# Student Responsents	% of Students
Strongly disagree	12	3%
Disagree	9	2%
Neither agree nor disagree	15	4%
Agree	121	32%
Strongly Agree	226	59%
Total responses	383	

74% of the 376 students indicated that they would like to learn more about water in Experience Question 4, while approximately 26% responded “no.”

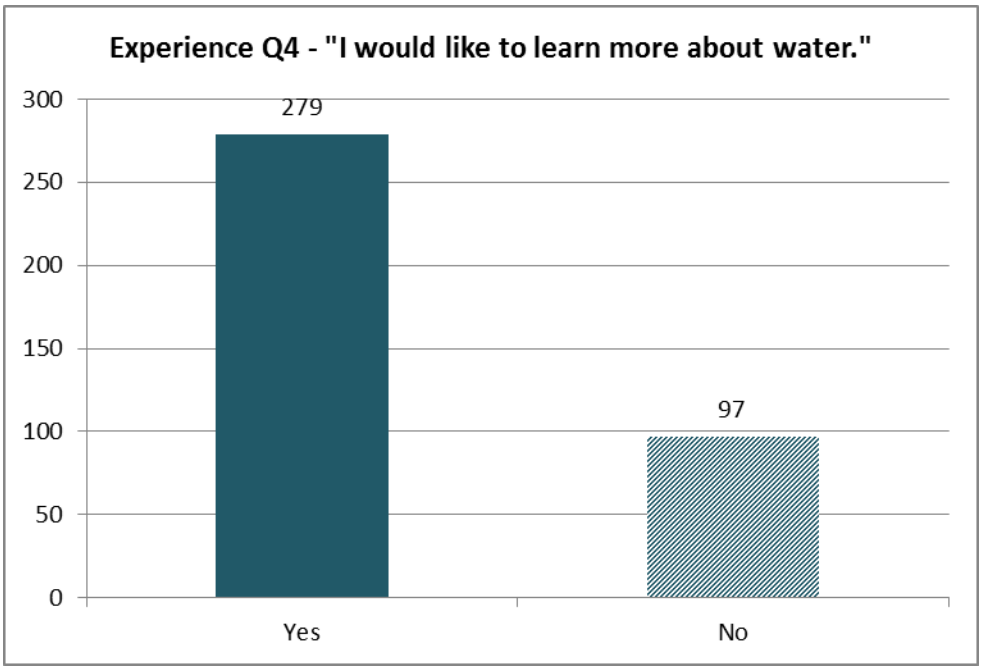


Figure 37. Experience Question 4.

Table 12. Experience Question 4.

Experience Q 4. Learning more about water		
	# Student Responses	% of Students
Yes	279	74
No	97	26
Total responses	376	

Finally, when asked whether or not students would like to come back to Aquarena Center and bring their parents, 69% of 376 respondents said they would like to do so, while 31% said they would not.

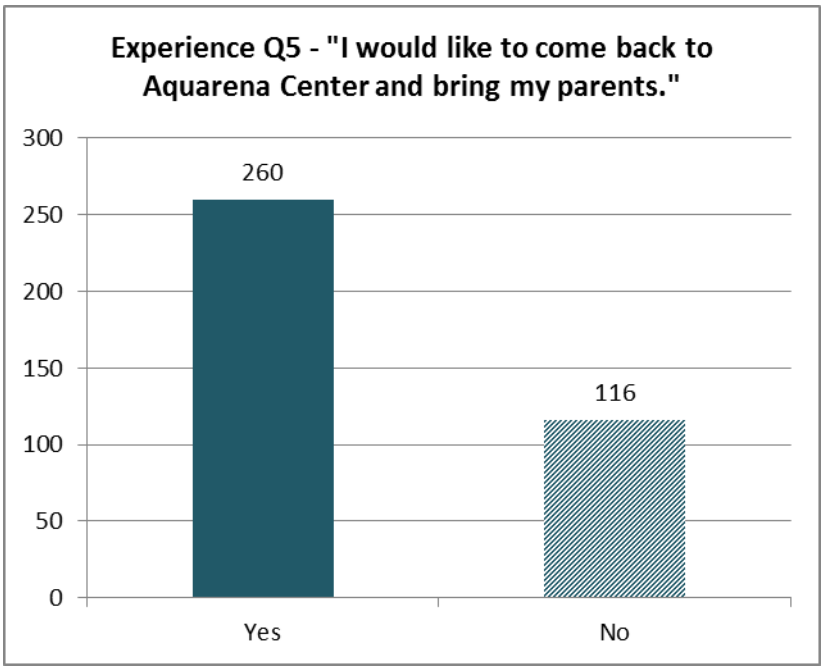


Figure 38. Experience Question 5.

Table 13. Experience Question 5.

Experience Q 5. I would like to come back to Aquarena Center and bring my parents.		
	# Student Responsents	% of Students
Yes	260	69%
No	116	31%
Total responses	376	

In general students responding to Questions 1-5 perceived their visit to Aquarena Center to be positive. Their visit increased or solidified students' understanding that water is important on many levels and their visit motivated students to learn more about water. The fact that students indicated strong enjoyment of the experience at Aquarena Center and that they desired to bring their parents back to visit the site with them proves that their visit had an impact on them, reinforced the learning of basic water concepts while there, and, inspired their continued interest. These responses clearly indicate the power of experiential or informal educational programs to enhance both the ability to absorb basic concepts and to stimulate continuing interest in the subject matter

PHASE II – Teacher Evaluations

The second phase of this research consisted of two surveys of teachers visiting Aquarena Center with their classes over the past two years and one in-depth survey of selected teachers. The first of these surveys was designed to augment the pre and posttests of students, to establish profiles of the teachers and to gauge their perspectives on the informal education programs at Aquarena Center. The analysis was conducted online using Survey Monkey, with 112 teachers responding. Results from this survey are reported below in the section titled "Inquiry I - Survey Monkey Tool."

The second teachers' survey was given to every departing instructor or adult leader following their participation in informal education activities at Aquarena Center. The survey results are reported in the section, "Inquiry II - Aquarena Center Field Trip Evaluation."

The in-depth interviews were given to a selected group of teachers that completed the survey monkey tool and indicated a willingness to provide more information. The results of the interviews are reported in the section, "Inquiry III – In-depth Interviews".

Inquiry I – Survey Monkey Tool

The subject of water is, by its nature, interdisciplinary with elements of science, social studies and even physical education. Therefore, this research was, in part, designed to determine the educational backgrounds of teachers who actually sought informal educational experiences for their students at Aquarena Center in order to help better understand their perspective and motivation for coming to the site in the first place. The first question asked teachers to identify the subject of their bachelor's degree (Appendix 3). Interestingly, four teachers indicated that although they did not currently

have a bachelor's degree, they were in the process of pursuing one. Of the 108 teachers who currently hold bachelor's degrees, only approximately 3% (3 teachers) of the responding teachers held degrees in Geography. Of the others, 22% possessed bachelor's degrees in Science (24 teachers), 41% in Education (44 teachers) and the remainder in other fields including Business, Sociology, Communications, Liberal Arts and Recreation (34% or 37 teachers).

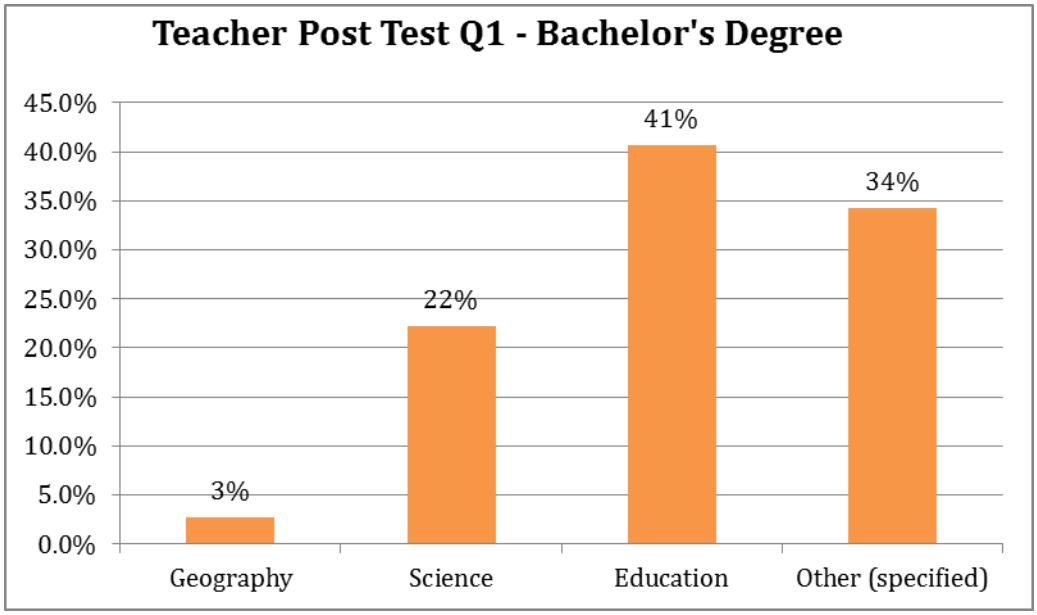


Figure 39. Teacher Post Test Question 1.

Table 13. Teacher Post Test Question 1.

Type of Bachelor's Degree	# Teachers	% Teachers
Geography	3	3
Science	24	22
Education	44	41
Other	37	34
Total	108	

When asked about Master's degrees in Question 2, no responding teacher indicated Geography was their major. A total of 18% of respondents held degrees in

Science (8 teachers), 43.2% in Education (19 teachers), and the balance in other fields, once again including Business Sociology, Communications, Liberal Arts and Recreation (26 teachers).

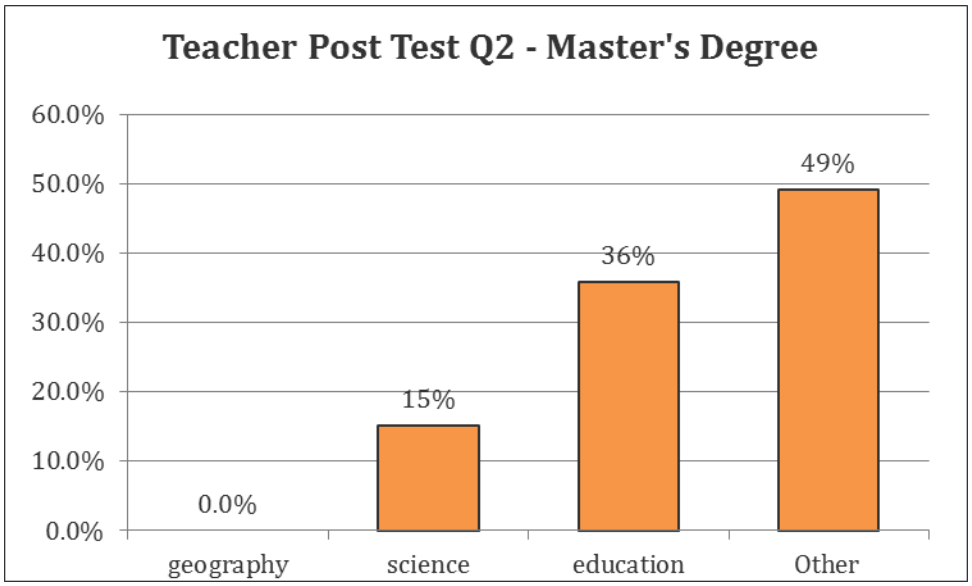


Figure 40. Teacher Post Test Question 2.

Table 14. Teacher Post Test Question 2.

Type of Master's Degree	# Teachers	% Teachers
Geography	0	0
Science	8	15
Education	19	36
Other	26	49
Total	53	

In response to the third question, only 9% (15) of responding teachers had earned Doctoral degrees. Interestingly, one respondent reported having a PhD in Geography; all others held degrees in the "Other" category, including oceanography, optometry, environmental engineering and Juris Doctor.

Table 15. Teacher Post Test Question 3.

Type of PhD	# Teachers	% Teachers
Geography	1	7
Science	0	0
Education	0	0
Other	14	93
Total	15	

In the fourth question, teachers were asked to indicate whether true or false to the statement: "I am more aware of issues pertaining to water and the environment after visiting Aquarena Center." To this question, 99% (110 out of 111) of respondents answered "True." This overwhelming response is a clear indication of the value of such informal water education programs, particularly for teachers from subjects other than science who would be least likely to be familiar or conversant in subject matter related to water.

Table 16. Teacher Post Test Question 4.

Teacher Post Test Q4. After visiting Aquarena Center, I am more aware of issues pertaining to water and the environment.		
Response	# Teacher	% Teachers
TRUE	110	99
FALSE	1	1
Total	111	

At the same time, in responding to Question 5, 97 teachers (89% of respondents), when asked whether they had incorporated insights and other content from their experience at Aquarena Center in their lessons, indicated that this was true. This response is one of the most encouraging of this research in that it indicates that teachers are actually taking "lessons learned" and insights from their experience at Aquarena

Center back to the classroom, thereby giving them life well beyond the one-time field trip experience.

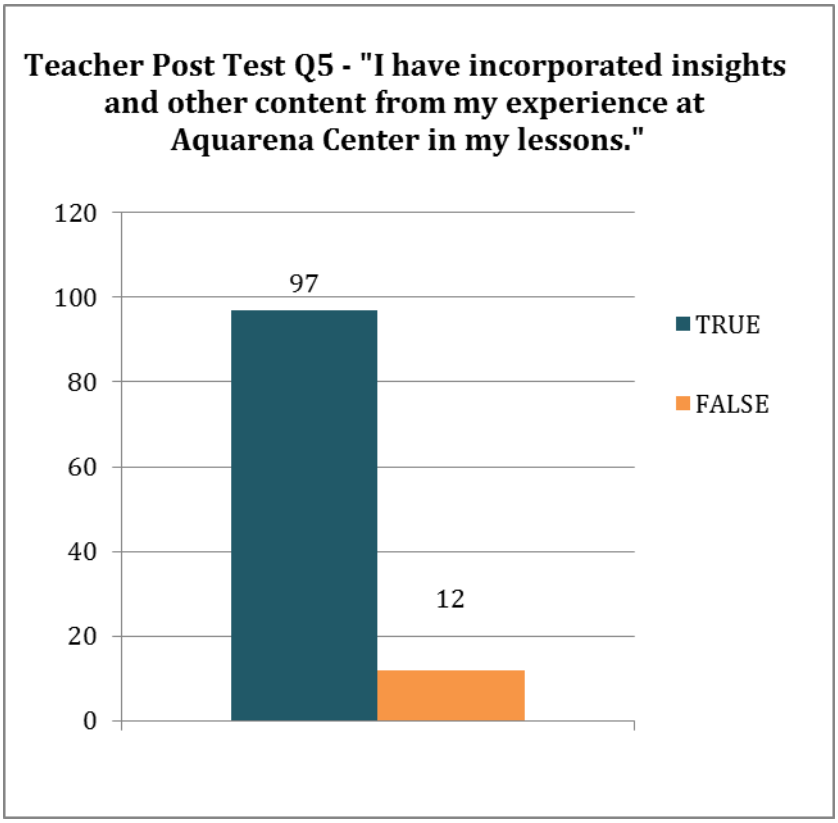


Figure 41. Teacher Post Test Question 5.

Table 17. Teacher Post Test Question 5.

Teacher Post Test Q5. I have incorporated insights and other content from my experience at Aquarena Center in my teaching		
Response	# Teacher	% Teachers
TRUE	97	89
FALSE	12	11
Total	109	

Further, when teaching back at their schools, 60% (65 respondents) answered True to the statement in Question 6: "I use activities and strategies modeled at Aquarena Center." In contrast to the responses to Question 5 that were overwhelmingly positive, a

full 40% of these respondents indicated they were not using activities or strategies from their experience at Aquarena Center. For both Questions 6 and 7 (below) this may be, among other plausible reasons, an indication that the educational standards teachers are now required to achieve leave little room for additional curricula or activities.

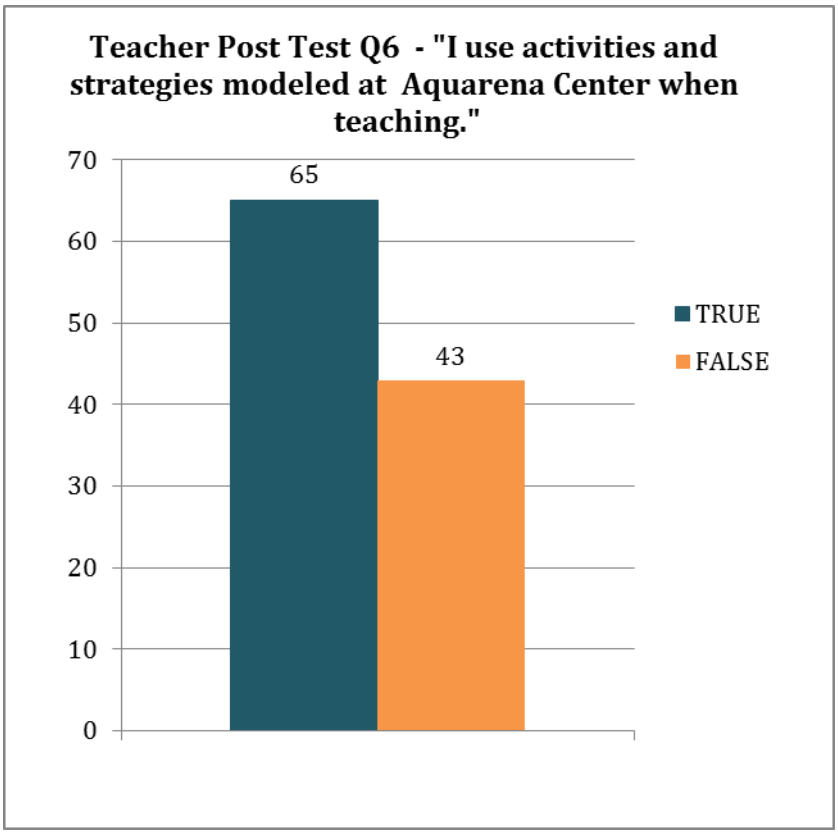


Figure 42. Teacher Post Test Question 6.

Table 18. Teacher Post Test Question 6.

Teacher Post Test Q6. I use activities and strategies modeled at Aquarena Center when teaching.		
Response	# Teacher	% Teachers
TRUE	65	60
FALSE	43	40
Total	108	

A smaller percentage, but still a majority of 108 teachers (55%), indicated in response to Question 7 that they had developed new lessons building on their experience at Aquarena Center.

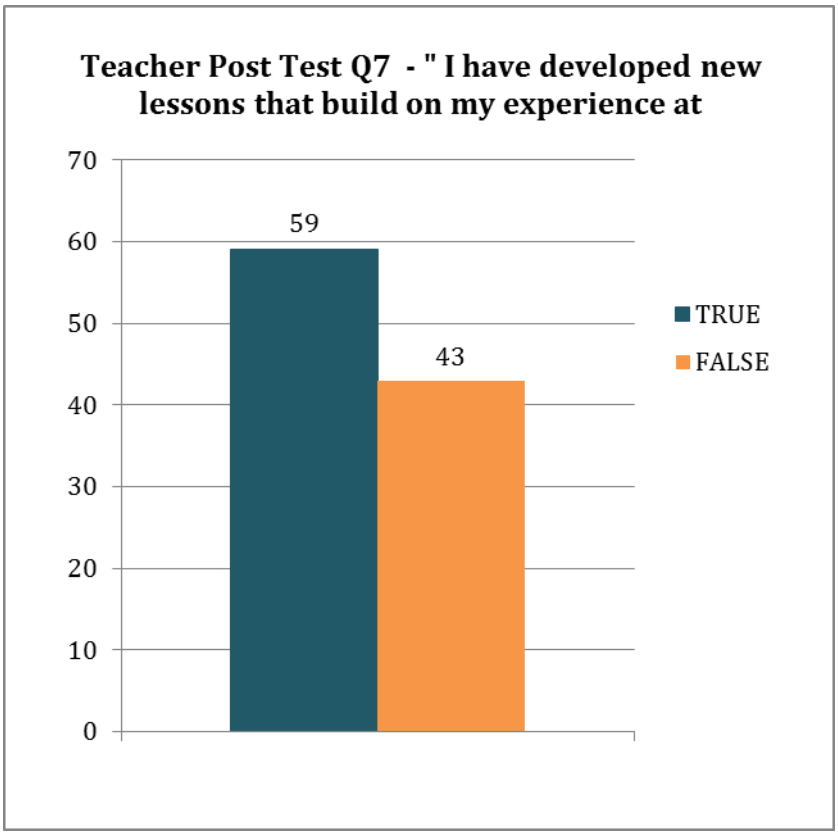


Figure 43. Teacher Post Test Question 7.

Table 19. Teacher Post Test Question 7.

Teacher Post Test Q7. I have developed new lessons that build on my experience at Aquarena Center		
Response	# Teacher	% Teachers
TRUE	59	55
FALSE	49	45
Total	108	

A strong majority of teachers, 82.4% of 108 teachers responded “True” when presented with the statement in Question 8: “I seek opportunities to learn more about

water issues, including water quality, conservation and sustainability." Here, the rate of positive response increased among teachers, indicating that, while interest in water was enhanced, and while teachers were inspired to increase their own water literacy, this increased level of interest does not necessarily conflict with other curriculum or content standards and activities required of them.

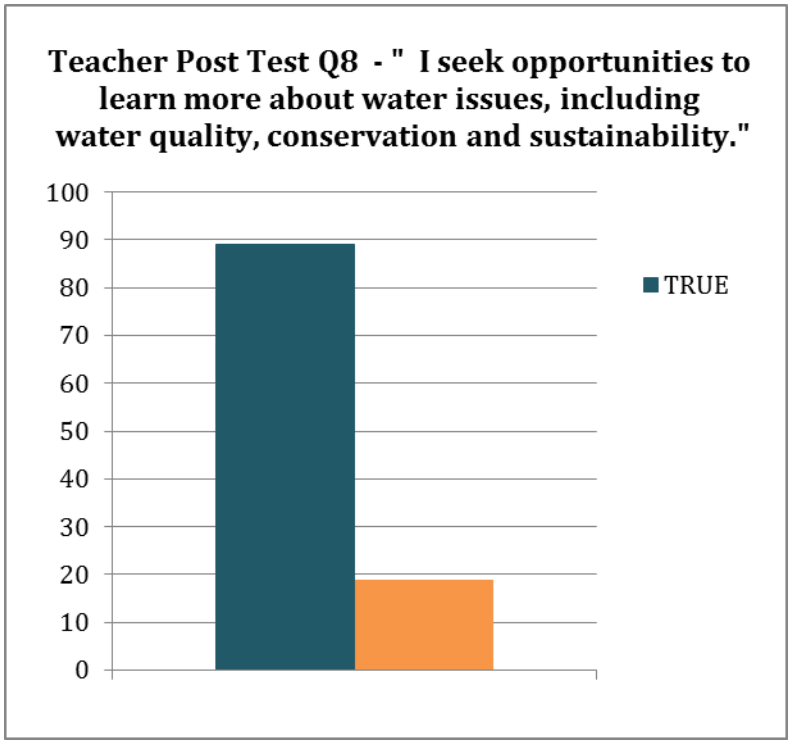


Figure 44. Teacher Post Test Question 8.

Table 20. Teacher Post Test Question 8.

Teacher Post Test Q8. I seek opportunities to learn more about water issues, including water quality, conservation and sustainability.		
Response	# Teacher	% Teachers
TRUE	89	82
FALSE	19	18
Total	108	

For Question 9, a full 100 out of 109 respondents (92%) answered "True" to the statement: "I seek other opportunities to provide my students with service or experiential outdoor learning activities. Clearly, though teachers' responding to the survey are less inclined to alter lessons or include additional content to that already required of them, they strongly value the ideas, insights, inspiration and reinforcement to be gained during informal educational experiences at venues such as Aquarena Center.

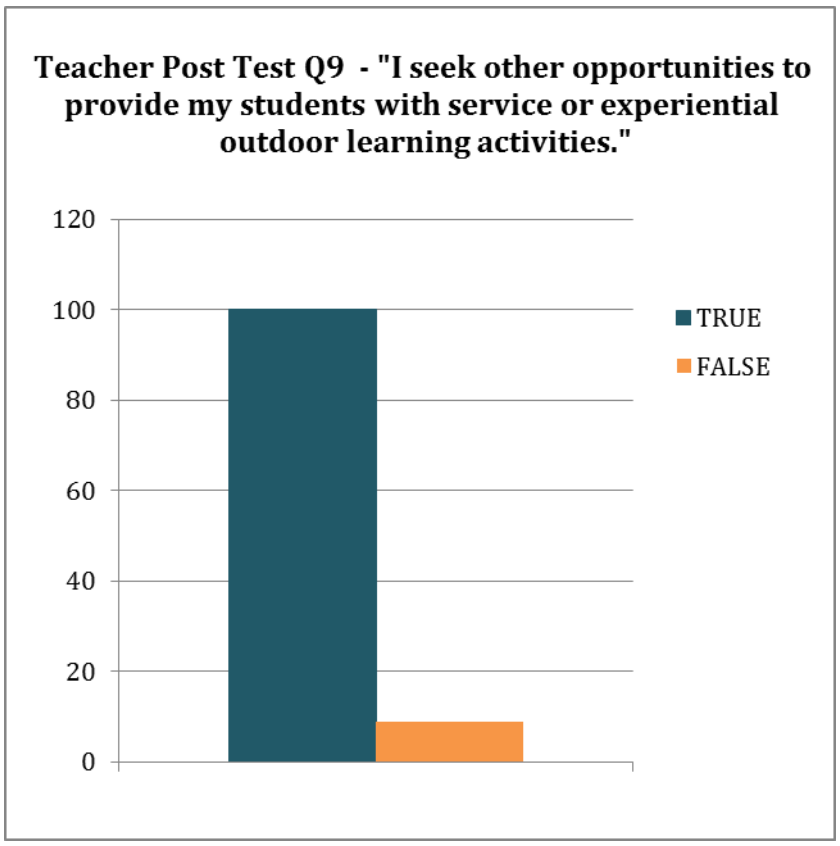


Figure 45. Teacher Post Test Question 9.

Table 21. Teacher Post Test Question 9.

Teacher Post Test Q9. I seek other opportunities to provide my students with service or experiential outdoor learning opportunities.		
Response	# Teacher	% Teachers
TRUE	100	92
FALSE	9	8
Total	109	

Finally, when teachers were asked if they sought opportunities to engage students in issues related to water and the environment using technology, 81% (88 out of 109 respondents) answered "True." While the conventional view among outdoor educators has been that the preoccupation of today's students with technology is an impediment to their understanding of nature, the use of technology combined with exposure to the

outdoors is viewed as actually contributing to that understanding. Thus, this research suggests that utilizing devices such as iPads and other mobile technology to assist in engaging children in the outdoors is fertile ground for future research and application.

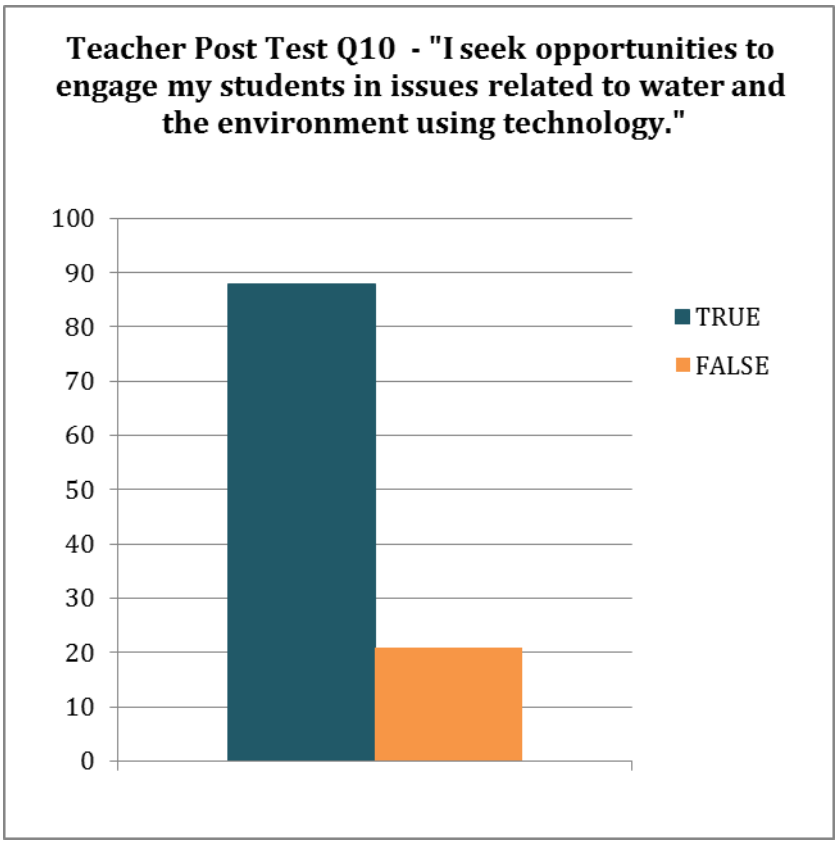


Figure 46. Teacher Post Test Question 10.

Table 22. Teacher Post Test Question 10.

Teacher Post Test Q10. I seek opportunities to engage my students in issues related to water and the environment using technology.		
Response	# Teacher	% Teachers
TRUE	88	81
FALSE	21	19
Total	109	

Inquiry II – Aquarena Center Field Trip Evaluation

The second teacher survey consisted of a small form given to every departing instructor or adult leader following participation in informal education activities at Aquarena Center. For purposes of this research, only those forms submitted by K-12 teachers were included in the analysis (Appendix 4). The data collected from this survey were entered and codified using Excel. Non-teachers answering the survey such as scout leaders were excluded. Respondents were asked to evaluate the educational content of the experience at Aquarena Center and indicate whether the field trip material was complimentary to the standardized TEKS Test. Of the 236 responding teachers, 189 (80%) indicated that the experience was "Great" (Figure 47).

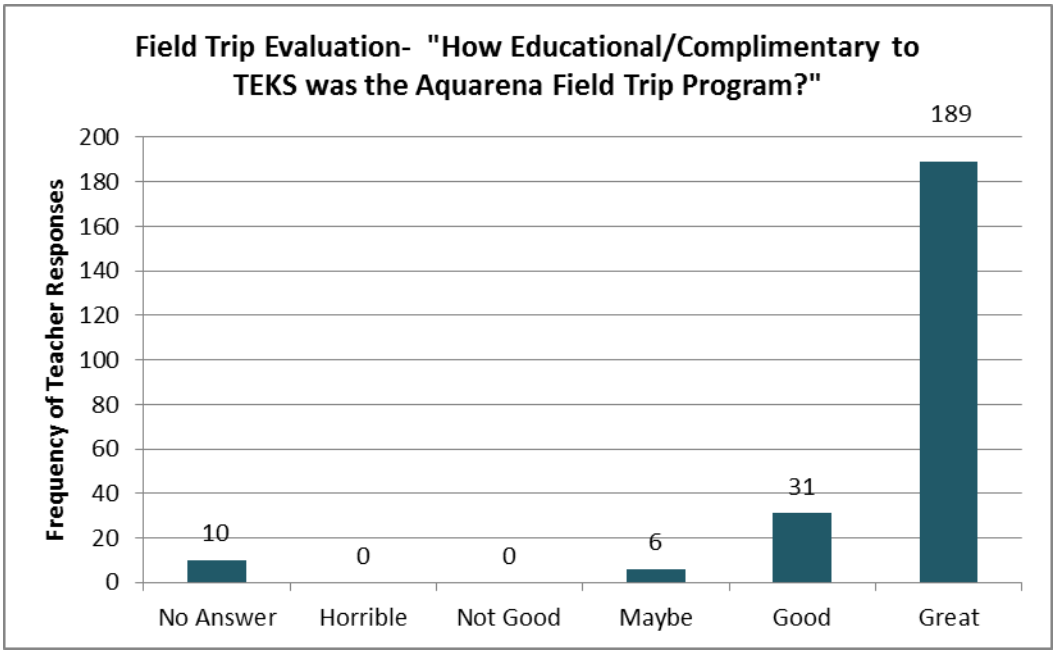


Figure 47. Field Trip Evaluation - TEKS.

When asked if they and their students had previously attended informal education programs at Aquarena Center, 208 responses were recorded. Only 78 teachers (33%), answered in the affirmative (Figure 48).

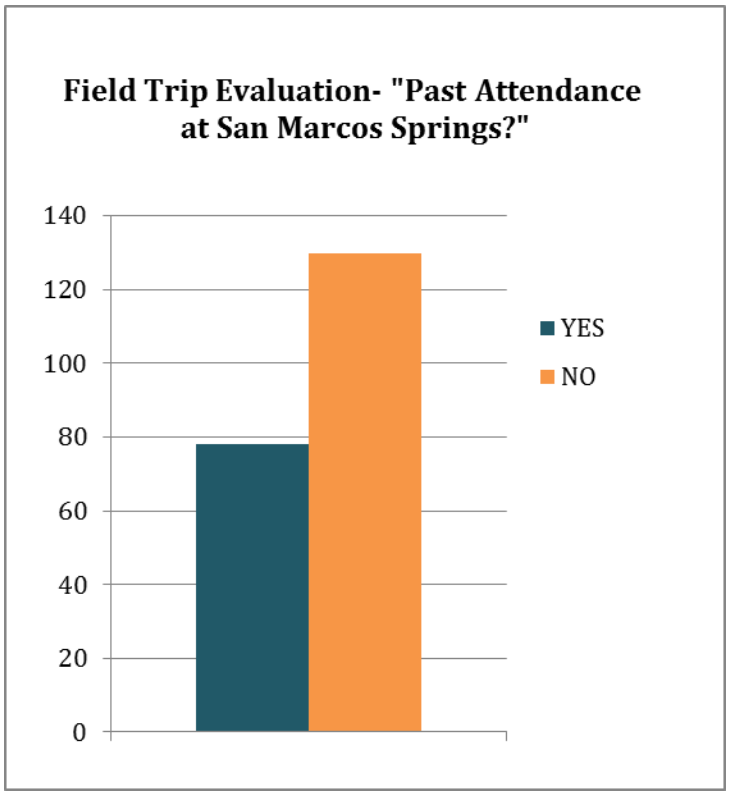


Figure 48. Field Trip Evaluation – Past Attendance.

Teachers were also asked to rate the facilities at Aquarena Center. This question is particularly pertinent in that since acquiring the Aquarena Springs Resort in the mid-1990s, the University has not invested heavily in maintaining the facilities and, in fact, has sought for more than a decade to secure funding for their demolition. In spite of the decline in the quality of facilities, 63% of responding teachers rated the facilities as "Great" (Figure 49). While the previous two questions by their nature have little statistical value, thereby not being incorporated into the principle conclusions of this research, they nevertheless provide a certain level of perspective as to teachers' overall impressions of the site and its programs.

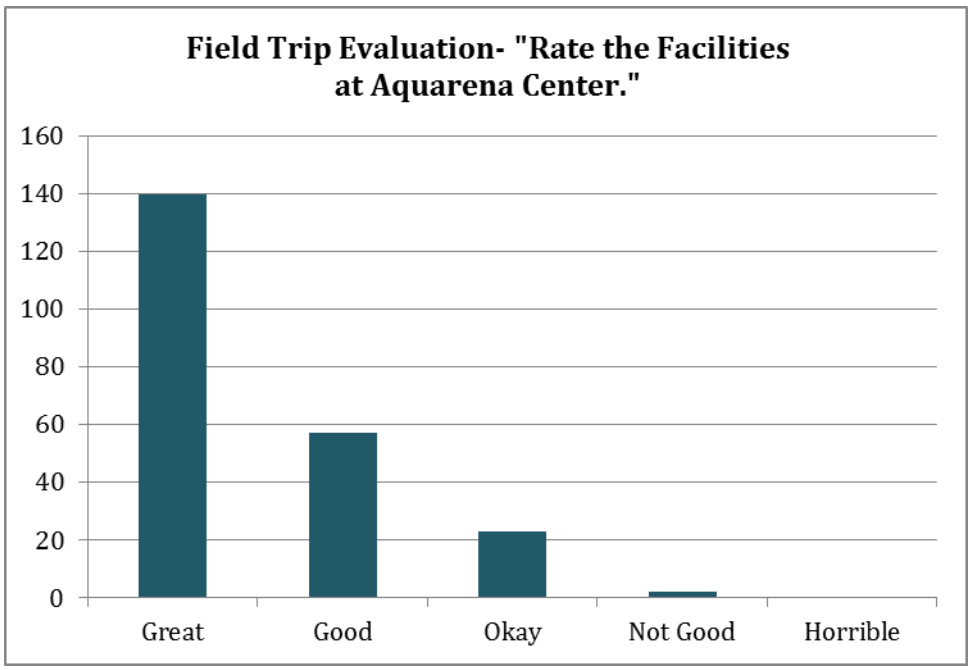


Figure 49. Field Trip Evaluation – Rate Facilities.

Teachers were also asked to rate the Tour Guides who led the informal education experience for their students. Significantly, most Aquarena Center Tour Guides are students at Texas State trained by senior personnel at the Center. A full 93% of teachers who took their students through the program rated their Tour Guide as "Great."

A very significant majority (85%) of teachers indicated that they considered the programming at Aquarena Center as Age Appropriate (Figure 50) and an almost identical number (86%) rated the length of the informal education program as "Great" (Figure 51).

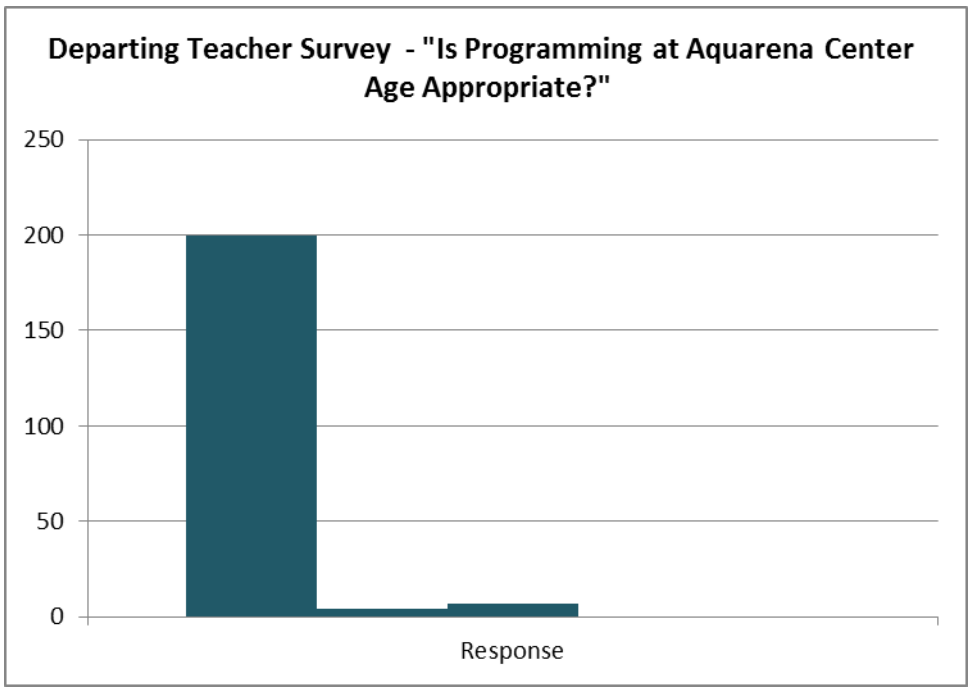


Figure 50. Field Trip Evaluation – Age Appropriate.

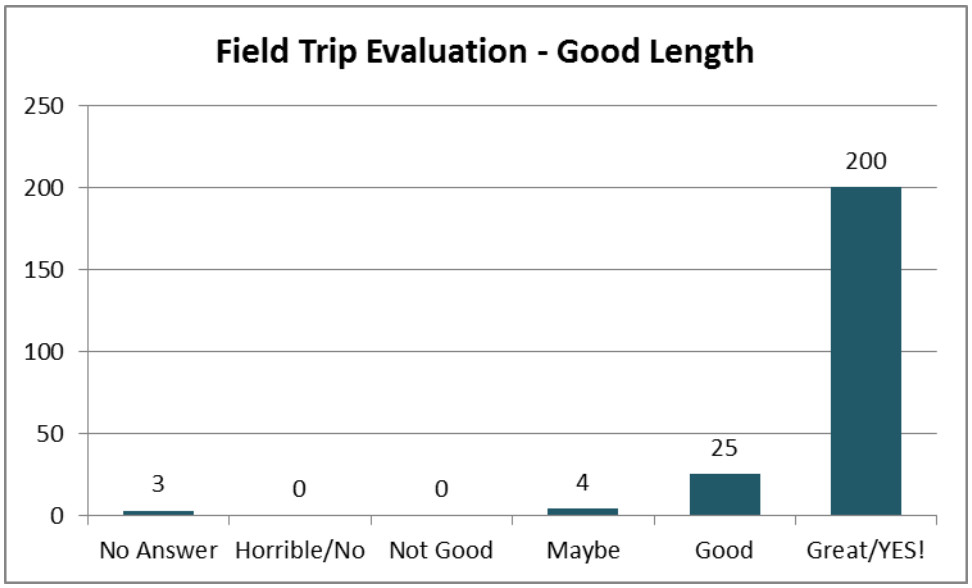


Figure 51. Field Trip Evaluation – Good Length.

Overall, 87% of the teachers responding to the survey rated their experience and that of their students at Aquarena Center as “Great” and a virtually equal number indicated that they would return with their students in the future.

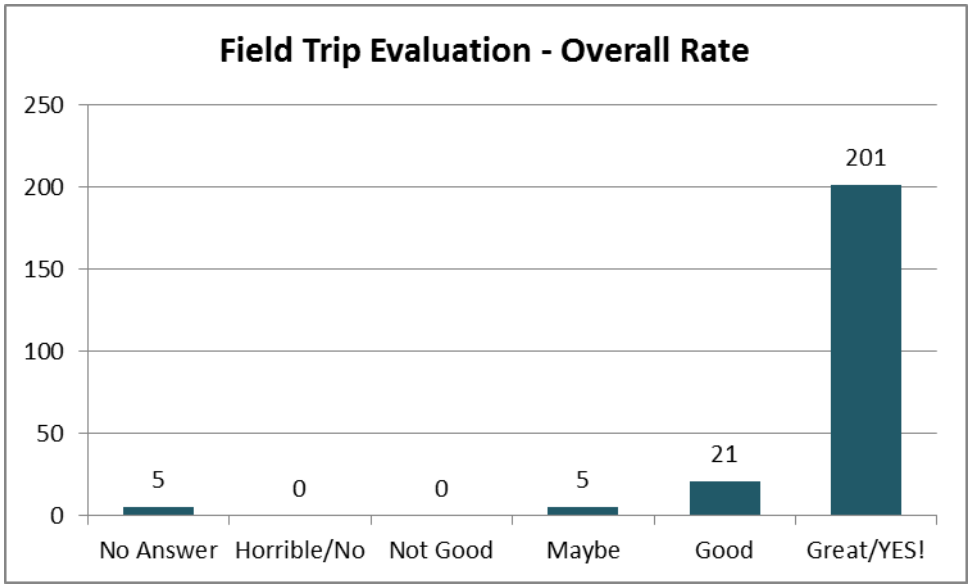


Figure 52. Field Trip Evaluation – Overall Rate.

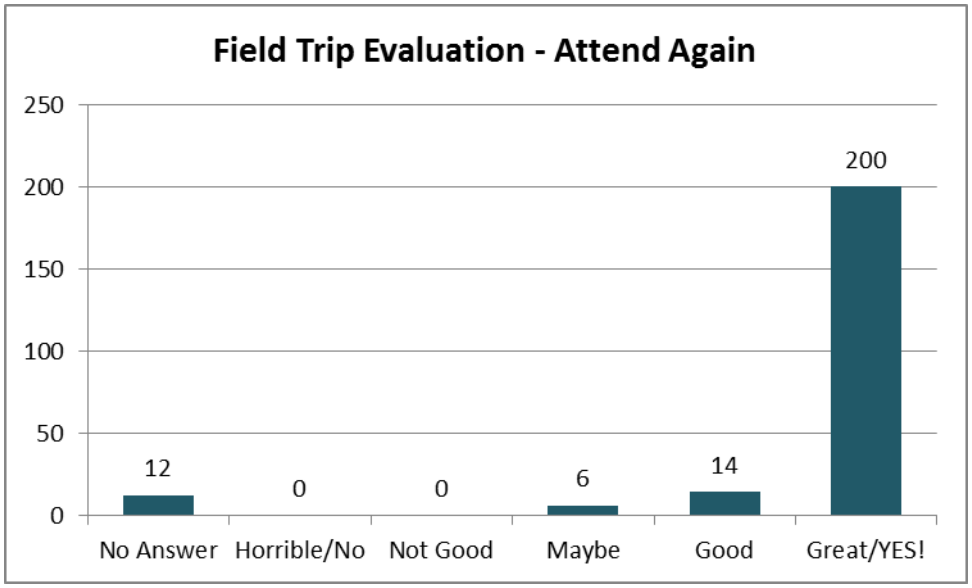


Figure 53. Field Trip Evaluation – Attend Again.

Overall, respondents completing the Field Trip Evaluation Form indicated their overwhelming agreement that the program was educational, age appropriate, and that the program and activities were good length. Further, 91% of respondents said that the field trip was good or great and that they would return again in the future.

Inquiry III – In-Depth Interviews

Following data collection and analysis of The Teacher's Survey conducted by Survey Monkey and the Aquarena Field Trip Evaluation Form, respondents to The Survey Monkey study were contacted to determine their willingness to participate in follow-up interviews. Potential participants were offered a $100.00 honorarium for the first twenty teachers who responded and interviews with them were scheduled by this researcher. All interviews were recorded and interviewees were asked before the conversation began if they had any objection to the recording process. No objections were noted. Due to variations in quality of the recordings, and because some of the respondents were not K-12, only twelve interviews were selected for analysis.

A questionnaire was developed for interviews with responding teachers (Appendix 5). All interviews were transcribed and analyzed using the qualitative data analysis computer software *NVivo.* This software is designed to assist the researcher in organizing and analyzing non-numerical or unstructured data. Basically, it is a program that facilitates the classification, sorting and arrangement of information and determination of relationships in the data (QSR International 2012).

Two analyzes were performed using the data collected by this researcher in interviews with responding teachers. First, a series of *nodes* were created around themes selected by this researcher to enhance, augment, or even contradict information collected from participants in the two previous surveys of teachers who had engaged their students in informal education programs at Aquarena Center. Then, using *NVivo,* queries were made in each of these *nodes* to evaluate responses to specific questions.

Second, a *global text search* was made of all interviews using key words to determine the frequency of appearance of key terminology in the transcripts. These frequencies tended to vary widely between questions answered simply yes or no and those by their nature demanding more in depth discussion.

Nodes were created for analysis around six primary themes: (1) Were insights from the experience at Aquarena Center incorporated into lessons back at school? (2) Did the experience at Aquarena Center result in a deeper understanding of water issues? (3) Did the experience result in a strengthened belief in the importance of water?; (4) What particular issues and experiences from the Aquarena field trip significantly contributed to the experience?; (5) Are teachers using Technology in the classroom or other venues?; and (6) Do teachers attempt to involve their students in service learning activities?

Summary of Results

With respect to the incorporation of experiences gained at Aquarena in lessons for the classroom, 83% of the teachers interviewed indicated that they did, while 17% indicated that they did not.

> 89% of the respondents have incorporated insights and other content from visiting Aquarena Center in existing lessons.
> a. Have you developed any new activities for your lessons?
> b. Can you describe them?
> c. How have you involved your students?

Most often mentioned, as an activity was the exercise at Aquarena Center whereby students actually collected invertebrates from the water and identified them. Several teachers indicated that their students were fascinated with the macro-invertebrates identification exercise. One teacher told this researcher that she herself became excited during the exercise and said to her students: "Look at these little guys.

They are so amazing and they're the ones that tell us how the water is doing, the quality of the water." She concluded by saying that she believed, for a moment, that her students felt like biologists.

Another teacher told this researcher that, upon returning to their school, students asked for a set of freshwater tanks for the classroom and several parents obliged and provided aquaria. The students subsequently took responsibility for the tanks and loved seeing the fish and caring for them. The text search on Incorporation of the Aquarena Experience in your Lessons resulted in 22 references (Figure 54).

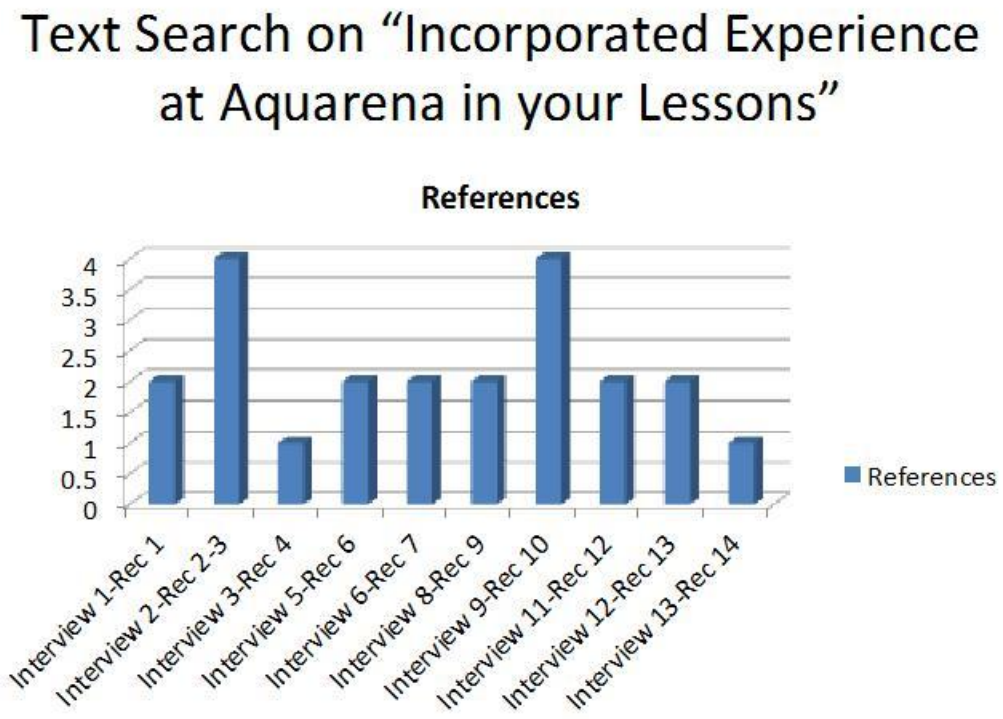


Figure 54. Text Search on "Incorporated Experience at Aquarena in your Lessons".

It is the opinion of this researcher that such activities both on the site at Aquarena Center and back in the classroom served to deepen the understanding of both students and

teachers of water issues and their importance. Analysis of the *NVivo nodes* for importance and understanding indicated that 100% of the teachers interviewed asserted that awareness and understanding of water and its importance in our lives increased significantly following their experience at Aquarena Center.

> 99% of teachers responding to the survey indicated a greater awareness of issues pertaining to water and the environment after visiting Aquarena Center.
> a. Can you describe how your visit brought about this greater awareness?
> b. What issues stick out in your mind?
> c. How important are they?
> d. Were you aware of them before you came?

Here, the text search resulted in 178 references for awareness and 144 for importance (Figure 55 and 56).

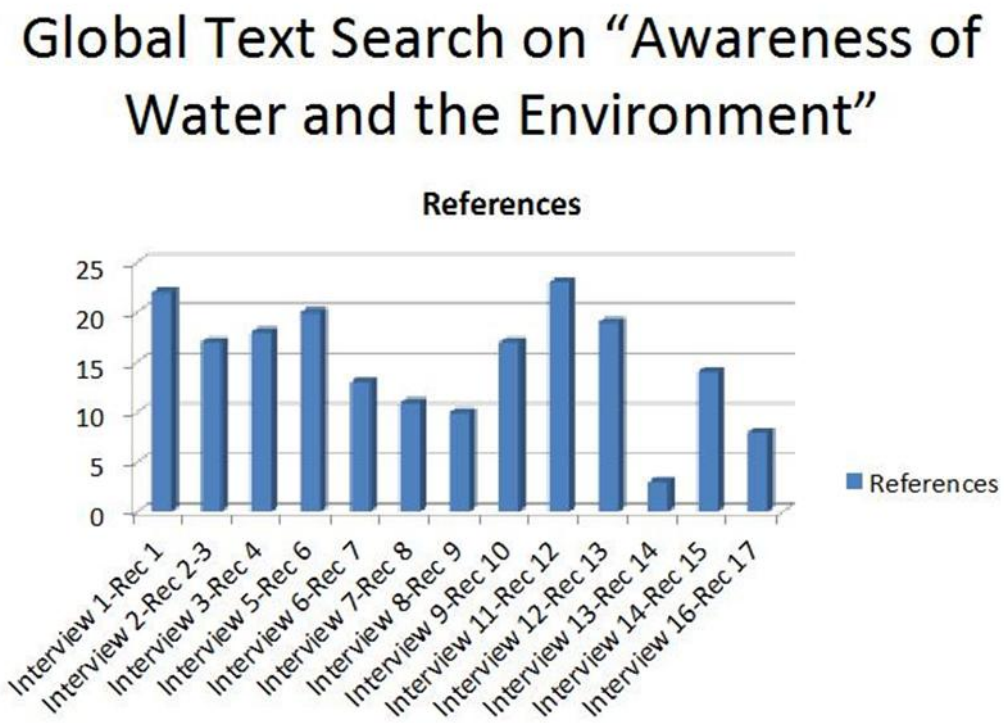


Figure 55. Global Text Search on "Awareness of Water and the Environment".

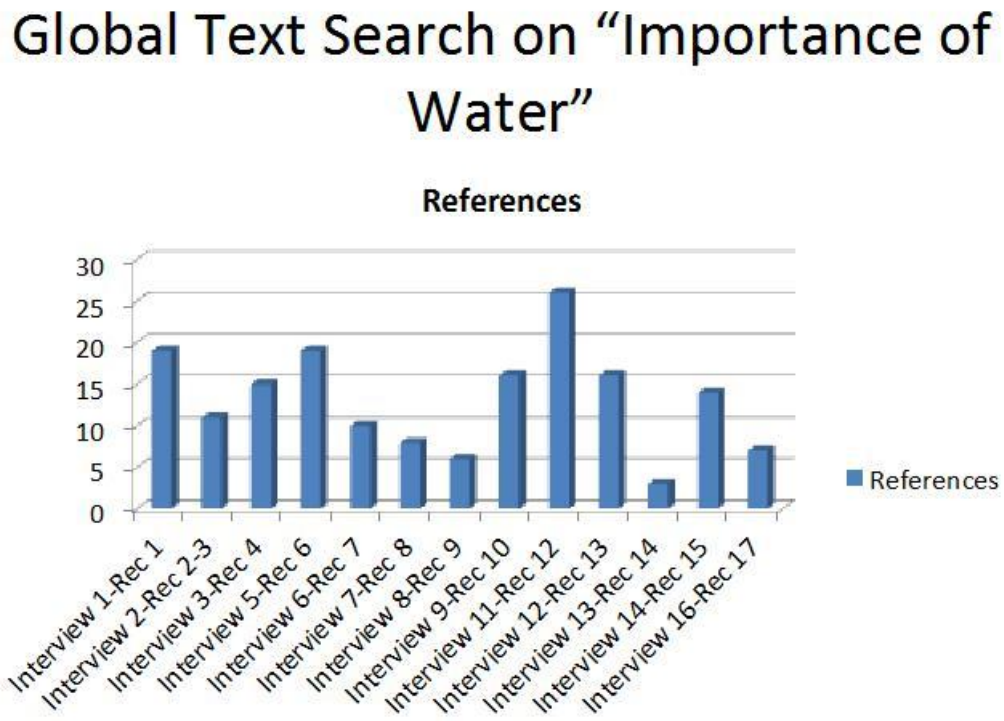


Figure 56. Global Text Search on "Importance of Water".

The interviews support the belief that appreciation of water issues was tied directly to individual experiences gained in the informal education program at Aquarena Center. Most often mentioned was the opportunity to actually view the springs coming up out of the Aquifer. One teacher told me that seeing the springs themselves was what "turned her students on the most." She said "seeing the actual springs coming up, seeing the water coming up like that and not coming out of a faucet" was both the most memorable activity for her students, as well as observing the activity that led them to say 'Oh, That's where it comes from.'" This reaction is particularly relevant to water education in that most students only know water from the tap in the kitchen, the toilet, or the swimming pool. The insight gained from actually seeing it come out of the ground may well be the most important impression made by the presentations at Aquarena

Center. Reaction to actually seeing the springs resulted in 41 references in the interview texts (Figure 57).

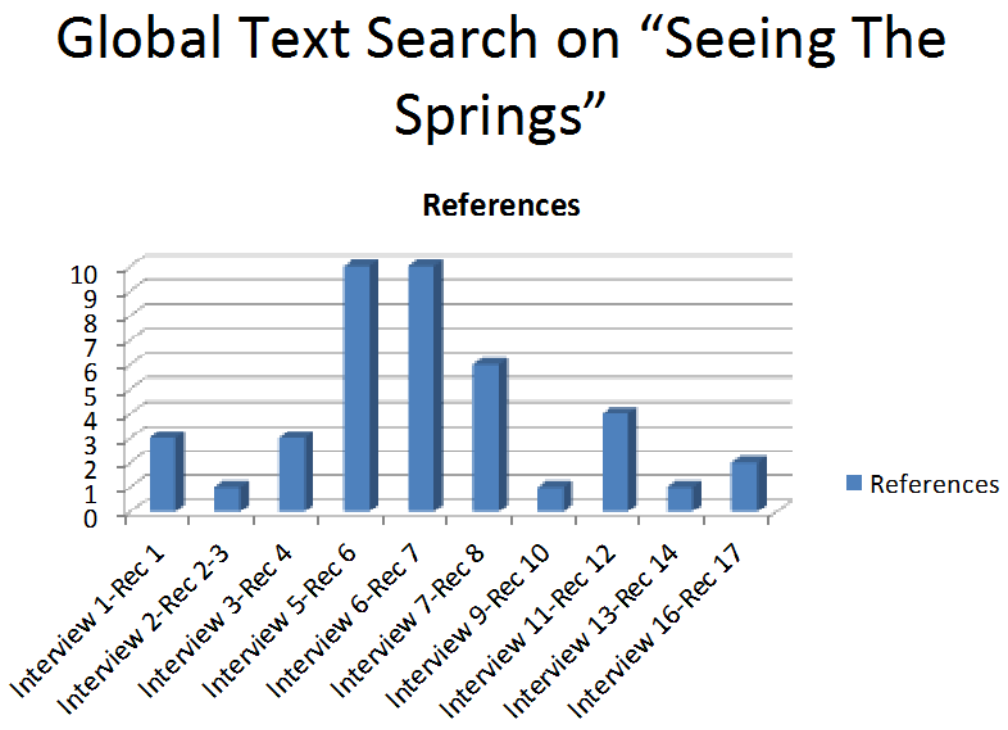


Figure 57. Global Text Search on "Seeing The Springs".

The interviews suggested that another activity that created both a lasting impression and an insight into the issues of water was related to explanations and viewing of the endangered species that inhabit the Edwards Aquifer, some of which can actually be viewed at Aquarena Center. One teacher told this researcher that learning that there are eight endangered species inhabiting the springs at Aquarena Center was, for her students "unbelievable." She further indicated that students generally think of endangered species as Tigers or Polar Bears rather than animals in "our local area." This insight was repeated over and over again as both a memorable part of the experience but also one that brought the importance of the water issue close to home.

Overall, the chance to actually see the springs emerging from the Aquifer and the endangered species that depend on their continued flow were indicated in interviews as the most important parts of the informal education program. Others mentioned were the insect activities, discussions of water conservation, and pollution. Figure 58 summarizes a breakdown of issues identified during the interviews.

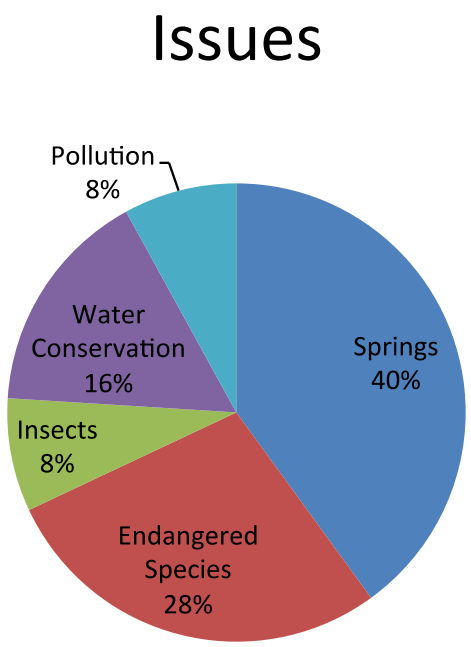


Figure 58. Issues.

When this researcher asked interviewees about the use of technology in their classrooms, 83% indicated that they did use it. One teacher had students bring digital cameras and make a slide show of their experience then take the cameras home and put together presentations on how they were conserving water in the home. Several teachers indicated that they were using an educational "social media" program called EDMODO which, in the words of one teacher, is sort of a "Facebook for the classroom" that parents are comfortable with.

Another technology example mentioned by several teachers is *Elmo* that is a document camera that allows a wide array of different types of information including documents photographs and other images to be brought to the classroom and displayed on the screen. Some interviewees indicated that they had begun experimenting with GIS and almost all are using the Internet in one way or another.

> 81% of the respondents tell us that they seek opportunities to engage students in issues related to water and the environment using technology.
> a. How have you done this?
> b. Internet?
> c. Video?
> d. GPS or other mobile devices?
> e. Google Earth?

The rather straightforward nature of this topic resulted in a total of 45 interview references. This researcher was surprised at the number of teachers who indicated they did use technology and it clearly appears that technology is an effective set of tools with which students are comfortable. The conclusion arising from this finding is that informal educators should find ways of incorporating technology in their educational offerings, including outdoor experiences (Figure 59).

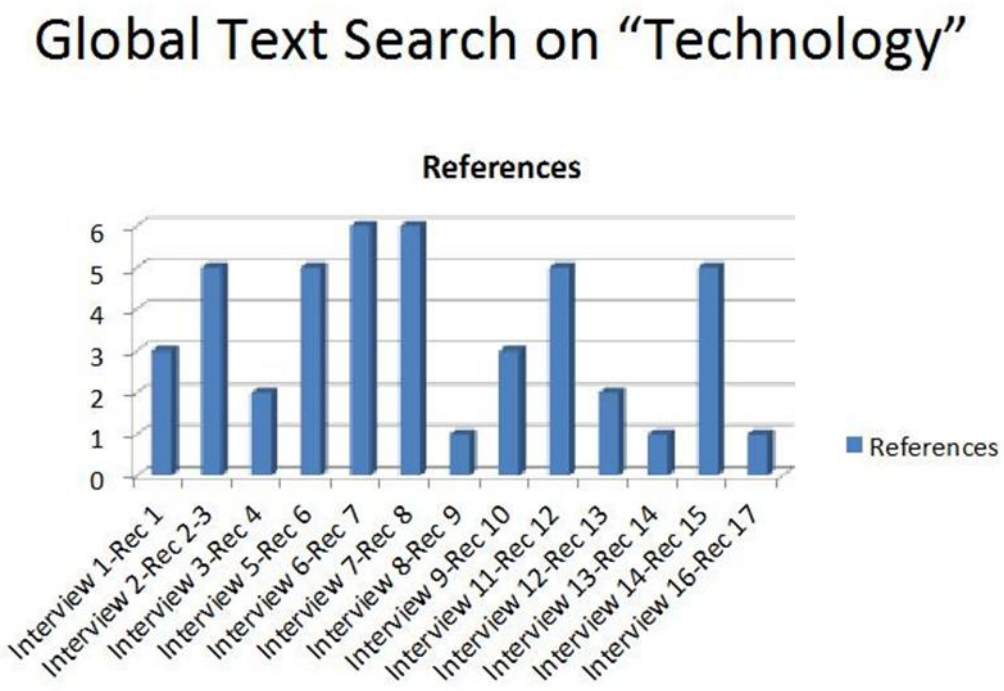


Figure 59. Global Text Search on "Technology".

Finally, a disappointing finding in the interview process was the relatively low number of teachers seeking to engage their students in various kinds of service learning projects. Fully 73% of those interviewed said that they did not involve students in service learning although several indicated that they would like to do so. One teacher indicated that she had discussed initiating some form of service learning activity with her students saying: "You know, that is something we would definitely like to do. A cleanup activity or something would be fun and I think it would be something that would teach them more on the subject." One opportunity for Aquarena Center, therefore, may be to devise appropriate service learning projects for students visiting the site. Although this would involve additional time, effort, and logistics, it could enhance the learning

experience while also helping to develop a culture of service among participating students.

> A full 92% of the teachers who have been to our site say that they seek other opportunities to provide students with service or experiential outdoor learning activities.
>
> a. How have you done this?
> b. Have the students responded well?
> c. Have you had the cooperation of the school district or administration?
> d. What barriers or challenges have you encountered?

Again, although the researcher was able to engage several teachers in limited discussion of this topic, only 45 references appeared as a result of the search (Figure 60).

Figure 60. Global Text Search on "Service Learning"

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CHAPTER VI

CONCLUSIONS

Following collection and analysis of date from the surveys, interviews and exit evaluations, correlations were made using a multi-level triangulation model to determine answers to the Research Questions.

Primary Research Question

How well does the informal education program at Aquarena Center convey water education to students and teachers?

Here, the program was found to be generally successful. In quantitative analysis, student knowledge of key water facts and messages increased sufficiently to be statistically significant in 5 out of 8 questions presented to participants both before and after the experience at Aquarena Center. Further in responses to the pretest, 75% of students indicated that water is important while only 65% indicated that it was important enough to include in classroom learning. Following the informal education program, fully 87% indicated that water was important and, significantly, 74% indicated that they would like to learn more about water. Teachers' responses also indicated strong improvement in water knowledge with 99% declaring that their awareness of water increased after participating in the program and 87% expressed a desire to learn more about water. Teachers further attested to the compatibility of the program with the TEKS Testing System in Texas (TEKS 2010) and affirmed that the experience at Aquarena

Center is both age appropriate and the right length in regard to time and content. Finally, in follow up interviews, 100% of respondents strongly stated that awareness of water and a deeper understanding of the subject increased following participation in the informal education program.

Based on these quantitative and qualitative findings, along with strong indications from the literature that informal experience in the outdoors not only increases content knowledge of the subject, but also improves student performance in other disciplines, this researcher has concluded that water education is conveyed well to both students and teachers in informal education programs at Aquarena Center.

Secondary Research Question

How did students and teachers rate the experience at Aquarena Center and what environmental and water education activities followed their visit?

Here again, it is possible to conclude that the informal education program at Aquarena is generally successful. Following their visit, 82% of participating students rated the program either "wonderful" or "interesting" and 68% indicated that they would like to come back and bring their parents. 86% of teachers responding to the field trip evaluation also declared that they would like to bring their students back in the future. 61% of these rated the aging facilities as great, and 87% gave the highest rating to the overall experience.

With respect to follow-up, 89% of teachers include insights and experiences gained at Aquarena Center, with 83% of respondents affirming this observation in individual interviews with the researcher. Fewer teachers, but still a majority use models

developed at Aquarena Center in their lessons or develop new ones based on the informal education experience.

Interestingly, although 91.7% of responding teachers indicate a desire to provide their students with experiential or service learning, follow-up interviews suggest that most may not actually do so. Further, 75% of student respondents indicated that they do not participate in any environmental clubs at school or in the community. This finding is clearly an area of opportunity for both formal and informal educators to create additional experiences for students that would be stimulating and provide significant life lessons.

Based on these insights, students and teachers rate the informal education experience at Aquarena Center at a sufficiently high level that they also express a clear desire to return. Further, teachers are using knowledge, perceptions and understanding received at Aquarena Center in their lessons. It was disappointing to learn from the data that, although there is interest, large numbers of students and teachers have not taken the opportunity for further engagement in service learning activities.

It was also disappointing to the researcher that so few of the teachers bringing students to Aquarena Center were Geography Teachers. Virtually all of the positive feedback about the transference of content knowledge, the deepening understanding of water and the inspiration of the students themselves is related to the experience of place at Spring Lake and in the Upper San Marcos Watershed.

Here it is the conclusion of this researcher that visitors to Aquarena rate the experience highly and that experience is contributing to lessons in the classroom but to a lesser extent, environmental engagement back home. Informal education at Aquarena

Center should seek means of connection beyond the field trip itself and market the program to teachers of geography.

Possibilities for Further Research

An interesting finding from the survey of students who visited Aquarena Center was that students from grades 7, 9, and 10 scored significantly higher statistically in the posttest than those from other grades. It would be interesting and potentially important to probe further into this finding to attempt to determine whether any conclusions could be drawn as to why these students' scores were significantly higher after the informal education experience. It could have something to do with the formal coursework for those grades or could potentially be due to differences among the schools themselves.

Another interesting avenue for further research is suggested by the finding that most water education is produced and distributed by water purveyors including utilities, water companies and others who sell water. A provocative inquiry would be to attempt to determine if the content of this messaging is influenced by the business goals of the providers, particularly with respect to alternatives for future water supplies.

Of particular concern to this researcher was the discrepancy between teacher responses to the Survey Monkey inquiry and those gleaned from the in-depth interviews regarding involvement of students in experiential or service learning. It would be important to plumb this area further to try and gain insights into whether there truly is a significant discrepancy and, if so, what factors may be influencing it.

A primary concern which surfaced in this research is the remarkable discrepancy which seems to exist in responses from large majorities of students that water is either important or very important contrasted with the conclusion that most either do not

practice water conservation at home or they don't know whether they do or not. This seems particularly significant, particularly in that most water education reviewed for this research indicated that a majority of the messaging concerned water efficiency and conservation. This opens up several avenues for further study including the efficacy of such messaging, whether it is even reaching students and their families, and whether the linkage between the importance of water and personal behavior is presented sufficiently in water educational materials.

Finally, there is evidence that, though teachers are increasingly interested in presenting water education to their students, many feel inadequate to do so. An interesting line of inquiry would be to survey teacher training materials and programs related to water and compare them; to test the effectiveness of those teacher training programs now in circulation including "Teaching with the Stars."

Public Policy Implications

While it was heartening to discover that large majorities of both students and teachers considered water to be important, there is little depth behind this expression. For example, the literature indicates that most Texans do not even know where their water comes from. While the initial response would seem to bode well for the support of legislative action concerning water, the presence of such a significant lack of understanding may well lead to uninformed decisions, particularly if the lack of in-depth knowledge is also present among policy makers who tend to generally reflect the population at large.

On the other hand, the very positive responses to the informal water education program at Aquarena Center suggest that public investment in such efforts might well

pay off for society in producing a more "water literate" population. Clearly, one questions the effectiveness of the TEKS standards on water when reviewing the survey results which indicate a significant lack of in-depth understanding of underlying water facts and issues. A greater emphasis on delivering this type of information through informal means may well make sense going forward as all research indicates that education is an absolute key to seeking solutions to Texas' water problems.

At a minimum, greater efforts should be made to connect teachers and students with the opportunity to experience informal water education programs such as that offered at Aquarena Center and there are potentially many other venues in Texas where such an experience is made available for student groups and families.

This line of reasoning is even more significant where water conservation is concerned. The Texas Water Plan, as we have found, calls for a full 1/3 of Texas' water supplies for the next fifty years to come from conservation and yet this researcher found that, at least among respondents to surveys of students visiting Aquarena Center, there was no strong indication that water conservation is occurring in the home. The policy implications of a proposed dependence on significant conservation contrasted with reported household behavior which is ambiguous at best would suggest a serious limitation on the potential success of the Plan itself.

Summary

In conclusion, though the informal water education program at Aquarena Center is generally successful in conveying content knowledge to its participants who also rate the experience as very positive, engagement beyond the experience itself is mixed. The experience can be enhanced by: accelerating efforts to include interactive technology as

an integral part of the offering; seeking additional opportunities to actually get students in the water; adding water quality testing as an activity; and linking the experience, if only virtually, with other parts of the basin, especially San Antonio Bay.

In order to increase the reach of the program and increase the level of connection beyond the experience itself, the staff at Aquarena Center should develop some targeted marketing aimed directly at the desired audience. At this time, most marketing expenditures are for billboards along I-35 which, in fact, do stimulate "walk-in" traffic. What might be more effective, given the Center's mission, would be to initiate a direct mail program to targeted schools or actually schedule visits to schools by Aquarena Center interpreters. Another innovation would be to seek collaborative opportunities among other kindred venues in Central Texas, including museums, nature centers, and preserves including Westcave and Jacob's Well and summer camps.

Specific enhancements to the curriculum could include greater presentation and emphasis on the basin as a whole, particularly with respect to the relationship of the headwaters to the Gulf of Mexico. The use of a watershed model to increase understanding of both the position of land, water and sky in the hydrologic cycle and the origins of non-point source pollution would strengthen the program. This is particularly true given the continued fragmentation of the Texas landscape. In addition, specific instruction on various household conservation opportunities might encourage more efficient use of water at home. The staff at Aquarena Center might seek "give-aways" such as flow restrictors for faucets and shower heads for the students to actually take with them.

Finally, the findings of this research and the ideas it has stimulated present an exciting agenda for increasing the impact of an already successful informal water education program at Aquarena Center designed to both increase the enjoyment and understanding of those who participate in it and, at the same time, make a real contribution to the water future of Texas.

APPENDIX I

AQUARENA CENTER STUDENTS QUESTIONNAIRE PRE TEST

Name:
School:
Town/City:
Grade:
Subject:
Teacher's name:
Age:

Principal Messages *Circle One*

1. A watershed is:
   A. A tank for storing water
   B. An ocean
   C. A spring at the headwaters (beginnings) of a river
   D. A geographic area from which rainfall flows to a river or stream

2. Healthy watersheds are important because:
   A. They are 100 gallon tanks used water for use during a drought
   B. It is impossible to pollute a healthy watershed
   C. They maintain water quality and quantity
   D. They are a great storage facility for garbage

3. An aquifer is:
   A. An underground formation containing and conducting water
   B. A wild animal
   C. A water treatment plant
   D. A bay on the Gulf of Mexico

4. The water cycle is:
   A. A two wheeled device for carrying water
   B. Evaporation, condensation, precipitation, and collection
   C. A rain storm
   D. The history of water on the earth

5. An estuary is:
    A. A winding stream
    B. A place where people are buried
    C. A geographic area on the coast where fresh and salt water mix
    D. A fish hatchery

6. The San Marcos River flows into:
    A. the Blanco River
    B. the Guadalupe River
    C. the Comal River
    D. the Nueces River

7. The water temperature of San Marcos Springs:
    A. varies depending on the air temperature
    B. is constant
    C. varies depending on the season
    D. is constantly changing from day to day

8. The rivers that make-up the San Marcos watershed are:
    A. the San Marcos River, the Blanco River, the Guadalupe River
    B. the San Marcos River, the Blanco River, the Comal River
    C. the San Marcos River, the Comal River, the Guadalupe
    D. the San Marcos River, the Nueces River, the Trinity

Connections *Circle One*

1. I belong to an environmental or outdoor club:
    A. Yes
    B. No

2. Being outdoors in nature is:
    A. Uncomfortable for me
    B. Not important to me
    C. Neither important or not important
    D. Somewhat important to me
    E. Very important to me

3. Water sports or recreation such as swimming, fishing and boating are:
    A. Things I don't like
    B. Neither important or not important
    C. Somewhat important to me
    D. Very important to me

Perceptions *Circle One*

1. Water is important for all life:
   A. Strongly disagree
   B. Disagree
   C. Neither agree or nor disagree
   D. Agree
   E. Strongly agree

2. In my home, we practice water conservation:
   A. Strongly disagree
   B. Disagree
   C. Neither agree or nor disagree
   D. Agree
   E. Strongly agree

3. In my class, learning about water is important:
   A. Strongly disagree
   B. Disagree
   C. Neither agree or nor disagree
   D. Agree
   E. Strongly agree

APPENDIX II

AQUARENA CENTER STUDENTS QUESTIONNAIRE POST TEST

Name:
School:
Grade Level:
Town/City:
Subject:
Teachers Name:
Age:

Principal Messages *Circle One*

1. A watershed is:

   E. A tank for storing water
   F. An ocean
   G. A spring at the headwaters (beginnings) of a river
   H. A geographic area from which rainfall flows to a river or stream

2. Healthy watersheds are important because:
   E. They are 100 gallon tanks used water for use during a drought
   F. It is impossible to pollute a healthy watershed
   G. They maintain water quality and quantity
   H. They are a great storage facility for garbage

3. An aquifer is:
   E. An underground formation containing and conducting water
   F. A wild animal
   G. A water treatment plant
   H. A bay on the Gulf of Mexico

4. The water cycle is:
   E. A two wheeled device for carrying water
   F. Evaporation, condensation, precipitation, and collection
   G. A rain storm
   H. The history of water on the earth

5. An estuary is:
    A. A winding stream
    B. A place where people are buried
    C. A geographic area on the coast where fresh and salt water mix
    D. A Fish Hatchery

6. The San Marcos River flows into:
    A. the Blanco River
    B. the Guadalupe River
    C. the Comal River
    D. the Nueces River

7. The water temperature of San Marcos Springs:
    A. varies depending on the air temperature
    B. is constant
    C. varies depending on the season
    D. is constantly changing from day to day

8. The rivers that make-up the San Marcos watershed are:
    A. the San Marcos River, the Blanco River, the Guadalupe River
    B. the San Marcos River, the Blanco River, the Comal River
    C. the San Marcos River, the Comal River, the Guadalupe
    D. the San Marcos River, the Nueces River, the Trinity

Experience *Circle One*

1. My favorite activity today was:
    A. Wetlands Boardwalk
    B. Aquarium
    C. Glass Bottom Boats
    D. Cave exhibit

2. Overall, my experience today was:
    A. Horrible
    B. Okay
    C. Interesting
    D. Wonderful

3. Based on my experience today, I believe water is important:
    A. Strongly disagree
    B. Disagree
    C. Neither agree or disagree
    D. Agree
    E. Strongly agree

4. I would like to learn more about water:
   A. Yes
   B. No

5. I would like to come to Aquarena Center and bring my parents:
   A. Yes
   B. No

APPENDIX III

INQUIRY I - TEACHERS' SURVEY MONKEY QUESTIONNAIRE

1. I have a bachelor's degree in:
    a. Geography
    b. Science
    c. Education
    d. Other (please specify)
2. I have a Master's Degree in:
    a. Geography
    b. Science
    c. Education
    d. Other (please specify)
3. I have a PhD Degree in:
    a. Geography
    b. Science
    c. Education
    d. Other (please specify)
4. After visiting Aquarena Center, I am more aware of issues pertaining to water and the environment.
    a. True
    b. False
5. I have incorporated insights and other content from my experience at Aquarena Center in my lessons.
    a. True
    b. False
6. I use activities and strategies modeled at Aquarena Center when teaching.
    a. True
    b. False
7. I have developed new lessons that build on my experience at Aquarena Center.
    a. True
    b. False

8. I seek opportunities to learn more about water issues, including water quality, conservation and sustainability.
    a. True
    b. False
9. I seek other opportunities to provide my students with service or experiential outdoor learning activities.
    a. True
    b. False
10. I seek opportunities to engage my students in issues related to water and the environment using technology.
    a. True
    b. False
11. Subject(s) I teach:
    a. _____
12. Grade(s) I teach:
    a. _____
13. Number of years I have been teaching
    a. _____
14. The class I brought to Aquarena Center was
    a. Grade:
    b. Subject:
15. Please share with us any other thoughts, comments, or suggestions about your experience at Aquarena Center.

APPENDIX IV

INQUIRY II - FIELD TRIP EVALUATION FORM

TEXAS STATE AQUARENA

Field Trip Evaluation Form

Please circle or fill in the blanks below and drop it off in the Gift Shop or with an employee.

Grade Level of Students (Please Circle all that apply) Pre-K K 1st 2nd 3rd 4th 5th 6th 7th 8th High School					
Estimated Number of Students that Attended this Field Trip: _____					
How did you hear about our programs? _____					
Has your group participated in Aquarena Center programs in the past?___ Yes ___No**(skip the next question)**					
Directions: Please read the question, then circle your response to according to the scale to the right.	**Horrible/ NO!**		**Okay/ Maybe**		**Great/ YES!**
How does your experience this time compare to your experience last time?	1	2	3	4	5
How would you rate the facilities at Aquarena?(restrooms, picnic area)tc.)	1	2	3	4	5
How was your Aquarena Center Tour Guide? Knowledgeable, friendly and entertaining? If possible please provide name _____	1	2	3	4	5
Was this program educational? Compliment material studied/TEKS?	1	2	3	4	5
Was this program age appropriate?	1	2	3	4	5
Were the program and activities a good length?	1	2	3	4	5
Overall, how would you rate this field trip?	1	2	3	4	5
Will your group attend an Aquarena Field Trip again in the Future?	1	2	3	4	5
What was the favorite activity? _____ Least favorite activity? _____					
Comments/Additional Suggestions about how we can improve our programs?					

APPENDIX V

INQUIRY III - QUESTIONS FOR IN-DEPTH INTERVIEWS WITH TEACHERS VISITING AQUARENA CENTER WITH THEIR STUDENTS.

1. 99% of teachers responding to the survey indicated a greater awareness of issues pertaining to water and the environment after visiting Aquarena Center.

    a. Can you describe how your visit brought about this greater awareness?
    b. What issues stick out in your mind?
    c. How important are they?
    d. Were you aware of them before you came?

2. 89% of the respondents have incorporated insights and other content from visiting Aquarena Center in existing lessons.

    a. Have you developed any new activities for your lessons?
    b. Can you describe them?
    c. How have you involved your students?

3. 60% of the survey respondents indicated that they use activities and strategies modeled at Aquarena Center when teaching. If you responded positively:

    a. How do your students respond?
    b. Do they seem to understand the importance of water in Texas?

4. 55% of the teachers visiting Aquarena Center reported that they have developed new lessons that build on their experiences at Aquarena. If you are one of those:

    a. Describe the lesson(s).
    b. How effective do you think they have been?
    c. Do the new lessons engage the students? Do they enjoy them?

5. 82% of the respondents tell us that they seek additional opportunities to learn more about water and water conservation. How have you done this?

    a. Internet
    b. Books
    c. Workshops?
    d. Other informal education, Nature Centers, etc.

6. A full 92% of the teachers who have been to our site say that they seek other opportunities to provide students with service or experiential outdoor learning activities.

    a. How have you done this?
    b. Have the students responded well?
    c. Have you had the cooperation of the school district or administration?
    d. What barriers or challenges have you encountered?

7. 81% of the respondents tell us that they seek opportunities to engage students in issues related to water and the environment using technology. How have you done this?

    a. Internet?
    b. Video?
    c. GPS or other mobile devices?
    d. Google Earth

8. Is there anything you would like to add? Generally, how would you rate your experience at Aquarena Center? What could we do to improve the experience for you and for your students?

APPENDIX VI

INSTITUTIONAL REVIEW BOARD CERTIFICATE OF APPROVAL

TEXAS STATE UNIVERSITY
SAN MARCOS
The rising STAR *of Texas*

Institutional Review Board

Request For Exemption

Certificate of Approval

Applicant: Andrew Sansom

Request Number : EXP2011T5670

Date of Approval: 07/07/11

Assistant Vice President for Research and Federal Relations

Chair, Institutional Review Board

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