Using Recycled Water For Potable Reuse In Santa Clara County, CA: High School Students' Knowledge and Acceptance

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USING RECYCLED WATER FOR POTABLE REUSE IN SANTA CLARA COUNTY, CA: HIGH SCHOOL STUDENTS' KNOWLEDGE AND ACCEPTANCE

A Thesis

Presented to

The Faculty of the Department of Environmental Studies

San José State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

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August 2017

The Designated Thesis Committee Approves the Thesis Titled

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APPROVED FOR THE DEPARTMENT OF ENVIRONMENTAL STUDIES

SAN JOSE STATE UNIVERSITY

August 2017

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ABSTRACT

USING RECYCLED WATER FOR POTABLE REUSE IN SANTA CLARA COUNTY, CA: HIGH SCHOOL STUDENTS' KNOWLEDGE AND ACCEPTANCE

by Nicholas R. Ajluni

The drought-prone State of California has an ever increasing demand for water. Potable reuse provides a viable alternative water supply, but public attitudes, knowledge, and acceptance have limited implementation. This study investigated the knowledge and acceptance that high school students have towards potable reuse. Previous research has identified four critical factors that influence acceptance of potable reuse: 1) knowledge of the wastewater treatment process, 2) knowledge of local water supplies, 3) trust in local water resource managers, and 4) belief in the need for a new water supply. This study uses both quantitative and qualitative methods through a Likert-style survey and open-ended questions on 174 students at three high schools to assess the knowledge, attitudes, and acceptance that they have towards potable reuse before and after an educational intervention. The results of this study showed that a short educational intervention had a significant impact on student knowledge and acceptance of potable reuse. The belief in the need for a new water supply had the largest impact on acceptance, and demographic variables were not significant. The results of this study will help local water managers better focus their efforts on outreach to improve attitudes toward acceptance of potable reuse.

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Introduction

The human population is currently over seven billion people with approximately one fifth, or 1.2 billion people, living in areas of water scarcity. These populations are projected to double by 2030 (United Nations Department of Economic and Social Affairs, 2014).   With such a high percentage of people living in arid regions of the world, society will be faced with serious social, environmental, and political challenges if the issue of water scarcity is not addressed. California is one state currently investing significant money and resources in developing resource management policies and water supply strategies to address water scarcity.

Since California water supply management plans have been reliant on traditional water supplies that are now overexploited, new sources of water are becoming ever more important. For the cities that rely on limited water sources to continue to thrive, sustainable sources of water are required and must be thoroughly vetted before implementation.

Public acceptance of new water sources, and of new technologies, has challenged the expansion and implementation of new water supplies and has been the topic of review for some time. The use of recycled wastewater as part of the water supply has seen a large expansion in California and elsewhere in the last fifty years, especially for non-potable uses such as irrigation. Currently, water supply managers are looking to expand those uses to potable reuse by mixing recycled water with current drinking water supplies. The current body of literature supports the hypothesis that as new technologies emerge, regardless of use, there is an inherent hesitation in the community based on perceived risk (Dolnicar & Schafer, 2009). Since decisions on public water supply are directly tied to public health, future development, environmental protection, and sustainability, the public has a high degree of hesitation in accepting new water supply methods and technologies and keeps a watchful eye on methods that water management agencies implement. The use of recycled water for potable reuse is no exception to this notion. Distrust of wastewater treatment technology falls under the sociological theory of “contagion.” “Contagion” is a term coined by anthropologists at the turn of the 20th century which helps explain why people feel that once they come into contact with an object that they feel is “disgusting,” they feel it is always disgusting no matter what happens to it in the future and no amount of purification or filtration can cleanse it (Frazer, 1959). This theory explains the hesitation that the public has with many technologies and applies to wastewater treatment. To counter the hesitation, industry researchers suggest that water managers focus on four factors that affect acceptance of potable reuse. The factors include knowledge of the wastewater treatment process, knowledge of local water supplies, trust in local water supply managers, and the belief in the need for a new water supply. These four factors have been utilized to create strategies to garner the public’s support of alternative water supply projects; however, previous work has focused only on adults, largely ignoring younger populations, which are critical for support of future projects.

Related Research

California Water Supply Background

As one of the largest and most arid states with the largest population and agricultural industry, California has a highly complex water supply system. In general, the northern third of the state receives over two-thirds of the annual precipitation that falls on California, yet the bulk of the population lives in the southern half of the state (PPIC, 2015). For example, the highest annual rainfall recorded in California was over 4,000 mm on the coast ranges in Northern California, compared to the lowest annual rainfall where no rain had fallen for over two years in Death Valley (WRCC, 2015). On average, over 200 million acre feet of freshwater fall in California each year, yet only 75 million acre feet is captured for human uses (PPIC, 2015).

To compound this, California experiences dramatic swings of precipitation with intense drought and times of intense precipitation following one another cyclically every few years (WRCC, 2015). Additionally, California's water supplies tend to be heavily reliant on runoff from melting snowpack. These supplies are likely to be diminished in the future due to global climate change resulting in earlier runoff and a longer, hotter dry season exasperating water shortages by reducing available conventional water supplies (Harris-Lovett & Sedlak, 2015).

California's water uses. California's limited water is being drawn on for urban, industrial, and agricultural uses. Californians used 122,755 acre feet of water per day in 2010 (USGS, 2015). In 2012, this vast quantity of water was used to irrigate 25 million acres of the most productive farm and rangeland in the United States, to fuel the eighth largest economy in the world, and to support a population of almost 40 million people (USDA, 2012).

The economy of California is dependent on ample supplies of water. Over 75% of all water used in California is used for agricultural and landscape irrigation (USGS, 2015). Of this amount, over 90% of water used for irrigation is used by agriculture (PPIC, 2015). However, agriculture is only 2% of the gross domestic product of the state and roughly 5 percent of the jobs (PPIC, 2012). Based on mandated efficiency practices, California has had a reduction of per capita water usage each year since the severe drought of the early 1980s, yet the state gross domestic product per capita has continued to increase, meaning that the state is producing more economic activity per unit of water used (USGS, 2015).

As California's economy continues to grow, so does it's population. The state's population is currently over 38 million and is expected to top 50 million by 2050 (PPIC, 2014). To accommodate the state's growth and ongoing development, it is important for the water systems of the state to also grow in a sustainable way. For this to happen, policy makers need to have a firm understanding of how the water systems of the state have developed and evolved and what the flaws are, so the new systems can be improved and made more resilient to major events such as droughts. New water supplies, such as recycled water and desalination, combined with water conservation will be needed to allow the state to maintain a healthy economy.

Potential solutions. The California water supply portfolio is divided into two main categories, conventional water supplies and alternative water supplies (Pacific Institute, 2014). Conventional water supplies follow the practices of the past 150 years and include the development of additional reservoirs on the state's rivers, additional management and utilization of groundwater resources, and additional water diversions from current surface waters. These water supply solutions have been largely exhausted. Except a few large-scale dams proposed upstream of current reservoirs, there are very few feasible locations where new reservoirs can be built (Pacific Institute, 2014). Additionally, California's groundwater supplies have already been tapped to the maximum sustainable yield, often leading to land subsidence. Alternative water supply enhancement options include water conservation measures, seawater desalination, and wastewater recycling. These water resource strategies are currently being implemented and improved upon in arid regions around the world. Each has unique benefits and drawbacks as well.

Water conservation is the preservation and protection of water resources and includes actions such as improving water use efficiency, limiting water use, planning water use and development, reducing water pollution, and educating the public on water related issues (Gleick, Christian-Smith, & Cooley, 2011). In 2015, the state of California mandated water conservation rates that required reduced water usage of 30% compared to that in 2013 (WaterBoard, 2015). Those goals were met demonstrating that in the past, up to 30% of the state's water consumption was overused and that more water could have been available if the population continuously conserved water instead of reducing consumption only during drought conditions. Having cheap, easily available water leads to overuse and further strains the water supply of the state due to the individual perception of an abundant supply (UC Davis, 2009). A major drawback in water conservation is that there is a limit to how much water can be conserved. At some point, water use will be minimized until it cannot be conserved further without an impact on economic and population growth. Due to a growing economy, population and global climate change, there will still be a shortage of water even with conservation efforts.

The second feasible alternative water supply for California is from seawater desalination. Desalination is the process in which seawater is either filtered or evaporated to remove salt from the water (Cooley, Gleick, & Woff, 2006). This water is then highly purified and can be used for drinking, irrigation, or industrial uses. This process is extremely costly, energy intensive, and can be environmentally destructive (Cooley et al., 2006). Due to the heat and energy needed to remove the salt from the seawater these projects have historically not been very successful in California (Latteman & Hopner, 2008). However, there are currently plans to develop California desalination plants in areas where other water supplies are not practical (Cooley et al., 2006). In addition to the high cost associated with building, operating, and maintaining these plants, there is an environmental impact that is hard to mitigate. When seawater is purified, the byproduct is a highly concentrated salty brine that contains heavy metals, chemicals, and concentrated salt that must be disposed of (Cooley et al., 2006).

In most cases, a pipeline is built several miles into the ocean for brine disposal. However, this can cause environmental harm to aquatic species. Mitigation for desalination plants is still studied worldwide, and the designs are constantly improved. The third alternative water supply is the utilization of recycled water and is the main focus of this study.

Recycled Water

Definition. Recycled water is defined as wastewater that has been treated and is suitable for a direct beneficial use or a controlled use that would not otherwise occur (Dolnicar & Saunders, 2006). The use of recycled water is strictly regulated by the California Department of Health Services, Division of Drinking Water, under Title 22 and Title 17 of the California Code of Regulations, the Water Code, and the Health and Safety Code (CDHS, 2001). There are varying degrees of treatment, and therefore quality of recycled water including primary treated effluent, secondary treated effluent, tertiary treated effluent, and advanced treated recycled water. Depending on the level of treatment, the regulations for recycled water use change, with more advanced treated water being allowed for closer human contact. Most urban areas that distribute recycled water use tertiary treated wastewater, and in some cases, advanced treated. The uses of recycled water vary based on permit regulations, but generally, tertiary water is used for non-potable, or non-drinking, applications including agricultural irrigation, landscape irrigation, sanitary services, and industrial processes and cooling. Advanced treated recycled water is now being used for more direct, potable uses, or drinking water purposes. These uses include groundwater aquifer recharge, swimming pools, streamflow augmentation, surface water augmentation, and direct potable reuse, where it is pumped directly to potable water treatment plants for distribution as part of the drinking water supply.

Potable reuse. There are two main potable reuse strategies currently being used for recycled water; they are direct and indirect potable reuse. Direct potable reuse is where advanced treated recycled water is introduced directly into the potable water distribution system just upstream of a drinking water treatment plant. This is opposed to indirect potable reuse which is the addition of recycled water to an environmental buffer such as surface water or groundwater supplies that will be the supply for potable water systems after it remains in the environmental buffer for a specific retention time (Advisory Group on the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse, 2016).

Figure 1 shows a comparison of the traditional water supply flow through process versus potable reuse cycles.

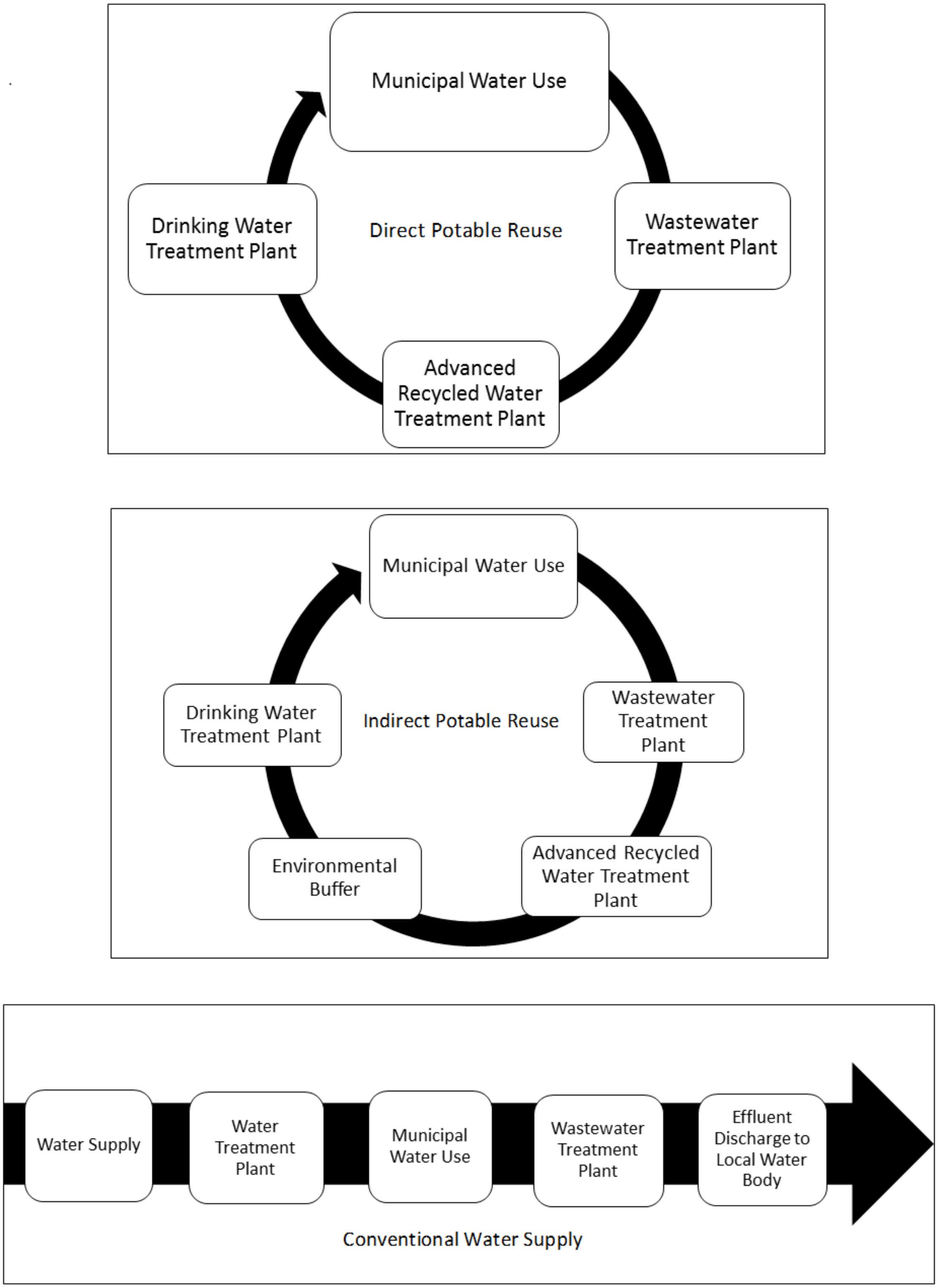

Figure 1. Comparison of Potable Reuse and Conventional Water Cycles

History of recycled water. All water on Earth is recycled through natural processes, and the water that is used today has been on the planet since its creation several billion years ago. In the modern water supply context, recycled water supplies have been developed since wastewater treatment technologies were first developed in the 1940's when primary treated wastewater effluent was discharged into rivers or other water bodies that were then used for drinking water by communities downstream. Since the onset of the Clean Water Act in 1972, all wastewater in the United States must be treated, so it does not pollute the waterway into which it is discharged. Commonly cited examples of historical uses of recycled water are the Mississippi and Colorado Rivers that act as the treated wastewater effluent outfalls for dozens of states and hundreds of communities in the United States (EPA, 2015). As communities along these rivers consume water, their wastewater effluent is discharged into the river to be pumped out and reused by communities downstream, such as St. Louis, New Orleans, Las Vegas, and Los Angeles. In California, water recycled after wastewater treatment is widely used for non-potable uses since the middle of the 20th century when the first regulations were implemented on wastewater treatment in the Dickey Water Pollution Act in 1949 and the Porter-Cologne Act in 1969 (SWRCB, 2015).

Recycled water in California. Given California's water supply shortages, recycled water has become a key component of the water supply and is likely the most feasible option for supporting California's population and economy. Since wastewater must be treated by law and is typically discharged into waterbodies, the additional cost of using the treated wastewater instead of discharging it is quite low, especially if it can be used for potable applications. Currently, total recycled water use in California is approximately 700,000 acre-feet of water per year. The statewide goal is to use 1,500,000 acre feet of recycled water by 2020 (SWRCB, 2015). An acre-foot of water is roughly 328,000 gallons or enough water for a family of four for 1-2 years.

Recycled water is currently used throughout California for both non-potable and potable uses based on treatment levels. The most common application is for non-potable uses such as agriculture, irrigation, and power generation, but direct and indirect potable uses such as groundwater recharge and streamflow augmentation are becoming more common as advanced treatment increases. Significant research has been performed to review public acceptance of recycled water for non-potable uses, and in most cases, recycled water use is strongly supported by members of the community (Liu, 2006; Dolnicar & Schafer, 2008). Regions such as San Diego, and Orange County have been using recycled water for indirect potable reuse since 1975. This practice remains very innovative, and, as a result, agencies have had to address challenges of public perception in the implementation of these technologies.

Challenges for recycled water. There are many challenges facing recycled water development in California. Current literature suggests the cost of implementing recycled water systems, and public perceptions of recycled water use are two main challenges that significantly hinder further development (Luthy & Bischel, 2010; Advisory group on the feasibility of developing uniform water recycling criteria for direct potable reuse, 2016; Bischel, Simon, Frisby, & Luthy, 2012). Literature that focused on what agencies perceive as the biggest challenges indicate that economic factors are the most important challenges (Luthy & Bischel, 2010). While research focused on a broader population find the main challenge to fully developing recycled water is public perceptions of the safety and economic benefits of using recycled water, especially for potable reuse (Advisory group on the feasibility of developing uniform water recycling criteria for direct potable reuse, 2016). It has been determined that the general public supports recycled water for non-potable uses such as irrigation, but that the acceptance and support for recycled water quickly diminish as the use gets closer to human contact and drinking water uses (Dolnicar & Schafer, 2008). Projects in both California and Australia have been canceled and delayed over public opposition to increased use of recycled water for more diverse uses such as groundwater recharge based on the image that the public has of recycled water (Dolnicar, Hurlimann, & Grunn, 2011). This phenomenon is called the "Yuck Factor, " and several sociological theories explain how it was created (Miller, 2012).

Yuck factor explained. Using recycled treated wastewater is a critical strategy that can greatly improve the quality of life, economy, and environment in arid regions around the world. In fact, researchers have shown that in theory, the problem of water shortage can be resolved by the vast array of engineered solutions that are now available for our use (Dolnicar et al., 2011). Unfortunately, the psychological aspect of accepting treated wastewater for potable uses has limited the expansion of recycled water use and has even prevented projects from being implemented in the Bay Area, and San Diego, California, and in Australia (Marks, 2006).

There are several social theories that can help explain the hesitation that the general public has towards using recycled water for potable consumption. The first is a theory developed in 1890 by Frazer called *magical contagion* (Frazer, 1929). This theory holds that humans believe that once they come into contact with something disgusting, they are always in contact with that thing. This theory has been confirmed with modern American adults and is especially important for recycled water development (Rozin, Haddad, Nemeroff, & Slovic, 2015). There are two aspects to the theory of the contagion, one is a material contamination, where there is a belief that the contagion can be washed, filtered, cleaned, and removed from the item deemed contaminated. The second is a mental contagion where the contamination is intangible and cannot be removed physically, rather, the feeling resides in the mind of the person and is much more difficult to respond to (Rozin et al., 2015). As described in the literature, there are conditions of mental contagion that must be overcome for the use of advanced treated recycled water for potable uses. They include the following:

1. Physical contact is needed for the contagion to occur
2. Once contamination has occurred, time nor spatial distance significantly reduces its effects
3. Brief contact with the contagion is sufficient to make the entity contaminated or disgusting

4. The contaminants are resistant to purification, and some can never be purified (Rozin et al., 2015; Nemeroff & Rozin, 1994).

These properties help explain the hesitation and distrust that the public has with using recycled water, especially for potable reuse. Since recycled water was once contaminated wastewater, the properties of the psychological theory of magical contagion hold that those contaminants can never fully be removed, no matter how much treatment is applied. As part of the assessment of whether or not a person accepts recycled water, intuitive toxicology must be considered.

Intuitive toxicology is the inherent and natural instinct that humans have to determine if an action or object is safe, and what level of risk there may be associated with it. This risk assessment takes parts from human senses of sight, smell, feeling, but also includes human emotions, as part of the calculations of the costs and benefits, and the communication of the risks (Kraus, Torbjorn, & Slovic, 2002). Since most people know what wastewater is, they make a risk assessment associated with the treatment and distribution of recycled water that is sourced from the wastewater. In addition to the source risk, recycled water tends to have a chlorine odor to it, which adds to the perception that it is inferior in quality. Additionally, State requirements, such as those in California, require placement of publicly visible warning signs and labels in areas where recycled water is used leading to additional negative perceptions of its quality and safety.

Another important theory in understanding people's attitudes towards a new technology or process is source characteristics. Source characteristics have long been recognized in social models that test population attitudes towards changing technologies. When testing and communicating hazards, people trust institutions that they perceive as honest, reliable, responsible, accurate, and focused on public welfare (Frewer, Howard, Hedderly, & Shephard, 1996). This institutional trust will be especially important as water managers begin to expand recycled water use and move towards more innovative uses such as direct and indirect potable reuse. An example where the public's level of trust was breached, leading to wide distrust of local water supply managers was lead contamination in Flint, Michigan caused by the local water agency attempting to cut costs and reduce maintenance efforts (APHA, 2016). This crisis led to community health concerns on a wide scale and diminished trust nationwide (APHA, 2016). The long-term impacts of this crisis on perceptions of new water supplies have not yet been studied.

Improving acceptance. Since recycled water for potable reuse has been widely seen as a risk to the public, much research has been done to help explain these perceptions, and what can be done to change the attitude of the public. Several key characteristics have been identified for successful public communication about recycled water projects. First, in the initial planning phase of a project, it is important for the water managers to understand the following three principles:

1. Professional knowledge provides the technical foundation for providing alternative water schemes
2. The community needs to desire new water schemes

3. Since public acceptance is usually low, it is essential for the managers to introduce the scheme in a segmented approach that resolves each issue facing the community (Dolnicar & Schafer, 2009).

It has also been found that there are six important considerations for issue management including:

1. Managing information.
2. Maintaining motivation.
3. Demonstrating organizational commitment.
4. Promoting communication with the public.
5. Ensuring fair decision making.
6. Building and maintaining trust with the public (Hartley, 2006).

For water managers to gain public trust and better communicate with the public, it is important to determine several key concerns regarding potable reuse. The key concerns are:

1. How the community currently perceives potable reuse.
2. Public's level of knowledge on potable reuse.
3. The stated likelihood that the public would use and support potable reuse.
4. What the characteristics of those people are (Dolnicar & Shafer, 2009).

Additionally, it is important that the words and language used to describe and promote recycled water be carefully crafted (Menegaki, Mellon, Vrentzou, Koumakis, & Tsakarakis, 2009). With this in mind, research has been done on public outreach and how to communicate most effectively, without negatively impacting the acceptance of recycled water for potable reuse (Macpherson & Slovic, 2011).

Four critical factors. To better understand a community's acceptance of recycled water for potable reuse, it is important to understand that acceptance is affected by four key concepts, belief in the need for a new water supply, knowledge of local water supplies, knowledge of the wastewater treatment process, and trust in local water supply managers. In this study, these four concepts have been named the Four Critical Factors that affect acceptance of potable reuse.

Perceived need. The first concept is the public's perception that there is a need for new water supply scheme (Dolnicar & Schafer, 2009). If the community believes that the current water supply is adequate, they are less likely to support a new water supply that they believe carries a significant amount of risk associated with it. Currently, California is in the midst of the worst drought in its history. The drought has led to significant media attention to the current inadequacy of water supplies within the State and has made water supply a concern for all residents. With this in mind, it is important for water managers to introduce new water schemes with a segmented approach that resolves concerns early on (Dolnicar & Schafer, 2009). It is also important for water supply managers to ensure new water supplies are established and presented regarding both short, and long term sustainability.

Knowledge of treatment process. The second and third concepts are that knowledge of the wastewater treatment process, and about the water supply, generally increases the acceptance of recycled water for potable reuse (Dolnicar, Hurlimann, & Nghiem, 2010). Some research shows that even though the public knows that we currently have the technology available that easily treats wastewater to a quality that is safe to drink, there is still hesitation about its use and implementation (Asano & Tchobanoglous, 1991). In response, it has also been shown that knowledge and information about treatment technology and the risk-benefit of recycled water significantly increases acceptance of its use for potable reuse (Fielding & Roiko, 2014).

Knowledge of water supply. Furthermore, education on the basic urban water cycle can help increase acceptance of recycled water for potable reuse since knowledge on the water cycle informs that all water is recycled naturally, or mechanically and has been since the Earth's creation (Rozin, et al., 2015). Exemplifying public perception challenges, research has indicated that the general population in the United States, including California, has a low knowledge in water supply, especially from alternative sources such as desalination and recycled wastewater (Dolnicar & Schafer, 2009). It has also been widely reported in the field of risk assessment that while scientists methodically weigh the risks and benefits, the public intuitively makes their decisions on the risk and benefit and tend to overplay the perceived risks and downplay the potential benefits (Miller, 2012).

Trust in local water resource managers. The fourth concept is that the level of trust in the water resources managers and purveyors significantly impacts the acceptance of recycled water use (Doria, 2010). Researchers in

Australia found that people who were satisfied with recycled water use tended to perceive water authorities as communicating well, trusted the authorities, saw a financial value to recycled water, and could tolerate water quality differences between traditional water supplies and recycled water (Hurlimann, Hemphill, McKay, & Geursen, 2008). Part of the problem associated with recycled water project development is that many water suppliers lack a common language or message when it comes to branding recycled water. Thus, the public is often confused and left doubting the quality of the product and the reliability of the water supply managers (Dolnicar, Hurlimann, & Grun, 2014). Figure 2 illustrates the Four Critical Factors affecting acceptance of potable reuse.

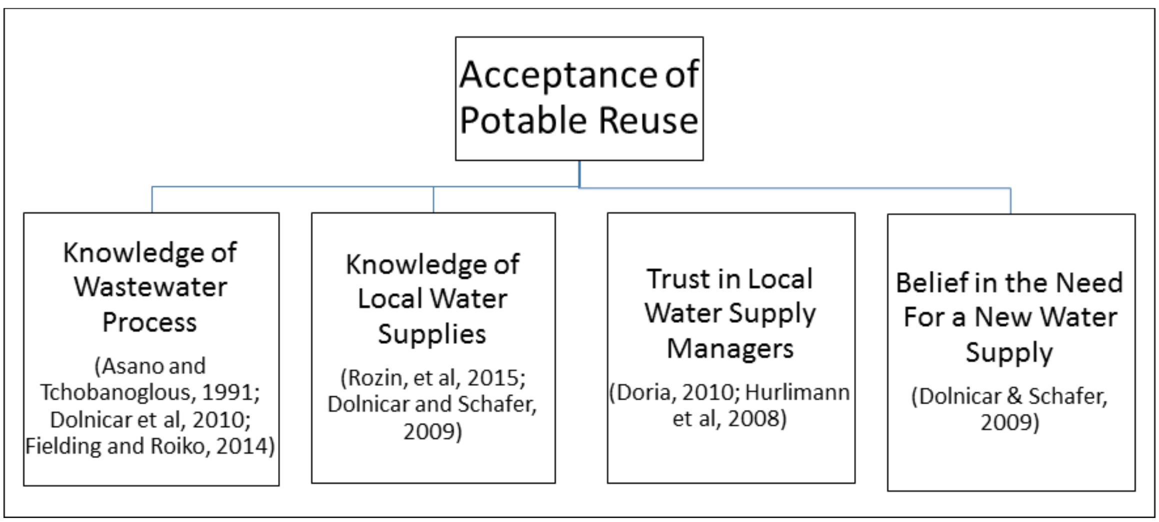

Figure 2. Four Critical Factors Affecting Acceptance of Potable Reuse

Recycled Water in Santa Clara County, California

Santa Clara County in Northern California is home to almost two million people and includes the Silicon Valley and vast tracts of agricultural lands to the south of it. It has been the goal of the Santa Clara Valley Water District, the water supplier and water wholesaler for the county to develop a recycled water program that will supply at least 10% of the water supply through recycled water by 2025 (SCVWD, 2014). So far, the county has supported recycled water systems in many communities including Gilroy, Palo Alto, Mountain View, Sunnyvale, Santa Clara, San Jose, and Milpitas. The largest producer of recycled water is the San Jose/Santa Clara Regional Wastewater Facility and South Bay Water Recycling program, which is one of the largest recycled water programs in Northern California. The Santa Clara Valley Water District's strategic plan states that recycled water for non-potable uses alone cannot meet the 10% goal, requiring the development of potable reuse technologies to meet regional water supply goals (SCVWD, 2014).

Future recycled water development. Due to the drought that started in 2012 and ended in 2017, recycled water is now more important than it has ever been for the future of the Santa Clara County water supply. As a result, the Santa Clara Valley Water District is now changing its messaging that separated recycled water from potable water to highlight the fact that there is one integrated water supply for the area and that recycled water is an integral part of regional water supply (SCVWD, 2014). In partnership with the many local agencies that produce recycled water, the water district is now undergoing recycled water strategic planning to establish the role of recycled water in the county water supply. In the next 10-20 years, the water district hopes to begin using recycled water for indirect and direct potable reuse, and thus, is working towards building the public's acceptance and knowledge of recycled water for potable uses (SCVWD, 2014). In partnership with the City of San Jose, the water district constructed a $72 million advanced water purification center that utilizes reverse osmosis, microfiltration, and ultraviolet sterilization to produce pure water. This purified water is currently blended with recycled water for non-potable uses but provides a pilot for the development of advanced treatment for potable resources in the future (SCVWD, 2014). This project was a major milestone for the water supply of the area, and more projects are currently under development.

Environmental and Water Education in Youth

Due to increasingly complex environmental issues, school administrators in the United States have found a necessity to teach students about water resources management and environmental issues in general (Gruver & Luloff, 2008). Many teachers use textbooks and materials that are national and international in scope and do not focus on local environmental issues (Gibson & Oberg, 2004). A new concept in teaching methods termed "curricular behavior" adapts curriculum to better fit the needs of the students both in time and in their geographic area (Gruver & Luloff, 2008). However, this process has proved difficult in that many teachers lack the expertise and confidence needed to thoroughly explore and teach about environmental issues (Gruver & Luloff, 2008). Using curricular behavior to teach about the environment, and helping teachers gain a thorough understanding of the topics is important, so students learn relevant information about the environmental issues facing them in their community. This study aims to assess the students' knowledge of local water issues and teach them about their local water supply. For youth to become active in environmental issues, there are three stages in environmental development that need to occur (Kempton & Holland, 2003):

1. becoming aware of environmental issues, or salience
2. identifying with or seeing one as an environmental actor
3. gaining knowledge on how to engage in the environmental issue

This process is termed the Kempton Environmental Identity Model, which helps to explain why people affected by environmental problems are more likely to support environmental efforts (Stapleton, 2015). The model also helps to show why this thesis project is important in that it helps students learn about local water issues, shows them how they can help, and teaches them about what is involved in finding a solution to the issue thereby allowing them to become more active.

Gaps in the Literature and Why it Matters

Although the water district and water supply agencies around the world have completed numerous studies to help understand factors that affect public acceptance and knowledge of recycled water for potable reuse, there has been very little research done on specific demographic groups in relation to recycled water (Dolnicar, et al., 2010). In particular, young populations such as high school aged students have not been studied and are critical to the success of future recycled water potable reuse projects. Since many potable reuse projects will not be fully implemented and funded for 10-20 years, it is crucial for water supply agencies to develop outreach and education programs aimed at younger generations. By doing this, when it comes time to implement potable reuse, the general public, taxpayers, and policymakers are already supportive and have an understanding of why recycled water development is important to Santa Clara County. The goal of this study is to develop a baseline understanding of the knowledge and acceptance students have for potable reuse of recycled water in Santa Clara County and what efforts can be made to improve knowledge and acceptance among this critical younger demographic.

Problem Statement

California has long had the challenge of supplying enough water to keep up with the demand of a quickly growing state population and economy. Already, California has one of the largest and most complex conventional water supply systems in the United States. As the state looks to recycled water for potable reuse to help augment its water supplies, policy makers are looking for information on public perceptions of recycled water to facilitate the adoption of this new water source.

While there has been extensive research on perceptions in the general population, little has been done to assess younger populations that will be making future decisions on the direction of public policy as it relates to water. Since large water supply projects take a long time to plan and implement, it is essential to garner the support of younger populations today, so the projects are supported in the future. Following the principles defined by Kempton and Holland (2003), environmental education can be effective in helping youth support projects that will help both the environment and natural resource management.

Studying high school students' knowledge, attitudes, and acceptance of potable reuse of recycled water is especially important in Santa Clara County where local water management agencies are actively planning the next phase of recycled water development which includes direct and indirect potable reuse. Having a firm understanding of what the youth population in Santa Clara County thinks about this resource will be important for key decision makers. This study assesses the knowledge, attitudes, and acceptance of potable reuse of several hundred Santa Clara County high school students to help local water supply managers find support for their future projects.

Water recycling has the potential to provide a sustainable local water supply, but efforts to implement these systems have been hampered by social conventions and widely held personal attitudes towards non-conventional sources. For the water supplies of the future to be secure, attitudes towards using alternative water supplies need to change. It is the responsibility of water supply agencies, the water industry, and water-based nonprofit organizations to fully understand social ideology and support of the informational needs of key audiences to develop support before implementation of new projects.

Hypotheses and Research Questions

This paper aims to determine if high school students in Santa Clara County, CA accept potable reuse of recycled waste water and whether their acceptance is influenced by increased knowledge on the topic. Factors that contribute to the general public's acceptance of recycled water use for both potable and non-potable uses have been widely studied. This study tested previously identified hypotheses and research questions which are based on previous studies to corroborate these theories as they apply to a younger demographic, high school students in Santa Clara County.

H_1: Perceived level of the four critical factors (Knowledge of the wastewater treatment process, knowledge of local water supplies, trust in local water supply managers, and belief in the need for a new water supply) will increase after an educational intervention.

H_2: Perceived levels of acceptance of recycled water for potable reuse will increase after an educational intervention.

H_3: Demographic variables will significantly affect students' gain scores of perceived level of the four critical factors.

H_4. Demographic variables will significantly affect students' gain scores of perceived acceptance of potable reuse.

RQ_1: Which of the four critical factors will have the greatest effect on acceptance of recycled water for potable reuse?

RQ_2: What are students' main concerns with potable reuse of recycled water?

RQ$_3$: What can local water managers do to increase understanding and comfort levels with potable reuse?

Methods

This study consisted of an experiment involving an educational intervention. Data were collected using a pre-survey and post-survey. The data collected were then analyzed using both quantitative and qualitative methods for testing high school students' knowledge and acceptance of potable reuse of recycled water in Santa Clara County. This study provides additional insight into public perceptions of potable reuse, with specific information related to younger demographics that have not been well studied.

Sample, Site Description, and Target Population

The sample was obtained from local high schools in Santa Clara County, CA. The population consisted of students ranging from ninth to twelfth grade at public high schools in the Morgan Hill Unified School District, and San Jose's East Side Union High School District.

High school students were chosen to study because, after an extensive literature review, no studies were discovered related to recycled water that primarily focused on minors. Additionally, California high school curricula now include lessons on the water cycle, water and wastewater treatment, and drought in California as part of the Next Generation Science Standards (CDE, 2015).

Participants were selected through the researcher's work with the Water Career Pathways Consortium, a regional educational outreach program between school districts in the area. A presentation was given to teachers participating in this program that solicited the participation of their students in this study. In all, four teachers participated from three high schools, Independence High School in San Jose, and Ann Sobrato and Live Oak High Schools in Morgan Hill.

The study sample size was between 60 and 100 students at each high school that was included in the study for a total of 174 individuals. Although additional students were included in the intervention, not all students completed the surveys. The schools are representative of the demographics of Santa Clara County, with some minor variation depending on the schools' locations. Santa Clara County is home to approximately 1.8 million residents, and 280,000 public schools enrolled K-12 aged students, from a diverse background that is roughly captured by the high school samples selected. This study sample can be used to generalize the acceptance and knowledge that similar students would have in Santa Clara County (Santa Clara County Office of Education, 2015). Table 1 shows the demographics of Santa Clara County and each school district studied.

Table 1. Key Demographics of Participating School Districts

	Santa Clara County	Morgan Hill Unified School District	East Side Union High School District
% White	33	36	19
% Black or African American	2	2	3
% American Indian	1	0.5	0.5
% Asian	34	10	39
% Native Hawaiian	0.5	0.5	0.5
% Hispanic	26	49	36
% 2 or More	3	2	2
	100	100	100
Median Household Income	$91,702	$96,812	$79,049

Source: Census Bureau ACS 2009 estimates retrieved from Proximityone.com

Study Design

The study design for this project included an experiment in the form of an educational treatment and a pre-treatment and post-treatment survey. The study design was experimental but did not have a control group due to school administration limitations of making a control group within the classrooms, which would have left students out of the educational portion. Before beginning the study, there was coordination with various school districts and San Jose State University to get permission to conduct the study at the high schools (Appendix A: ESUHSD Permission Letter; Appendix B: Live Oak HS Permission Letter; Appendix C: Sobrato High School Permission Letter). After gaining permission, the researcher worked with the schools and San Jose State University to develop parent consent forms and student assent forms that would fulfill the requirements of the schools and the Institutional Review Board (Appendix D: Parent Consent Form, Appendix E: Student Assent Form). On the day prior to the educational intervention, the teachers administered a pretest survey consisting of Likert-style questions that all participating students completed using an online survey using Google Forms (see Appendix F: Pre-Survey Questions). The survey is a self-report on the student's knowledge of local water supplies and wastewater treatment process, trust in local water supply managers, belief in the need for a new water supply, and acceptance towards potable reuse of recycled water. After taking the pre-survey at home, the students were directed to watch two online educational videos created by various water agencies that total approximately 20 minutes and highlight the wastewater treatment process, the water cycle, and potable reuse of recycled water (City of San Jose, 2003; Wate360 Resources for Reuse, 2016). During the educational intervention, I enhanced this educational material with a presentation and conversation with the students and answered any questions that they had during the one-hour class period. The educational intervention included additional information on the water cycle, wastewater and water treatment processes, recycled water history and uses local water supplies and water managers, and risks and benefits of using recycled water for potable reuse. A short, hands-on exercise was also given where students tried to identify beakers of wastewater and potable water that have gone through the various levels of treatment starting with primary, through advanced treated wastewater.

After the educational intervention was performed, the entire sample was then broken into groups of 4-5 to answer group discussion questions (Appendix G: Group Discussion) and re-assessed using the same survey questions administered in the pretest (Appendix H: Post-Survey Questions). Both the group discussion questions and the post-test were given as hard copies that the students had to hand-write responses to. These surveys were then analyzed for changes in knowledge and acceptance towards recycled water potable reuse. Using the same test, and assessing the group with a pre and post assessment helped reduce potential bias and external factors that could have influenced the data collected.

This method of experimental research design is called a pretest-posttest design with one group manipulated within an experimental study design

(Montello & Sutton, 2013). Table 2 is an illustration of the experimental study design that was used in this study and copied from Montello & Sutton, 2013.

Table 2. Illustration of Study Design

Observation 1	Manipulation 1	Observation 2
O1	M1	O2

Source: Montello & Sutton, 2013

Instrumentation and Measurement

The administered assessment included limited demographic information, a quantitative section of categorized Likert-style questions on a four-point scale that force either a positive or negative response from the participants, and a short answer, qualitative section that provide a better understanding of why the students gave their particular answers (Appendix F: Pre-Survey Questions, Appendix G: Group Discussion Questions, Appendix H: Post-Survey Questions). The assessment tests students' perceived levels because it is a self-assessment of the participant.

The Likert-style assessment is valuable in that it provides unambiguous, ordinal responses to the questions (Babbie, 2001). Additionally, a four point scale was utilized in the Likert questions to provide direction of responses which provides more meaningful analysis (Babbie, 2001). The questions fit into five categories: 1. Knowledge of recycled water source and treatment process, 2. Knowledge about local water supply, 3. Acceptance of potable reuse of recycled water, 4. Trust in local water supply management, and 5. Need for alternative water supply; each of which had multiple questions. Together, knowledge of recycled water source and treatment process, knowledge of local water supply, trust in local water supply management, and belief in the need for an alternative water supply represent the Four Critical Factors affecting acceptance of potable reuse. These survey categories and the Four Critical Factors were developed by assessing various surveys used in related literature that have been shown to influence acceptance of potable reuse (Dolnicar & Schafer, 2009; Dolnicar et al., 2010; Asano & Tchobanoglous, 1991; Fielding & Roiko, 2014; Rozin, et al., 2015; Doria, 2010; Hurlimann et al., 2008.)

The second portion of the assessment included a group discussion qualitative section that helps explain the students' attitudes and perceptions towards recycled water potable reuse through open-ended questions that identify the students' main concerns with recycled water use and information on how water supply managers can make the sample audience more comfortable with its use. This section gives the students the opportunity to express thoughts and concerns that cannot be captured with the Likert-style questions (Babbie, 2001). The results of this section allowed qualitative analysis to be performed using descriptive statistics and deductive coding to explain the attitudes and perceptions towards potable reuse (Babbie, 2001). Open-ended questions were selected allow the students to discuss their concerns and come up with their responses. One shortfall of using open-ended questions, however, is the risk that respondents may give answers that are irrelevant to the question making conclusions more difficult to draw (Babbie, 2001).

Data Analysis

Both quantitative and qualitative analytical methods were used to gain a better understanding of the factors that influence high school students' perceived level of knowledge and acceptance of potable reuse of recycled water and to understand how demographic factors influence their choices. For quantitative analysis, Statistical Package for Social Sciences (SPSS v.16) program was used to conduct Independent Samples Mann-Whitney U tests, Independent Samples Kruskal-Wallis tests, and Multiple Regression Analysis. For qualitative analysis, inductive coding was used to answer the qualitative research questions. The data collected on the post-test survey and the short discussion question responses were hand entered into Microsoft Excel and combined with the pre-test survey responses provided by Google Forms.

Coding and indexing. In statistical data analysis, it is important to code and transform the raw data to normalize the responses (Babbie, 2011). Before conducting data analysis I entered, sorted, and normalized the demographic, quantitative, and qualitative data through inductive coding following guidelines established in the literature (Thomas, 2006). Appendix I lists the coding scheme used for the demographic independent variables including Gender, Primary Language Spoken at Home, Grade Level, and Current Availability of Recycled Water in the Community and the code categories for the qualitative short answer discussion questions.

The three qualitative short answer discussion questions were hand entered into Excel verbatim and coded using inductive coding. The responses were coded into themes produced from observations. The purpose of inductive coding is three-fold: to condense extensive raw data into a more manageable format, to establish clear links between research objectives and the findings in the raw data, and to develop a model or theory of the underlying structure of responses (Thomas, 2003). The following steps developed in the literature (Thomas, 2003) were used for inductive coding: 1.Initial read through of text data, 2. Identify specific segments of information, 3. Label the segments of information to create categories, 4. Reduce overlap and redundancy of categories, 5. Create a model incorporating most important categories. This entire process narrowed down dozens of different responses to the three short answer discussion questions to no more than seven categories in any questions. The code categories are included in Appendix I (Appendix I: Coding and Indexing Scheme).

The responses to the Likert-style assessment questions were coded and scored for each respondent with a "1" corresponding to the most negative response and a "4" the most positive response. The Likert-style questions fit into five categories: knowledge of the wastewater treatment process, knowledge of local water supplies, acceptance of potable reuse of recycled water, trust in local water managers, and belief in the need for a new water supply. Each category had between 3 and 6 individual questions that were combined into a single measure that averaged the response between all of the questions in that category. The Four Critical Factors variable is a composite of the question categories: knowledge of recycled water source and treatment process, knowledge of local water supply, trust in local water supply management, and belief in the need for an alternative water supply. Using composite measures of variables to combine indicators into a single measure is commonly used by quantitative analysts (Babbie, 2011). Using composite measures allows the researcher to have a more comprehensive and accurate indication of a given variable (Babbie, 2011). Table 3 is an example of an index that explains the measurement of the recorded scores.

Table 3. Example Coding Index

Average Score On Survey on Knowledge-Based Questions	Meaning
1	Very Low Knowledge
2	Low Knowledge
3	High Knowledge
4	Very High Knowledge

Variables. Each hypothesis is associated with a set of independent and dependent variables. Table 4 below illustrates the variables and tests used to analyze each question:

Table 4. Hypotheses and Associated Variables and Statistical Tests

Hypothesis	Independent Variable	Dependent Variable	Test Performed
H_1: Perceived level of the four critical factors will increase after an educational intervention.	Educational Intervention	Four Critical Factors	Independent Samples Mann-Whitney U Test
H_2: Perceived levels of acceptance of recycled water potable reuse will increase after educational intervention.	Educational Intervention	Acceptance of potable reuse of recycled water	Independent Samples Mann-Whitney U Test
H_3: Demographic variables will significantly affect students' gain scores of perceived level of the four critical factors.	Demographic Factors	Gain score of perceived knowledge of the four critical factors that affect potable reuse	Independent Samples Mann-Whitney U Test and Independent Samples Kruskal-Wallis Test
H_4. Demographic variables will significantly affect students' gain scores of perceived acceptance of potable reuse.	Demographic Factors	Acceptance of potable reuse of recycled water	Independent Samples Mann-Whitney U Test and Independent Samples Kruskal-Wallis Test
RQ_1: Which of the four critical factors has the greatest effect on acceptance of potable reuse	Four Critical Factors	Acceptance of potable reuse of recycled water	Multiple Regression Analysis
RQ_2: What are the students' main concerns with potable reuse of recycled water			Inductive Coding
RQ_3: What can local water managers do to increase understanding and comfort with potable reuse			Inductive Coding

* The four critical factors that affect acceptance of potable reuse are the level of knowledge of local water supplies, knowledge of wastewater treatment process, trust in local water managers, and belief in the need for a new water supply

Independent samples Mann-Whitney U test. Independent Samples Mann-Whitney U tests were performed to evaluate if an educational intervention significantly changed the perceived level of the four critical factors that affect acceptance of potable reuse in high school students and if an educational intervention significantly changed perceived level of acceptance of potable reuse in high school students (Hypotheses 1 and 2). Independent Samples Mann-

Whitney U tests were also performed to evaluate whether demographic variables with no more than two categories (i.e. gender), and recycled water availability in the have a significant impact on the gain score in the perceived level of the four critical factors and the gain score in perceived acceptance of potable reuse (Hypotheses 3 and 4). The use of the Mann-Whitney U test was determined to be the most appropriate statistical test for this study because the assumptions needed for a parametric test (t-test and ANOVA) were not met.

The Mann-Whitney U test is a non-parametric statistical test. An Independent Samples Mann-Whitney U test is used to compare differences between independent groups when the variables are continuous and not normally distributed (Laerd Statistics, 2015). It is often used as an alternative to the independent samples or paired *t*-test when the data are not normally distributed (Hart, 2001). The Mann-Whitney U test can detect differences in distributional shape, spread, and medians between two independent variables (Hart, 2001). There are four main assumptions that must be met in order for the Mann-Whitney U test to be accurately performed: Assumption 1) There must be one dependent variable that is measured on the continuous or ordinal level; Assumption 2) One independent variable that consists of two categorical, independent groups; Assumption 3) Independence of observation; and Assumption 4) Determine whether the distribution for each group is similar or a different shape (Laerd, 2015). This research met all of the above-mentioned assumptions in the data pertinent to the research questions tested using the Mann-Whitney U test method.

Independent samples Kruskal-Wallis test. Independent samples Kruskal-Wallis tests were performed to evaluate if demographic variables with three or more categories, such as primary language spoken at home and grade level, have a significant impact on the gain score in the perceived level of the four critical factors that affect acceptance of potable reuse and the gain score in perceived acceptance of potable reuse (Hypotheses 3 and 4). Similar to the Mann-Whitney U test, the Kruskal-Wallis test is a non-parametric test that is used to determine if there are statistically significant differences between independent groups on a continuous dependent variable (Laerd, 2015). The Kruskal-Wallis is used as an alternative to the one-way ANOVA test for non-normally distributed data, much like the Mann-Whitney U is used as an alternative to the *t*-test (Laerd, 2015). The Kruskal-Wallis test has similar assumptions to the Mann-Whitney U test that were described in the previous section that must be met to be accurately used. The primary difference is the independent variable must have more than two categories to be used (Green & Salkind, 2004). This research met all of the above-mentioned assumptions in the data pertinent to the research questions tested using the Kruskal-Wallis test method.

Multiple regression analysis. To examine which of the four critical factors that affect acceptance of potable reuse has the greatest impact on the acceptance of potable reuse (Research Question 1) I used a Multiple Regression Analysis. A Multiple Regression Analysis can be used to model the relative contribution of each predictor, or independent variable, to the total variance of the outcome, or dependent variable (Laerd, 2015). Social researchers often use

Multiple Regression Analysis to explore which factors affect a dependent variable the most (Babbie, 2001). In this case, the perceived gain score for each of the four critical factors that affect potable reuse are the independent variables, and perceived acceptance of potable reuse is the dependent variable. For a Multiple Regression Analysis to be accurately performed, several assumptions must be met through statistical testing. Those assumptions are Assumption 1. There must be one dependent variable measured at the continuous level; Assumption 2. Two or more independent variables measured at the continuous level; Assumption 3. Independence of errors (residuals); Assumption 4. There should be a linear relationship between predictor variables and the dependent variable; Assumption 5. There should be no multicollinearity; Assumption 6. There should be no significant outliers, and Assumption 7. The errors should be approximately normally distributed (Laerd, 2015). This research met all of the above-mentioned assumptions in the data pertinent to the research questions tested using Multiple Regression Analysis.

Coding of qualitative data. Inductive Coding was used to answer the last two research questions: What are the main concerns that high school students have with potable reuse of recycled water, and what can local water supply managers do to increase high school students' understanding and comfort levels of potable reuse of recycled water (Hypotheses 6 and 7). Appendix I shows the code categories for the responses to the qualitative, short answer discussion questions. The data from the short answer questions were used to answer research questions six and seven. The results of these questions will help develop recommendations to local water management authorities on how to proceed and if additional outreach is needed to the young adult and high school population in Santa Clara County.

Limitations

Control group. The methods for this project require classroom participation from the students. The main limitation of having a study designed like this is that having a control group of students is not possible due to the school's desire to have all students gain the same knowledge base, as the curriculum will fulfill key curriculum standards for the students. After careful evaluation of the methods with the schools and Thesis Committee, it was decided that a control group would not be included in the study design. The disadvantage of not having a control group is that the results of the study are not as strong since outside variables may influence the results. This study tried to limit outside variables by controlling for as many variables as possible. The post-survey was conducted shortly after the pre-survey to attempt to limit variables.

Sample size. The sample size of this study is relatively small in comparison to the total population of high school students in Santa Clara County, but the number should be sufficient to represent students throughout the County. It was the goal of this study to assess at least 3 schools in different communities to get the best possible representation of the high school population in Santa Clara County. Since Santa Clara County is extremely ethnically, economically, and socially diverse, the schools that agreed to participate might not represent the entire County, and surely are not a full representation of the region, the state, or broader contexts due to the diversity outside Santa Clara County. The demographics of each school district and the County are included in the Study Design section. With these limitations in mind, the results from available study sites will be valuable for the water resources managers of the region regardless of any bias created by sample size limitations or demographics because there is still very little information available on high school students and young adults.

Inherent bias. Discrepancies amongst schools' student education levels, and teacher effectiveness may provide external factors that can bias the results. This bias was hard to overcome as teachers that participated were also likely more involved in teaching water-related topics and may have already focused on those topics in the classroom. Classrooms were randomly chosen as much as possible, however, only teachers interested in the topic granted the researcher access to the classes.

Limited educational treatment period. Because the educational material provided needed to be condensed into a one-hour timeframe to fit into the students' schedules, the depth of coverage was limited, which may affect student retention. Additionally, the educational material that was used for instruction was obtained from water and wastewater agencies and could be seen as promotional in nature, and thus reduced the unbiased standard of this study. Educational material was thoroughly vetted, and the least biased, yet thorough materials were used.

Despite these limitations, this study provides valuable data that can be used in the planning process for potable reuse projects in Santa Clara County. The

Santa Clara Valley Water District and other local and state agencies can use these methods and results to develop outreach campaigns to garner the support of younger generations that will be voters and policymakers shortly.

Study Results

Descriptive Statistics

This study examined 174 high school students at three high schools in Santa Clara County: Independence High School, Live Oak High School, and Ann Sobrato High School. Table 5 shows demographic information for the students that completed the survey. Three hundred eighty students participated in the classrooms, but out of the 380, 174 full data sets were completed. Therefore N is 174 for all of the tested hypotheses.

Table 5. Demographic Variable Statistics

Demographic Variables							
Gender		RW Availability in the Community		Grade Level		Primary Language Spoken at Home	
Males	109	Without RW	78	9th	84	English	116
Females	69	With RW	96	10th	26	Vietnamese	24
				11th	29	Spanish	19
				12th	35	Other	15

Hypothesis 1

H_1: Perceived level of the four critical factors (Knowledge of the wastewater treatment process, knowledge of local water supplies, trust in local water supply managers, and belief in the need for a new water supply) will increase after an educational intervention.

Tests were run to see if an educational intervention would affect high school students' perceived level of the four critical factors. The four critical factors that affect acceptance of potable reuse are knowledge of the wastewater treatment process, knowledge of local water supplies, trust in local water supply managers, and the belief in the need for a new water supply. Each of these four critical factors had Likert-style questions associated with it on both the pre-survey and the post-survey. The survey questions appear in Appendix F and Appendix G.

Four critical factors composite. To test if the educational intervention had a significant effect on the student participants' perceived level of the four critical factors, a series of Independent Samples Mann-Whitney U tests were performed. The first test was a composite measure of the average score of all of the questions related to the four critical factors. The average score of the four categories on the pre-survey was compared to the average score of the four categories on the post-survey through an Independent Samples Mann-Whitney U test to see if there was a statistically significant difference. A Mann-Whitney U test was run to determine if there were significant differences in perceived level of the four critical factors that impact acceptance of potable reuse before and after an educational intervention. Distributions of the reported perceived levels before and after the intervention were similar, as assessed by visual inspection. Perceived levels of the four critical factors that impact acceptance of potable reuse was significantly higher after the educational intervention (Median (Mdn) = 3.37) than before (Mdn = 2.88), $U = 6,360$, $z = -9.356$, $p < 0.001$. With these test results, the null hypothesis is rejected, and Hypothesis 1 that high school students will significantly increase their perceived level of the four critical factors after an educational intervention that focused on the four critical factors is accepted. The difference in the medians of 0.485 is quite substantial, especially since the Likert scale is a 4 point scale, and means that the perceived level of the four critical factors affecting acceptance significantly increased by 16% after the intervention. Appendix J includes the SPSS output for each of the hypotheses tests (Appendix J: SPSS Outputs).

Knowledge of the wastewater treatment process. In addition to testing the composite of the four critical factors together, each of the four factors was tested individually by comparing the average score of the responses to each of their question sets from the pre-survey and the post-survey. A Mann-Whitney U test was run to determine if there were significant differences in perceived knowledge of the wastewater treatment process before and after an educational intervention. Distributions of the reported perceived knowledge of the wastewater treatment process before and after the intervention were similar, as assessed by visual inspection. Perceived level of knowledge of the wastewater treatment process was significantly higher after the educational intervention (Mdn = 3.33) than before (Mdn = 2.67), $U = 6{,}725$, $z = -9.113$, $p < 0.001$. With these results in mind, the null hypothesis that there was no significant change in the distribution of scores between the pre-survey and the post-survey is rejected. These results show the educational intervention substantially increased the high school students' perceived level of knowledge of the wastewater treatment process by 0.66, or approximately 22% of the total range.

Knowledge of local water supplies. A Mann-Whitney U test was run to determine if there were significant differences in perceived level of knowledge of local water supplies before and after an educational intervention. Distributions of the reported perceived knowledge of local water supplies before and after the intervention were similar, as assessed by visual inspection. Perceived knowledge of local water supplies was significantly higher after the educational intervention (Mdn = 3.25) than before (Mdn = 2.50), U = 5,357.50, z = -10.489, p < 0.001. With these results in mind, the null hypothesis that there was no significant change in the distribution of scores between the pre-survey and the post-survey is rejected. These results show the educational intervention substantially increased the high school students' perceived level of knowledge of the local water supplies by an average of 0.75, or 25% of the range.

Trust in local water resources managers. A Mann-Whitney U test was run to determine if there were significant differences in the level of perceived trust in local water resources managers before and after an educational intervention. Distributions of the reported perceived trust in local water resources managers before and after the intervention were similar, as assessed by visual inspection. Perceived trust in local water resources managers was significantly higher after the educational intervention (Mdn = 3.33) than before (Mdn = 3.00), U = 10,125.50, z = -5.450, $p < 0.001$. With these results in mind, the null hypothesis that there was no significant change in the distribution of scores between the pre-survey and the post-survey is rejected. These results show the educational intervention moderately increased the high school students' perceived level of trust in local water managers by an average of 0.33 or 11%. It also shows that as students learn more about what local water managers do, they gain more trust in them which in turn, increases acceptance of potable reuse.

Need for a new water supply. A Mann-Whitney U test was run to determine if there were significant differences in perceived belief in the need for a new water supply before and after an educational intervention. Distributions of the reported perceived belief in the need for a new water supply before and after the intervention were similar, as assessed by visual inspection. Perceived belief in the need for a new water supply was significantly higher after the educational intervention (Mdn = 3.67) than before (Mdn = 3.415), U = 12,092.50, z = -3.324, p = 0.001. With these results in mind, the null hypothesis that there was no significant change in the distribution of scores between the pre-survey and the post-survey is rejected. These results show the educational intervention moderately increased the high school students' perceived belief in the need for a new water supply, by approximately 0.255, or 8% of the total range. Also, the belief in the need for a new water supply was already high, most likely due to increased public awareness on the recent drought in the region; but the educational intervention further increased the belief in the need for a new alternative water supply such as potable reuse.

Hypothesis 2

H_2: Perceived levels of acceptance of recycled water potable reuse will increase after an educational intervention.

Tests were run to see if the educational intervention significantly changed high school students' perceived acceptance of potable reuse. As the four critical factors increase with the educational intervention, it was expected that acceptance would also increase. A Mann-Whitney U test was run to determine if there were significant differences in perceived acceptance of potable reuse before and after an educational intervention. Distributions of the reported perceived acceptance of potable reuse before and after the intervention were similar, as assessed by visual inspection. Perceived acceptance of potable reuse was significantly higher after the educational intervention (Mdn = 3.25) than before (Mdn = 3.00), $U = 11{,}125$, $z = -4.311$, $p < 0.001$. With these results in mind, the null hypothesis is rejected, and hypothesis 2 that high school students will significantly increase their perceived acceptance of recycled water potable reuse after an educational intervention that focuses on the four critical factors is supported. This result is substantial because it shows that a simple one-hour educational intervention can significantly increase acceptance of potable reuse in younger populations by as much as 0.25 or 8% of the range.

Hypothesis 3

H_3: Demographic variables will significantly affect students' gain scores of perceived level of the four critical factors.

Tests were run to see if demographic variables including gender, primary language spoken at home, grade level, and whether or not recycled water is currently available in the participant's community, affected the students' gain score in perceived level of the four critical factors shown to affect acceptance of potable reuse. Demographic variables that had two categories were tested using Independent Samples Mann-Whitney U tests, while variables with three or more categories were tested using Independent Samples Kruskal-Wallis H tests.

Gender. A Mann-Whitney U test was run to determine if there were significant differences in gain score of perceived level of the four critical factors that affect acceptance of potable reuse among genders in high school students. Distributions of the reported gain score were similar among genders, as assessed by visual inspection. There was no statistical difference in gain score of perceived level of four critical factors that affect acceptance of potable reuse among genders. Median gain scores in Males (Mdn = 0.46) and Females (Mdn = 0.48) were not significantly different, $U = 3{,}220$, $z = -1.004$, $p = 0.316$. With these results in mind, the null hypothesis that there was no significant gain in the distribution of scores between genders is accepted.

Availability of recycled water in the community. A Mann-Whitney U test was run to determine if there were significant differences in gain score of perceived level of the four critical factors that affect acceptance of potable reuse among students based on the availability of recycled water in their community. Distributions of the reported gain score were similar among communities with and without recycled water, as assessed by visual inspection. There was no statistical difference in gain score of perceived level of the four critical factors that affect acceptance of potable reuse among communities. Median gain scores in communities where recycled water is currently available (Mdn = 0.45) and those where it is not (Mdn = 0.48) were not significantly different, $U = 3{,}643$, $z = -0.306$, $p = 0.760$. With these results in mind, the null hypothesis that there was no significant gain in the distribution of scores among students that live in communities with and without recycled water currently available is accepted.

Primary language spoken at home. A Kruskal-Wallis H test was run to determine if there were differences in the gain of perceived level of the four critical factors that affect acceptance of potable reuse between high school students' primary language spoken at home: English (n = 116), Spanish (n = 19), Vietnamese (n = 24), and Other (n = 15). Distributions of gain score were approximately similar for all groups, as assessed by visual inspection of a boxplot. Median gain scores were not statistically different between groups, H (3) = 3.533, p = 0.316. With these results in mind, the null hypothesis that there was no significant change in the distribution of scores among students that speak different languages at home is accepted.

Grade level. A Kruskal-Wallis H test was run to determine if there were differences in the gain of perceived level of the four critical factors that affect acceptance of potable reuse between high school student grade levels: 9th (n = 84), 10th (n = 26), 11th (n = 29), and 12th (n = 35). Distributions of gain score were approximately similar for all groups, as assessed by visual inspection of a boxplot. Median gain scores were not statistically different between groups, H (3) = 6.955, p = 0.073. With these results in mind, the null hypothesis that there was no significant change in the distribution of scores between students in different grades at the high schools is accepted; however, the level of significance is relatively low, so there may be a slight relationship between the different groups.

Hypothesis 4

H_4. Demographic variables will significantly affect students' gain scores of perceived acceptance of potable reuse.

Tests were conducted to see if demographic variables including gender, primary language spoken at home, grade level, and whether or not recycled water is currently available in the participant's community, affected the students' gain score in perceived level of acceptance of potable reuse. Demographic variables that had two categories were tested using Independent Samples Mann-Whitney U tests, while variables with three or more categories were tested using Independent Samples Kruskal-Wallis H tests.

Gender. A Mann-Whitney U test was run to determine if there were significant differences in gain score of perceived acceptance of potable reuse among genders in high school students. Distributions of the reported gain score were similar among genders, as assessed by visual inspection. There was no statistical difference in gain score of perceived level of acceptance of potable reuse among genders. Median gain scores in Males (Mdn = 0.25) and Females (Mdn = 0.25) were not significantly different, $U = 3{,}673$, $z = 0.409$, $p = 0.683$. With these results in mind, the null hypothesis that there was no significant change in the distribution of scores between genders in high school students is accepted.

Availability of recycled water in the community. A Mann-Whitney U test was run to determine if there were significant differences in gain score of perceived acceptance of potable reuse among students based on the availability of recycled water in their community. Distributions of the reported gain score were similar among communities with and without recycled water, as assessed by visual inspection. There was no statistical difference in gain score of perceived acceptance of potable reuse among communities. Median gain scores in communities where recycled water is currently available (Mdn = 0.25) and those where it is not (Mdn = 0.25) were not significantly different, U = 3,483.50, z = -0.794, p = 0.427. With these results in mind, the null hypothesis that there was a significant change in the distribution of scores between communities with and without recycled water currently available is accepted.

Primary language spoken at home. A Kruskal-Wallis H test was run to determine if there were differences in gain scores of acceptance of potable reuse between students that speak four different primary languages at home: English (n = 116), Spanish (n = 19), Vietnamese (n = 24), and Other (n = 15). Distributions of acceptance gain scores were similar for all groups as assessed by visual inspection of a boxplot. Median gain scores of acceptance of potable reuse were statistically significantly different between groups, $H(3) = 7.824$, p = 0.050. Subsequently, pairwise comparisons were performed using Dunn's procedure (Dunn, 1964) with a Bonferroni correction (Dunn, 1961) for multiple comparisons. Adjusted p-values are presented. This posthoc analysis revealed that no statistically significant differences in median gain scores were found between the language groups; English (Mdn = 0.25), Spanish (Mdn = 0.00), Vietnamese (Mdn = 0.125), and Other (Mdn = 0.00). With these results in mind, the null hypothesis that there would be no significant change in the distribution of scores among students that speak different languages at home is rejected. However, the statistical significance is low, and when comparing all categories together there is a significant difference, but there are no statistically significant differences between individual categories. This result is interesting since California and Santa Clara County are very culturally diverse and the gain in acceptance was higher in students that speak English and Vietnamese as their primary language at home compared to Spanish and other languages. Appendix J includes more detail into the results of this analysis.

Grade level. A Kruskal-Wallis H test was run to determine if there were differences in the gain of perceived level of acceptance of potable reuse between high school student grade levels: 9th (n = 84), 10th (n = 26), 11th (n = 29), and 12th (n = 35). Distributions of the gain score were approximately similar for all groups, as assessed by visual inspection of a boxplot. Median gain scores were not statistically different between groups, H (3) = 4.551, p = 0.208. With these results in mind, the null hypothesis that there was no significant change in the distribution of scores between grade levels of high school students is accepted.

Research Question 1

$RQ_{1:}$ Which of the four critical factors will have the greatest effect on acceptance of potable reuse?

Tests were conducted to see which of the four critical factors that affect acceptance of potable reuse has the greatest effect on the gain of perceived acceptance. The four factors are knowledge in the wastewater treatment process, knowledge of local water supplies, trust in local water managers, and belief in the need for a new water supply. A Multiple Regression Analysis was used to determine the significance of each factor individually since we already found out in the results when we tested Hypothesis 1 that the cumulative of all four critical factors significantly increases acceptance of potable reuse. A multiple regression was run to predict gain in acceptance of potable reuse from gain in perceived level of each of the four critical factors that affect acceptance. There was linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.845. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were 4 studentized deleted residuals greater than ± 3 standard deviations in this dataset. There were no leverage values greater than 0.2, and the values for Cook's distance above 1. The assumption of normality was met, as assessed by a Q-Q Plot. The multiple regression models statistically significantly predicted gain in acceptance of potable reuse, $F(4, 169) = 5.759$, $p < 0.001$, adj. $R^2 = 9.9\%$. Knowledge of the wastewater treatment process ($B = -0.004$, p = 0.97), knowledge of local water supplies ($B = 0.124$, $p = 0.118$), and trust in local water supply managers (B **=** -0.032, $p = 0.579$) did not statistically significantly add to the prediction. Belief in the need for a new water supply was the only variable that significantly added to the prediction ($B = 0.360$, $p < 0.001$). The results of this analysis are interesting because literature and this study support the finding that the cumulative level of the four critical factors affects acceptance of potable reuse, however, this test shows that the belief in the need for a new water supply is by far the most significant predictor, and moderately correlates with an increase in acceptance, whereas the other predictors are much less so, or even have a slight negative correlation. All related SPSS output data can be found in Appendix J.

Research Question 2

RQ_2: What are students' main concerns with potable reuse of recycled water?

Tests were conducted to find what the main concerns that high school students have with potable reuse of recycled water. It was expected that constituents of emerging concern and pharmaceuticals would be the main concerns that high school students had with potable reuse and was supported. It was the first qualitative research question testing responses from the in-class short discussion group questions. Inductive coding was used to group the responses from the participants, and then those responses were analyzed. The response category with the most responses was "remaining contaminants" with 25 out of the 75 responses, or 32%. The next most common response category was general safety with 19 out of 75 responses or 25%. Other responses included "No concerns," with 14 responses (19%), "pharmaceuticals," with eight responses (11%), and reliability, with eight responses (11%). Table 6 shows the breakdown of responses.

Table 6. Specific Concerns With Potable Reuse

Response Category	Count of Responses	Percentage of Total
Remaining Contaminants	24	32%
General Safety	19	25%
No Concerns	14	19%
Pharmaceuticals	8	11%
Reliability	8	11%
No Response	2	2%
TOTAL	75	100%

Research Question 3

RQ_3: What can local water managers do to increase understanding and comfort levels with potable reuse

Research Question 3 is the last of the research questions but uses analysis from multiple short answer group discussion questions to test what local water supply managers can do to increase high school students' understanding and comfort levels of potable reuse of recycled water. Inductive coding was used to categorize the responses from each group. One question was "what do you want to know about using recycled water as a source of drinking water to make you more comfortable with its use at home", while the second question was "what can local water supply managers, such as the Santa Clara Valley Water District do to help you better understand the local water supply and recycled water use".

The most common response to the first question was that high school students wanted be reassured that recycled water is clean and safe (31 out of 75 responses, 41%). The other responses included ensuring potable reuse is the best option for alternative water supplies (13 out of 75 responses, 17%), more information on the treatment process (10 out of 75 responses, 13%), understanding risks and benefits of use (9 out of 75 responses, 12%), no response (7 out of 75 responses, 10%), and no additional information (5 out of 75 responses, 7%). In general, this shows that the participants want to be sure that the recycled water is clean and safe, that all options have been studied, and that the treatment process is robust and limits risks. Table 7 shows a breakdown of the responses.

Table 7. What Information Would Make You More Comfortable with Potable Reuse?

Response Category	Count of Responses	Percentage of Total
Reassured its safe and clean	31	41%
Best Option	13	17%
More education on treatment	10	13%
Understanding risk and benefits	9	12%
No response	7	10%
No additional information	5	7%
TOTAL	75	100%

The second related question dealt with what water managers can do to help participants better understand the process, and the most common response to this question was that students wanted additional educational outreach (41 out of 75 responses, 55%) followed by explaining where our water comes from and the recycled water treatment process in detail (22 out of 75 responses, 29%), no response (10 out of 75 responses, 13%), and no additional information needed (2 out of 75, 3%). Table 8 shows a breakdown of the responses.

Table 8. What Can Water Supply Managers do to Increase Understanding?

Response Category	Count of Responses	Percentage of Total
Educational outreach	41	55%
Explain treatment process	22	29%
No response	10	13%
No additional information needed	2	3%
TOTAL	75	100%

Discussion

This section includes a discussion of the findings from this study and how they relate to both the stated hypotheses and findings from prior research on potable reuse. It also includes a discussion on implications of the results of this study, the limitations of this study, how this study design could be changed and suggestions for further research.

Major Findings

Knowledge and acceptance. The results of this study support the assertion that an increase in perceived level of the four critical factors is associated with an increase in acceptance of potable reuse. In the Dolnicar & Schafer study (2009), the researchers found that one of the critical factors that affect the public's acceptance of potable reuse is the belief in the need for a new water supply. In later studies, Dolnicar et. al (2010), found that knowledge of the wastewater treatment process increases acceptance of potable reuse in the general public; this is the second critical factor. Rozin et al. (2015) found that knowledge of the water cycle and water supplies increase acceptance as well, which is the third critical factor. In addition to knowledge of the treatment process, information on the reliability and technology that goes into the process helps increase trust in local water managers, which is the fourth critical factor (Asano & Tchobanoglous, 1991; Fielding & Roiko, 2014; Doria, 2010; Hurlimann et al., 2008; Dolnicar et al., 2014).

This study expands the findings of the above-mentioned studies to include high school students. In general, the perceptions of minors and young adults on this topic have not been well studied. This concept is important because high school students will be the next generation of voters that will likely be a major part of the constituency of the policy makers that decide whether or not potable reuse will be used. The results of this study show that youth and young adults have similar attitudes to those of adults. Importantly, this study shows that any person with a high school level of education would have similar levels of acceptance of potable reuse.

Level of the four critical factors. In general, this study found that the perceived level of the composite of the four critical factors that affect acceptance was already quite high among high school students before the educational intervention (Mdn = 2.88), but after the intervention, perceived levels increased significantly (Mdn = 3.37). These results show that there is already a high level of perceived knowledge, which in turn means a high likelihood that the general public accepts potable reuse. Additionally, it shows that a short educational intervention, such as the one performed as part of this study, can have a significant impact on acceptance. This fact is important for water resource managers to understand since they must make calculated decisions on how much money and effort to invest in outreach campaigns as they plan for potable reuse projects. If the public already largely has a high perceived level of the four critical factors affecting acceptance, and a high level is correlated with a high level of acceptance, they can target outreach resources accordingly.

Level of acceptance. This study found that the average perceived level of acceptance for potable reuse was already high before the educational intervention (Mdn = 3.00). After the intervention, acceptance increased significantly (Mdn = 3.25). Water resource managers would find this important since younger populations such as the one included in this study will be eligible to vote for future water bonds related to reuse. This research indicates that this group may require less convincing than originally thought and that potable reuse is viewed as an acceptable means of supplementing the local water supplies.

Demographic variables. There has been little done to study specific demographic variables related to recycled water (Dolnicar, 2010). This study is one of the first to deal exclusively with high school aged participants. Additionally, since Santa Clara County is a very diverse community, additional demographic details were examined to see if the intervention had the same effect on all demographic groups equally. The demographic variables that were tested were gender, grade level, primary language spoken at home, and whether or not recycled water was currently available in the participants' community. Each demographic variable was tested to see if it made a significant difference in the students' perceived gain in knowledge and acceptance of potable reuse. The only variable that showed any significant correlation was the participants' primary language spoken at home, and even then only English (Mdn = 0.25), and Vietnamese (Mdn = 0.125) speaking participants showed a significant correlation. The gain in acceptance found was barely significant as the *p*-value was 0.05.

This finding is important because it shows local water managers that the educational information they develop will largely have the same effect on all groups that have had some high school education in the county. Since Santa

Clara County is very diverse, this information is important for developing effective and cost-effective marketing campaigns. This study, however, did not examine whether or not educational interventions tailored to specific demographics would be more effective, but that could be a topic for further research in the future.

Significance of critical factors. The related research has shown that there are four critical factors that affect acceptance of potable reuse. As mentioned previously, the four factors are knowledge of the wastewater treatment process, knowledge of local water supplies, trust in local water supply managers, and the belief in the need for a new water supply (Dolnicar & Schafer, 2009; Dolnicar et al., 2010; Asano & Tchobanoglous, 1991; Fielding & Roiko, 2014; Rozin, et al., 2015; Doria, 2010; Hurlimann et al., 2008.) This study is different from the previous studies because it focuses solely on high school age students, where most other studies have focused on the general public. The results of this study indicate that out of the four critical factors, the only one that significantly predicted a gain in acceptance of potable reuse was a belief in the need for a new water supply ($B = 0.360$, $p < 0.001$). Figure 3 illustrates that the belief in the need for a new water supply is the most important of the four critical factors. This finding is important because it shows that if the water resource managers want to improve acceptance of potable reuse, the most effective means of doing so is to show that there is a need for a new water supply. Since California has frequent droughts and is currently in the midst of one of the worst droughts in its history, the study results may have been skewed since there is a strong belief by many that new water supplies are needed to alleviate ongoing effects of drought.

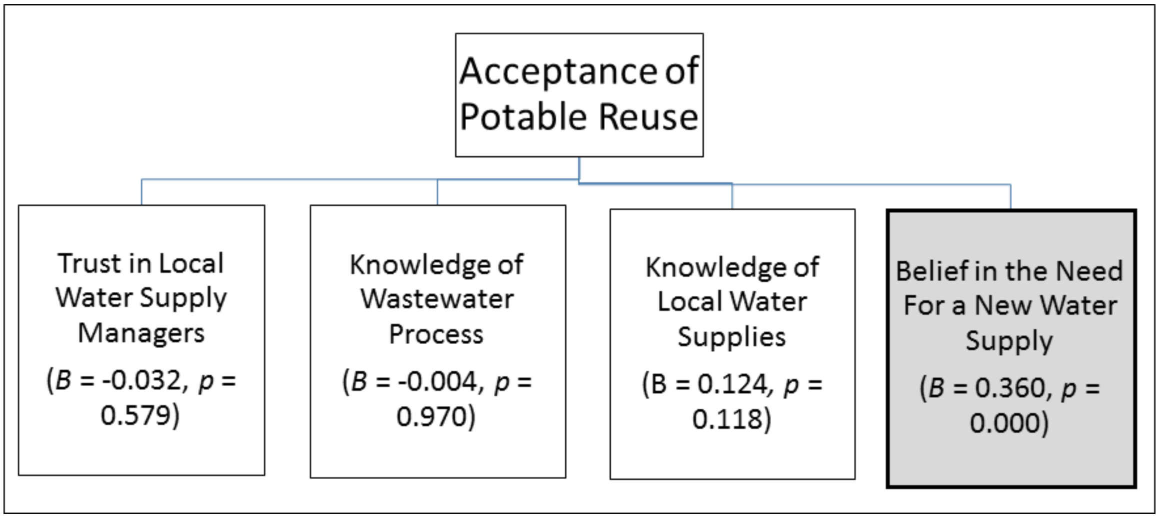

Figure 3. Finding Five, Most Important of the Four Critical Factors Highlighted

Main concerns. This study found that the participants of the survey were mostly concerned about remaining contaminants including constituents of emerging concern (32% of responses) and the safety of using potable reuse (25% of responses). These findings are not unexpected and are important for water resource managers to understand. In general, health concerns are a main limiting factor in public acceptance of potable reuse (Dolnicar & Schafer, 2008; Dolnicar et al., 2011; Miller, 2012). These findings corroborate the findings of past research and expand those findings to include high school aged participants. To fully improve acceptance of potable reuse, campaigns that educate on the four critical factors needs to include information on the risks and benefits of potable reuse as it relates to effects of chronic exposure to low levels of constituents of emerging concern. Ensuring participants gain an elementary understanding of risk assessment and toxicology would improve acceptance as they would understand the scale of the risks and their effects on the body.

Information most important to participants. Based on responses to an open-ended question, study participants want to be reassured that recycled water is safe and clean (41% of responses) and that potable reuse is the best option for an alternative water supply (17% of responses). Additionally, study participants wanted utilities to provide more educational outreach (55% of responses), more information on where their water comes from, and more information on the recycled water treatment process (29% of responses). This additional information is important as it helps focus water utilities on information that study participants that specifically stated that they want to make them feel more comfortable and understanding of potable reuse.

Implications and Recommendations

There has been extensive research done on the general population's knowledge and acceptance of potable reuse. However, this study is the first that specifically targets younger demographics, namely high school age students. Furthermore, this study focused on students in Santa Clara County, a region that will likely start implementing potable reuse strategies in the next five to ten years under the direction of the Santa Clara Valley Water District. For regions that are planning on implementing potable reuse projects to succeed, further research is needed on younger, diverse, demographics. In addition to age, other demographic variables may need further research as this study found there was no significant difference in gains of knowledge and acceptance among demographic groups, with the exception of gain in acceptance among participants that speak different primary languages at home. Below are recommendations for further research that would benefit the current body of literature on potable reuse acceptance.

Recommendation 1 – Further study on demographic variables. The findings of this study showed that demographic variables had little significant impact on the perceived gain in the level of knowledge and level of acceptance of potable reuse. With that in mind, additional studies should be conducted to verify these results both in Santa Clara County and elsewhere. Since California is a very diverse region, it would be relatively easy to sample specific demographic groups to test for differences in their response. Also, determining what types of educational information have the greatest effect on each demographic group could be very important for water supply managers to know when they are preparing outreach campaigns. For example, targeting outreach efforts to specific demographics would be the most efficient way to improve acceptance. Since this study and the educational treatment supports the Next Generation Science Standards set for these classes, access to the classes was easy to obtain from the school. High school administrators were also happy to have a supplemental curriculum focused on water policy and wastewater treatment provided by this study as it directly relates to classes such as Environmental Science, Geology, Biology, and Pre-Engineering. In light of this, future studies should indicate that they support educational standards to make access to classes easier.

Recommendation 2 – Importance of the four critical factors. This study showed that the most important of the four critical factors that affect acceptance of potable reuse was the belief in the need for a new water supply. Although this is supported by the current literature (Dolnicar & Schafer, 2009), additional research is required to see why this is the most important when compared to the other three critical factors. Also, additional research should be done to see what specific information is most important in each of the four critical factors. For example, knowing what information on the wastewater treatment process increases knowledge and acceptance specifically would be very helpful in determining what information to focus on in outreach campaigns.

Additionally, future research into the effects that media coverage of droughts and floods have on the population's acceptance of potable reuse would help water supply managers better time their outreach efforts and the focus of those efforts.

Recommendation 3 – Study a wider variety of students. Santa Clara County is a very diverse region. This study focused on three diverse high schools. Expanding the sample population to include even more schools and participants from different socio-economic and social backgrounds would be important to see differences in demographic variables. Little has been done to study demographic variables of younger populations and their effect on the acceptance of potable reuse. A study could be performed that includes a wider variety of students from across the county and other regions to see if there are significant differences.

Conclusion

With the current drought in California being the worst on record, and as cities and regions grow and look for new sources of water, ensuring potable reuse is a viable option in the eyes of the public is crucial, and this study will help ensure project acceptance. As potable reuse projects are planned and implemented in the coming years, it will become critical that all age groups support their development, especially as young voters cast their ballots in larger numbers each election. This study is the first of its kind since it examined the perceived knowledge and acceptance that high school students have regarding potable reuse.

The studied high school students showed that a short educational intervention significantly increases their perceived level of the four critical factors and that the increase was associated with increased levels of acceptance of potable reuse. This study also found that the participants have a pretty high level of knowledge and acceptance, to begin with, but after the educational intervention increased their acceptance levels. Additionally, this study found that demographic variables did not significantly affect gains in perceived knowledge or acceptance of potable reuse. Further research into how demographic variables affect knowledge and acceptance would be important to help water managers more effectively focus their outreach efforts.

Understanding what concerns high school students have about potable reuse, and explaining what would make them feel more comfortable with its use are important findings. This study found, as expected, that information on general safety and constituents of emerging concern are important to participants to increase their acceptance. Additionally, having a wide scale outreach campaign that increases knowledge and transparency is also important to the participants of this study.

In all, potable reuse is largely accepted by high school students in Santa Clara County, and studies of similar populations elsewhere in California may yield similar results. Further research into the four critical factors and what specifically affects acceptance would be beneficial to the California water community as a whole, and therefore, beneficial to the state. As potable reuse is one of the most cost-effective, and feasible alternative water supplies available in California, water supply managers have taken a great deal of interest in it. For these managers to expand their potable reuse programs, they should focus their outreach using the recommendations and major findings identified through this study. In the end, the use of highly treated wastewater for potable reuse can be a solution to ongoing water shortages in California as long as the programs are implemented following the guidelines provided by this study and other similar studies.

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Appendices

Appendix A: ESUHSD Permission Letter

East Side Union High School District - Independence High School

830 North Capitol Avenue
San Jose, CA 95133
CastroG@esuhsd.org BergB@esuhsd.org
Bjorn Berg - Associate Prinicpal of Educational Services
Grettel Castro-Stanley – Principal

Office of Research
San José State University
Re: Nicholas Ajluni
One Washington Square
San José, CA 95192-0025

To whom it may concern;

We grant permission for Nicholas Ajluni to conduct his thesis study, "Recycled Water Potable Reuse in Santa Clara County, CA: High School Students' Knowledge and Acceptance", at Independence High School, 1776 Educational Park Drive, San Jose, CA during the 2015-2016 academic year.

As long as the school site administrators and teachers agree to work with Mr. Ajluni, the district has no issues with the study under the following assumptions:

1. The school must have a copy of the questions and the signed parent permission forms before any surveys go home and/or are conducted in class.
2. Any questions being asked of the students outside of the curriculum based questions, must be listed on the parent permission forms and no student responses of any kind are to be obtained or used without signed parent permission.
3. Students must be informed that their participation is completely voluntary and they have the right to not respond to any particular question.
4. No student names are to be used in any reports produced and should be kept completely confidential at all times.
5. No additional information about the students will be requested or supplied by anyone.

Assuming all of the above is put into place, the study may proceed.

If there are any further questions, please feel free to contact us.

Sincerely,

Bjorn Berg and Grettel Castro-Stanley

Appendix B: Live Oak High School Permission Letter

LIVE OAK HIGH SCHOOL
1505 E. MAIN AVE • MORGAN HILL, CA 95037 • (408) 201-6100

October 5, 2015

Office of Research
San Jose State University
One Washington Square
San Jose, CA 95192-0025

I grant permission for Nicholas Ajluni to conduct his thesis study, "Recycled Water Potable Reuse in Santa Clara County, CA: High School Students' Knowledge and Acceptance," at Live Oak High School during the 2015-2016 academic year.

Best Regards,

Lloyd Webb
Principal
408-201-6100

Appendix C: Ann Sobrato High School Permission Letter

ANN SOBRATO HIGH SCHOOL

401 Burnett Avenue • Morgan Hill, CA 95037 • (408) 201-6200 • FAX (408) 201-6241

October 5, 2015

Office of Research
San José State
University One
Washington
Square
San José, CA 95192-0025

I grant permission for Nicholas Ajluni to conduct his thesis study, "Recycled Water Potable Reuse in Santa Clara County, CA: High School Students' Knowledge and Acceptance", at Ann Sobrato High School during the 2015-2016 academic year.

Best Regards,

Courtney Macko
Principal
408-201-6201

Appendix D. Parent Consent Form

SAN JOSÉ STATE
UNIVERSITY

College of Social Sciences
Environmental Studies Department
One Washington Square
San José, California 95192-0115
Voice: 408-924-5450
Fax: 408-924-5477
www.sjsu.edu

REQUEST FOR YOUR CHILD'S PARTICIPATION IN RESEARCH STUDY

Title of the Study
Recycled Water Potable Reuse in Santa Clara County, CA: High School Students' Knowledge and Acceptance

Name of Researcher
Nick Ajluni, Department of Environmental Studies
San Jose State University

Name of Thesis Committee
Dr. Katherine Cushing, Thesis Committee Chair/Advisor
Dr. Dustin Mulvaney, Thesis Committee Member
Michele Young, M.S., Thesis Committee Member

Purpose of the Research
You are invited to permit your child to participate in a research study to evaluate their knowledge and acceptance of recycled water use in Santa Clara County. Local water supply managers are currently expanding the use of recycled water in Santa Clara County, with the possibility of using recycled water to increase drinking water supplies. Although there has been significant research in knowledge and acceptance in the general population, there has been no research completed on younger populations such as those in high school. Your child is eligible to participate at their high school. The following information is provided to help you make an informed decision about whether or not to allow your child to participate. If you have any questions, please do not hesitate to ask.

Procedures
High school students in either 9th or 10th grade that are currently enrolled in a science class are eligible to participate in this study. This study will be conducted in class at your students' high school.

In this study, your child will complete a short, multiple choice pre-test survey at home, with questions about the water cycle, and the acceptance of using recycled water as a drinking water source. Afterwards, the student will watch several short educational videos focusing on the water cycle, wastewater treatment, and recycled water use. On the following day, the researcher from San Jose State University, will attend one of your students' 55 minute classes and provide additional educational information and an opportunity for the students to ask questions, this session will have an audio recording only to be used by the researcher to record the responses to the questions. After this, the researcher will discuss careers in the water and wastewater industry and answer additional questions. After the educational portion, a second, post-survey will be given to the students to see how their knowledge and acceptance changed regarding recycled water. This study will help local water policy makers understand how younger populations perceive recycled water as a drinking water supply. This information will help them plan and implement water recycling programs in the future.

Should you or your child choose not to participate, your child will not complete either the pre or post survey and will not be asked to actively participate in the in-class discussion. However, your child may still be required to sit in during the in-class lesson as it is part of the teacher's lesson plan.

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UNIVERSITY

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Environmental Studies Department
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San José, California 95192-0115
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Fax: 408-924-5477
www.sjsu.edu

Non Curriculum Related Questions
The survey includes several non-curriculum related questions that will aid in the analysis of data collected in this study. The questions below are included in the study. Again, the surveys will remain anonymous and all data collected will only be used by the researcher for data analysis.

Questions:

1. What is the primary language that you speak at home?
2. What is your gender?
3. What is your parents' profession?
4. What science class are you currently enrolled in and what grade are you in?

Risks and/or discomforts
The risks or discomforts associated with this research are minimal. Your child may experience frustration in being assigned a short additional homework assignment from their teacher for this study. You and your child may discontinue participation in the study at any time.

Benefits
The participants in this study will benefit from this study by learning about the water cycle, wastewater treatment, and recycled water uses, which are tied to their science curriculum required by the California Department of Education. Additionally, the participants will learn about careers in water and wastewater industries.

Compensation
No compensation is being offered for participation in this study

Confidentiality
The information obtained in this study may be published in scientific journals or presented at scientific meetings, but no information that could identify your child will be shared. Your child's identity will remain strictly confidential. Results of the study will be reported collectively and will not contain information that could be traced back to individual participants.

The hard copies of the study data will be stored in a locked cabinet at the researcher's home and will be kept for two years after the study. After the study and results are published, the data will be destroyed after two years. All electronic and audio data will be saved on password protected electronic devices such as the researcher's laptop and external hard-drive.

Participants' Rights
You are free to decide whether or not to permit your child to participate in this study. You may refuse to allow his or her participation in the entire study or any part without negative effect on your relations with San Jose State University. Your child may also decide to stop at any time.
This consent form is not a contract. It is a written explanation of what will happen during the study if you decide to allow your child to participate. You will not waive any rights if you choose not to allow your child to participate and there is no penalty for stopping your child's participation in this study.

SAN JOSÉ STATE
UNIVERSITY

College of Social Sciences
Environmental Studies Department
One Washington Square
San José, California 95192-0115
Voice: 408-924-5450
Fax: 408-924-5477

www.sjsu.edu

Opportunity to ask questions
You and your child may ask any questions about this research and have those questions answered before agreeing to participate. You or your child may also ask questions during the experiment.

- For further information about this study, please contact Nick Ajluni at (408) 607-5090
- Complaints about the research may be presented to Dr. Rachel O'Malley, Chair of the Department of Environmental Studies, at (408) 924-5450.
- For questions about participants' rights or if you feel your child has been harmed by participating in this study, please contact Dr. Pamela Stacks, Associate Vice President of the Office of Research, at (408) 924-2479

DOCUMENTATION OF INFORMED CONSENT
Parent/Guardian Signature
Your signature indicates that you voluntarily agree to allow your child to be part of the study, that the details of the study have been explained to you and your child, that you have been given time to read this document, and that your questions have been answered. You will be given a copy of this consent form, signed and dated by the researcher, to keep for your records.

________________________ ________________________
Name of Child or Minor Parent or Guardian Name (Printed)

________________________ ________________________
Relationship to Child or Minor Parent or Guardian Signature Date

Researcher Statement
I certify that the minor's parent/guardian has been given adequate time to learn about the study and ask questions. It is my opinion that the parent/guardian understands his/her child's rights and the purpose, risks, benefits, and procedures of the research and has voluntarily agreed to allow his/her child to participate. I have also explained the study to the minor in language appropriate to his/her age and have received assent from the minor.

____
Nick Ajluni (Researcher) Date

Appendix E: Student Assent Form

SAN JOSÉ STATE UNIVERSITY

College of Social Sciences
Environmental Studies Department
One Washington Square
San José, California 95192-0115
Voice: 408-924-5450
Fax: 408-924-5477
www.sjsu.edu

REQUEST FOR YOUR PARTICIPATION IN A RESEARCH STUDY

NAME OF THE STUDY: Recycled Water Potable Reuse in Santa Clara County, CA: High School Students' Knowledge and Acceptance

NAME OF THE RESEARCHER: Nick Ajluni, Master's Student, San Jose State University

ADVISOR NAME: Dr. Katherine Cushing, Thesis Committee Chair/Advisor

Dear Student,

You are invited to take part in this research study that that will take place as part of the regularly scheduled class that you are receiving this in.

In this study, I will ask you to complete a short pre-survey on your knowledge and acceptance of recycled water and water policy in California. I will then ask that you watch two short educational videos at home. The following day I will perform an in class lecture and discussion on what you learned, followed by a short post-survey. To do the study, I will audio record the discussion in class and then code the responses that I receive from the conversation for my data analysis.

Participating in this study will teach you about water policy and new water supplies for Santa Clara County and fulfill curriculum requirements set forth by the State. It will also teach you about careers in the water and wastewater industry for all levels of education. The study will help both me and local water managers understand the concerns that high school students have towards water resources in Santa Clara County.

I will also be sending home a parent permission form for you to have your parents sign. Please talk this over with them before you decide whether or not to participate. You may ask questions at any time.

You do not have to participate in this study if you choose not to. You can also stop at any time. If you check "yes," it means that you have decided to participate and have read everything that is on this form.

_____ Yes, I would like to be in the study.

_____ No, I do not want to be in the study.

____
Name of Participant and Signature   Date

Signature of Researcher
In my judgment the minor is voluntarily and knowingly giving assent to participate in this research study.

____
Nick Ajluni, Principal Investigator   Date

Appendix F: Pre Survey Questions

Pre-Survey
First Name, Last Name Initial ________________________________
School ________________________________
Teacher ________________________________

SJSU
Department of Environmental Studies

APPENDIX A: Pre-Self Assessment
Survey on Recycled Water Potable Reuse

What is the primary language that you speak at home?
1. English
2. Spanish
3. Vietnamese
4. Other

What is your gender?
1. Male
2. Female

What is your parents' profession? 1.__________________ 2.____________________

What science class are you currently enrolled in?______________________________

What grade are you in?
1. 9th
2. 10th
3. 11th
4. 12th

Answer the following questions about using recycled water as a source of drinking water in Santa Clara County.

Recycled Water Source and Treatment Process

1) How familiar are you with recycled water?
    1. Not familiar at all
    2. Slightly unfamiliar
    3. Somewhat familiar
    4. Extremely familiar

2) How familiar are you with where your water comes from and where it goes after it goes down the drain?
    1. Not familiar at all
    2. Slightly unfamiliar
    3. Somewhat familiar
    4. Extremely familiar

3) How confident are you that we currently have technology to reliably turn recycled wastewater into water that is safe to drink?
    1. Not confident at all
    2. Slightly confident
    3. Somewhat confident
    4. Extremely confident
    5. Do not know

4) True or False: Recycled water is currently being used as a part of a public drinking water supply system in California.
    1. True
    2. False

5) True or False: Wastewater comes from sources such as sinks, showers, and toilets.
    1. True
    2. False

6) True or False: After the tertiary wastewater treatment process, 99% of all contaminants in wastewater is removed.
    1. True
    2. False

Recycled Water Acceptability

7) How acceptable do you believe it is to drink recycled water?
    1. Totally unacceptable
    2. Unacceptable
    3. Slightly acceptable
    4. Perfectly acceptable
    5. Do not know

8) Do you think it is okay to use recycled water for non-drinking purposes such as irrigation, industrial processes, firefighting, and agriculture?
    1. Totally unacceptable
    2. Unacceptable
    3. Slightly acceptable
    4. Perfectly acceptable
    5. Do not know

9) Would you find it acceptable to drink recycled water mixed with normal drinking water in your community?
    1. Totally unacceptable
    2. Unacceptable
    3. Slightly acceptable
    4. Perfectly acceptable
    5. Do not know

10) How risky do you believe using recycled water for a drinking water supply is?

1. Extremely risky
2. Somewhat risky
3. Not very risky
4. Perfectly safe
5. Do not know

Knowledge About Local Water Supply

11) Are you aware of what the Santa Clara Valley Water District is and what it does?
    1. Not Aware
    2. Slightly Aware
    3. Somewhat Aware
    4. Extremely Aware

12) How familiar are you with where your drinking water comes from?
    1. Not familiar at all
    2. Slightly unfamiliar
    3. Somewhat familiar
    4. Extremely familiar

13) How familiar are you with where recycled water comes from?
    1. Not familiar at all
    2. Slightly unfamiliar
    3. Somewhat familiar
    4. Extremely familiar

14) How familiar are you with how wastewater is treated?
    1. Not familiar at all
    2. Slightly unfamiliar
    3. Somewhat familiar
    4. Extremely familiar

Trust in Local Water Supply Management

15) How trustworthy do you think the people that manage our local water supply are?
    1. Not trustworthy at all
    2. Not trustworthy
    3. Somewhat trustworthy
    4. Completely trustworthy
    5. Do not know

16) What quality of work do you think the people that manage our local water supply do?
    1. Poor
    2. Okay
    3. Good
    4. Excellent
    5. Do not know

17) Do you agree the people that manage our local water supplies have the skills and knowledge to safely, and reliably deliver drinking water, no matter what source the water is from?
   1. Strongly disagree
   2. Disagree
   3. Agree
   4. Strongly Agree
   5. Do not know

Need for New Water Supply

18) How important do you think it is that Santa Clara County find new sources of drinking water?
   1. Not important at all
   2. Not important
   3. Important
   4. Extremely important
   5. Do not know

19) Do you agree that using recycled water as a drinking water supply will help Santa Clara County have more reliable water during times of drought and water shortage?
   1. Strongly disagree
   2. Disagree
   3. Agree
   4. Strongly Agree
   5. Do not know

20) In what timeframe do you think you would be comfortable with using recycled water as part of a drinking water supply?
   1. Never
   2. 10-15 years
   3. 5-10 years
   4. 1-5 years
   5. Already comfortable

21) Where do you get your information on current events?
   1. Internet
   2. TV
   3. Newspaper
   4. Electronic Social Media (Facebook, Instagram etc)

Thank you for taking the time to fill out this self-assessment and participate in this study.

Appendix G: Group Discussion Questions

In Class Group Discussion Questions

*Please work in groups of 3 or 4 to answer the following questions. If you need more information, please use the back of this sheet. We will discuss the answers after 10 or so minutes

1) What specific concerns do you have about using recycled water for drinking? ______

2) What do you want to know about using recycled water as a source of drinking water to make you more comfortable with its use at home? ______

3) What can local water supply managers, such as the Santa Clara Valley Water District do to help you better understand the local water supply, and recycled water use? ______

4) Between the videos and in class discussion, what was the most effective and why? ______

Appendix H: Post- Survey Questions

Post Survey
First Name, Last Name Initial ______________________________
School ______________________________
Teacher______________________________

SJSU
Department of Environmental Studies

APPENDIX C: Post-Self Assessment
Survey on Recycled Water Potable Reuse

Answer the following questions about using recycled water as a source of drinking water in Santa Clara County.

Recycled Water Source and Treatment Process

1) How familiar are you with recycled water?
   1. Not familiar at all
   2. Slightly unfamiliar
   3. Somewhat familiar
   4. Extremely familiar

2) How familiar are you with where your water comes from and where it goes after it goes down the drain?
   1. Not familiar at all
   2. Slightly unfamiliar
   3. Somewhat familiar
   4. Extremely familiar

3) How confident are you that we currently have technology to reliably turn recycled wastewater into water that is safe to drink?
   1. Not confident at all
   2. Slightly confident
   3. Somewhat confident
   4. Extremely confident
   5. Do not know

4) True or False: Recycled water is currently being used as a part of a public drinking water supply system in California.
   1. True
   2. False

5) True or False: Wastewater comes from sources such as sinks, showers, and toilets.
   1. True
   2. False

6) True or False: After the tertiary wastewater treatment process, 99% of all contaminants in wastewater is removed.
   1. True
   2. False

Recycled Water Acceptability

7) How acceptable do you believe it is to drink recycled water?
    1. Totally unacceptable
    2. Unacceptable
    3. Slightly acceptable
    4. Perfectly acceptable
    5. Do not know

8) Do you think it is okay to use recycled water for non-drinking purposes such as irrigation, industrial processes, firefighting, and agriculture?
    1. Totally unacceptable
    2. Unacceptable
    3. Slightly acceptable
    4. Perfectly acceptable
    5. Do not know

9) Would you find it acceptable to drink recycled water mixed with normal drinking water in your community?
    1. Totally unacceptable
    2. Unacceptable
    3. Slightly acceptable
    4. Perfectly acceptable
    5. Do not know

10) How risky do you believe using recycled water for a drinking water supply is?
    1. Extremely risky
    2. Somewhat risky
    3. Not very risky
    4. Perfectly safe
    5. Do not know

Knowledge About Local Water Supply

11) Are you aware of what the Santa Clara Valley Water District is and what it does?
    1. Not Aware
    2. Slightly Aware
    3. Somewhat Aware
    4. Extremely Aware

12) How familiar are you with where your drinking water comes from?
    1. Not familiar at all
    2. Slightly unfamiliar
    3. Somewhat familiar
    4. Extremely familiar

13) How familiar are you with where recycled water comes from?
    1. Not familiar at all
    2. Slightly unfamiliar
    3. Somewhat familiar

4. Extremely familiar

14) How familiar are you with how wastewater is treated?
    1. Not familiar at all
    2. Slightly unfamiliar
    3. Somewhat familiar
    4. Extremely familiar

Trust in Local Water Supply Management

15) How trustworthy do you think the people that manage our local water supply are?
    1. Not trustworthy at all
    2. Not trustworthy
    3. Somewhat trustworthy
    4. Completely trustworthy
    5. Do not know

16) What quality of work do you think the people that manage our local water supply do?
    1. Poor
    2. Okay
    3. Good
    4. Excellent
    5. Do not know

17) Do you agree the people that manage our local water supplies have the skills and knowledge to safely, and reliably deliver drinking water, no matter what source the water is from?
    1. Strongly disagree
    2. Disagree
    3. Agree
    4. Strongly Agree
    5. Do not know

Need for New Water Supply

18) How important do you think it is that Santa Clara County find new sources of drinking water?
    1. Not important at all
    2. Not important
    3. Important
    4. Extremely important
    5. Do not know

19) Do you agree that using recycled water as a drinking water supply will help Santa Clara County have more reliable water during times of drought and water shortage?
    1. Strongly disagree
    2. Disagree
    3. Agree
    4. Strongly Agree
    5. Do not know

3

20) In what timeframe do you think you would be comfortable with using recycled water as part of a drinking water supply?
    1. Never
    2. 10-15 years
    3. 5-10 years
    4. 1-5 years
    5. Already comfortable

21) Where do you get your information on current events?
    1. Internet
    2. TV
    3. Newspaper
    4. Electronic Social Media (Facebook, Instagram etc)

Thank you for taking the time to fill out this self-assessment and participate in this study.

Appendix I: Coding and Indexing Scheme

Appendix I

Coding and Indexing Scheme for Variables

Gender
1 = Female
2 = Male

Grade Level
9th = 1
10th = 2
11th = 3
12th = 4

Primary Language Spoken at Home
English = 1
Other = 2
Spanish = 3
Vietnamese = 4

Current Availability of Recycled Water in the Community
1 = No
2 = Yes

Categories for:
What specific concerns do you have about using recycled water potable reuse as part of our drinking water supply?

- Remaining Contaminants
- General Safety
- No Concerns
- Pharmaceuticals
- Reliability
- N/A

What do you want to know to make you more comfortable with potable reuse?

- Reassured it is clean and safe
- Is it the best option
- More information on treatment process
- Risks and benefits of use
- N/A
- None

What can water managers do to help you understand more about potable reuse?

- More educational outreach
- Explain where our water comes from and the recycled water treatment process in detail
- N/A
- None

What was the most effective learning tool?

- Class discussion
- Class discussion/Q&A
- Class discussion/Hands-on exercise
- Class discussion/examples
- Educational videos
- N/A
- Both

Appendix J: SPSS Outputs

H_1: Perceived level of the four critical factors will increase after an educational intervention.

Level of composite of four critical factors before and after intervention

Hypothesis Test Summary

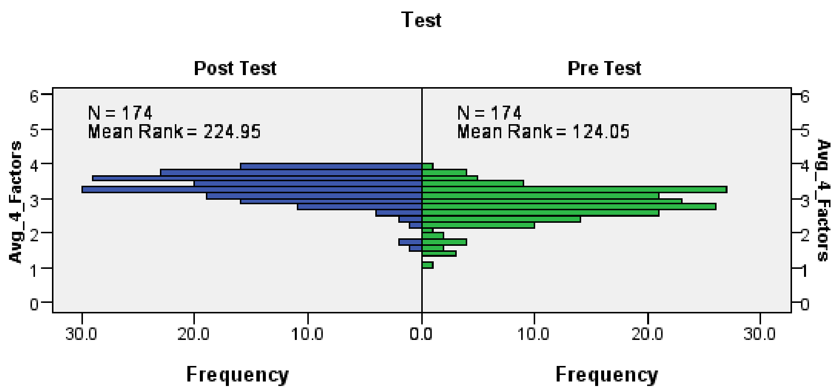
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Avg_4_Factors is the same across categories of Test.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Median Report

Test	Avg_4_Factors
Post Test	3.3650
Pre Test	2.8800
Total	3.1000

Independent-Samples Mann-Whitney U Test



Total N	348
Mann-Whitney U	6,360.000
Wilcoxon W	21,585.000
Test Statistic	6,360.000
Standard Error	938.225
Standardized Test Statistic	-9.356
Asymptotic Sig. (2-sided test)	.000

Perceived average level of knowledge of wastewater treatment process before and after intervention

Hypothesis Test Summary

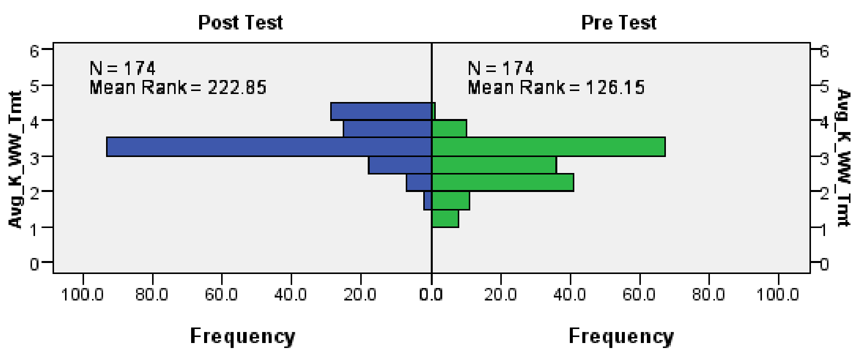
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Avg_K_WW_Tmt is the same across categories of Test.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Median Report

Test	Avg_K_WW_Tmt
Post Test	3.3300
Pre Test	2.6700
Total	3.0000

Independent-Samples Mann-Whitney U Test



Total N	348
Mann-Whitney U	6,725.000
Wilcoxon W	21,950.000
Test Statistic	6,725.000
Standard Error	923.139
Standardized Test Statistic	-9.113
Asymptotic Sig. (2-sided test)	.000

Perceived level of knowledge of local water supplies before and after education intervention

Hypothesis Test Summary

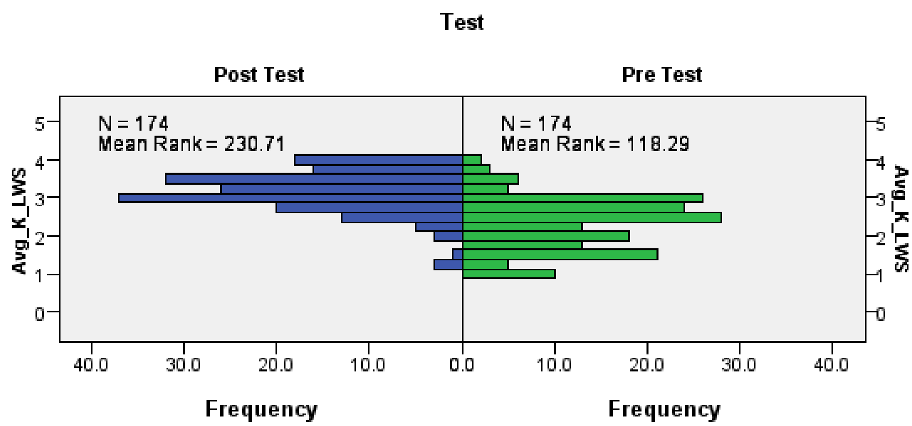
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Avg_K_LWS is the same across categories of Test.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Median Report

Test	Avg_K_LWS
Post Test	3.2500
Pre Test	2.5000
Total	2.7500

Independent-Samples Mann-Whitney U Test



Total N	348
Mann-Whitney U	5,357.500
Wilcoxon W	20,582.500
Test Statistic	5,357.500
Standard Error	932.414
Standardized Test Statistic	-10.489
Asymptotic Sig. (2-sided test)	.000

Perceived level of trust in local water supply managers before and after educational intervention

Hypothesis Test Summary

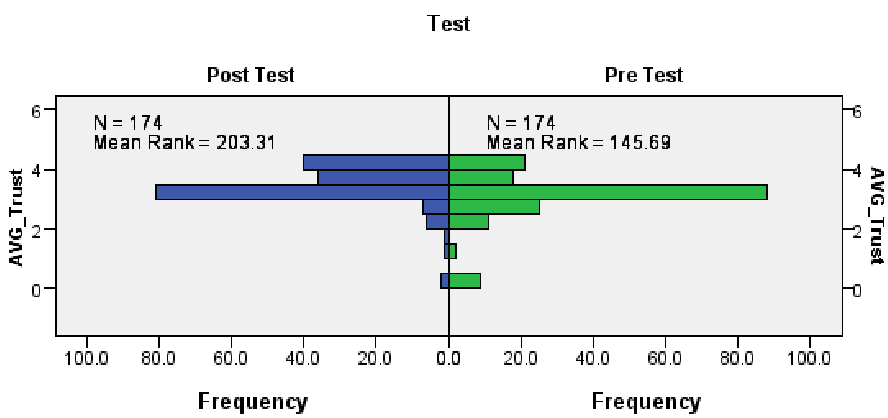
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of AVG_Trust is the same across categories of Test.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Median Report

Test	AVG_Trust
Post Test	3.3300
Pre Test	3.0000
Total	3.3300

Independent-Samples Mann-Whitney U Test



Total N	348
Mann-Whitney U	10,125.500
Wilcoxon W	25,350.500
Test Statistic	10,125.500
Standard Error	919.713
Standardized Test Statistic	-5.450
Asymptotic Sig. (2-sided test)	.000

Perceived level of the belief in the need for a new water supply before and after an education intervention

Hypothesis Test Summary

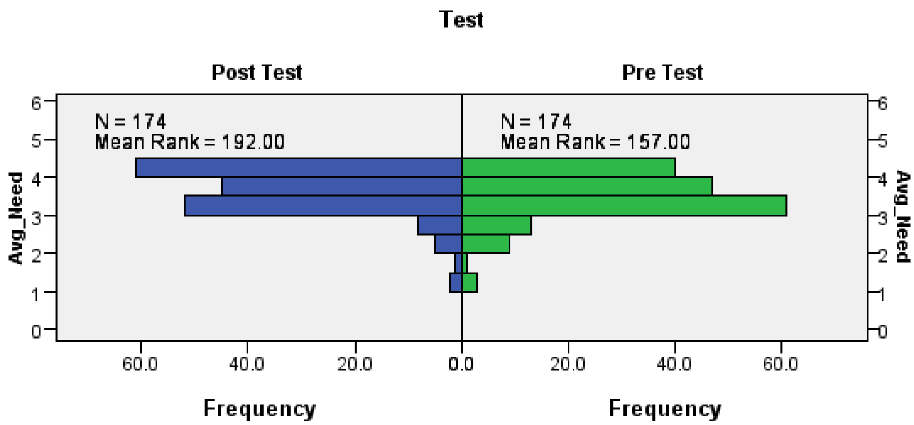
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Avg_Need is the same across categories of Test.	Independent-Samples Mann-Whitney U Test	.001	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Median Report

Test	Avg_Need
Post Test	3.6700
Pre Test	3.4150
Total	3.5000

Independent-Samples Mann-Whitney U Test



Total N	348
Mann-Whitney U	12,092.500
Wilcoxon W	27,317.500
Test Statistic	12,092.500
Standard Error	916.236
Standardized Test Statistic	-3.324
Asymptotic Sig. (2-sided test)	.001

H_2: Perceived levels of acceptance of recycled water potable reuse will increase after educational intervention.

Hypothesis Test Summary

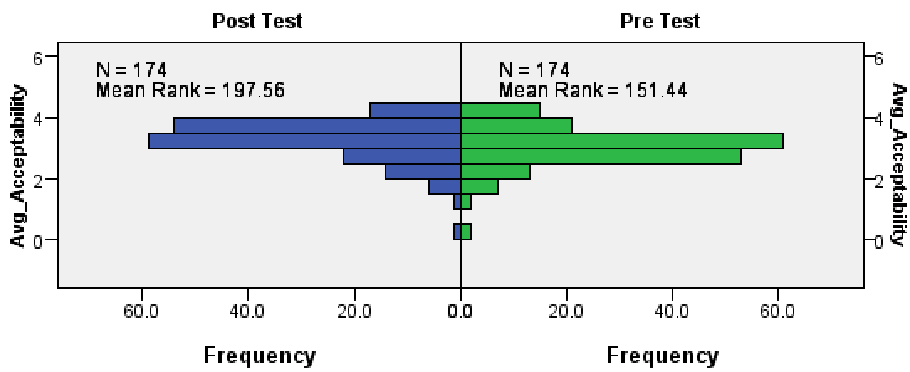
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Avg_Acceptability is the same across categories of Test.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05

Median Report

Test	Avg_Acceptability
Post Test	3.2500
Pre Test	3.0000
Total	3.0000

Independent-Samples Mann-Whitney U Test



Total N	348
Mann-Whitney U	11,125.000
Wilcoxon W	26,350.000
Test Statistic	11,125.000
Standard Error	930.930
Standardized Test Statistic	-4.311
Asymptotic Sig. (2-sided test)	.000

H_3: Demographic variables will significantly affect students' gain scores of perceived level of the four critical factors.

Gender

Hypothesis Test Summary

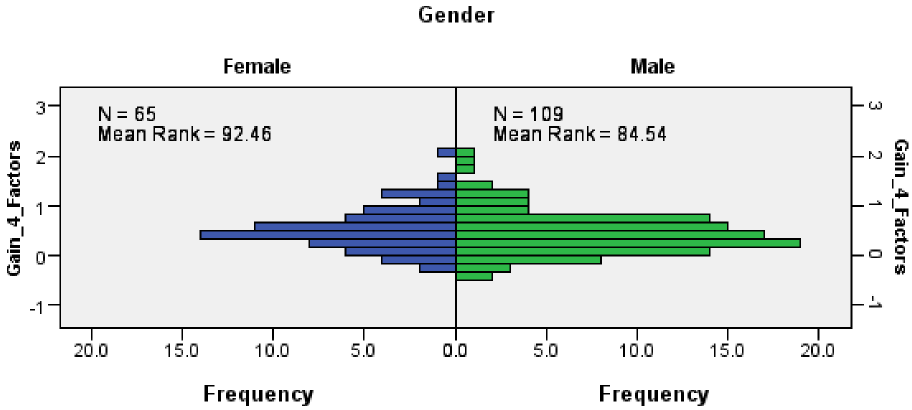
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Gain_4_Factors is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.316	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Median Report

Gender	Gain_4_Factors
Female	.4800
Male	.4600
Total	.4600

Independent-Samples Mann-Whitney U Test



Total N	174
Mann-Whitney U	3,220.000
Wilcoxon W	9,215.000
Test Statistic	3,220.000
Standard Error	321.365
Standardized Test Statistic	-1.004
Asymptotic Sig. (2-sided test)	.316

Primary language spoken at home

Hypothesis Test Summary

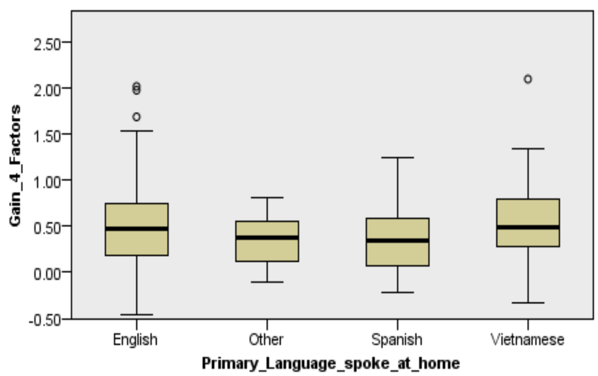
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Gain_4_Factors is the same across categories of Primary_Language_spoke_at_home.	Independent-Samples Kruskal-Wallis Test	.316	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Gain_4_Factors Median Report

Primary_Language_spoke_at_home	Median	N
English	.4800	116
Other	.3800	15
Spanish	.3500	19
Vietnamese	.4900	24
Total	.4600	174

Independent-Samples Kruskal-Wallis Test



Total N	174
Test Statistic	3.533
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	.316

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Grade level

Hypothesis Test Summary

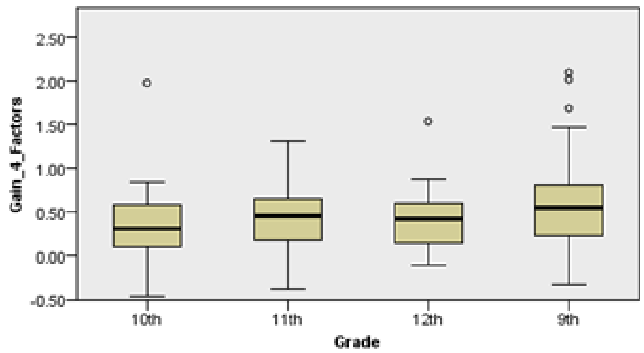
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Gain_4_Factors is the same across categories of Grade.	Independent-Samples Kruskal-Wallis Test	.073	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Gain_4_Factors Median Report

Grade	Median	N
10th	.3200	26
11th	.4600	29
12th	.4200	35
9th	.5500	84
Total	.4600	174

Independent-Samples Kruskal-Wallis Test



Total N	174
Test Statistic	6.955
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	.073

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Current availability of recycled water in the community

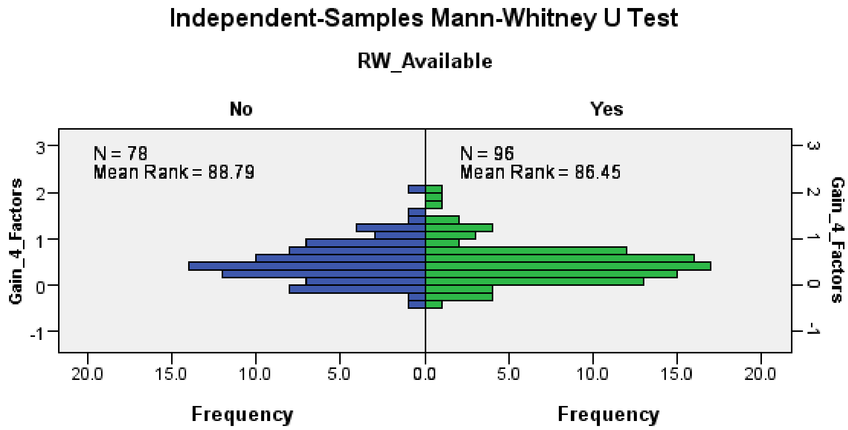
Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Gain_4_Factors is the same across categories of RW_Available.	Independent-Samples Mann-Whitney U Test	.760	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Median Report

RW_Available	Gain_4_Factors
No	.4800
Yes	.4500
Total	.4600



Total N	174
Mann-Whitney U	3,643.000
Wilcoxon W	8,299.000
Test Statistic	3,643.000
Standard Error	330.378
Standardized Test Statistic	-.306
Asymptotic Sig. (2-sided test)	.760

H_4. Demographic variables will significantly affect students' gain scores of perceived acceptance of potable reuse.

Gender

Hypothesis Test Summary

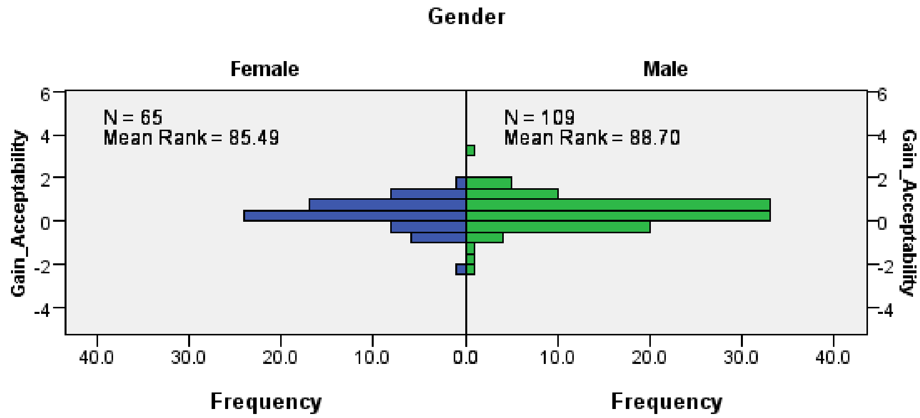
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Gain_Acceptability is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.683	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Median Report

Gender	Gain_Acceptance
Female	.2500
Male	.2500
Total	.2500

Independent-Samples Mann-Whitney U Test



Total N	174
Mann-Whitney U	3,673.000
Wilcoxon W	9,668.000
Test Statistic	3,673.000
Standard Error	319.287
Standardized Test Statistic	.409
Asymptotic Sig. (2-sided test)	.683

Primary language spoken at home

Hypothesis Test Summary

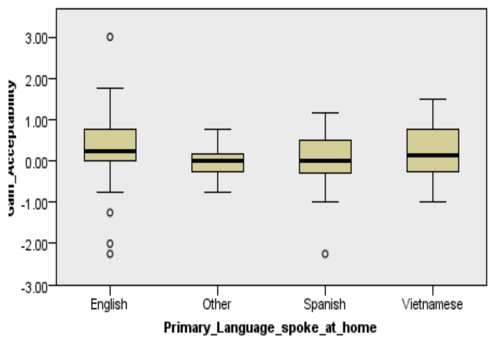
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Gain_Acceptability is the same across categories of Primary_Language_spoke_at_home.	Independent-Samples Kruskal-Wallis Test	.050	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Gain_Acceptance Median Report

Primary_Language_spoke_at_home	Median	N
English	.2500	116
Other	.0000	15
Spanish	.0000	19
Vietnamese	.1250	24
Total	.2500	174

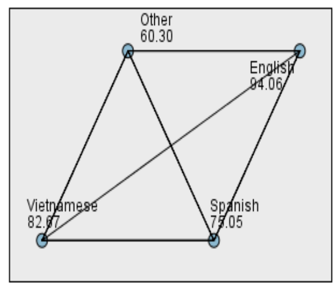
Independent-Samples Kruskal-Wallis Test



Total N	174
Test Statistic	7.824
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	.050

1. The test statistic is adjusted for ties.

Pairwise Comparisons of Primary_Language_spoke_at_home



Each node shows the sample average rank of Primary_Language_spoke_at_home.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Other-Spanish	-14.753	17.282	-.854	.393	1.000
Other-Vietnamese	-22.367	16.469	-1.358	.174	1.000
Other-English	33.756	13.729	2.459	.014	.084
Spanish-Vietnamese	-7.614	15.365	-.496	.620	1.000
Spanish-English	19.003	12.384	1.535	.125	.749
Vietnamese-English	11.389	11.221	1.015	.310	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

Grade level

Hypothesis Test Summary

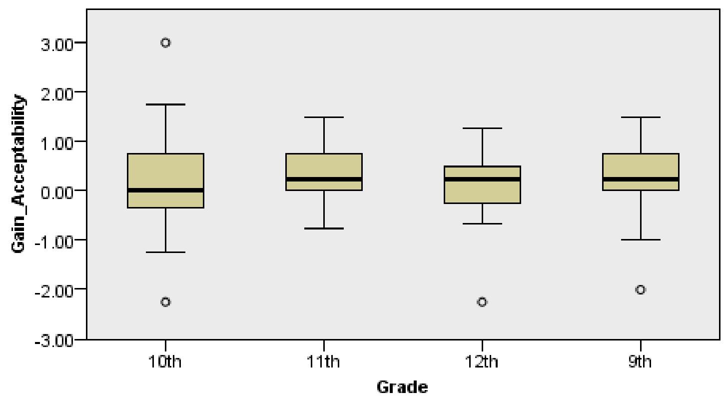
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Gain_Acceptability is the same across categories of Grade.	Independent-Samples Kruskal-Wallis Test	.208	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Gain Acceptance Median Report

Grade	Median	N
10th	.0000	26
11th	.2500	29
12th	.2500	35
9th	.2500	84
Total	.2500	174

Independent-Samples Kruskal-Wallis Test



Total N	174
Test Statistic	4.551
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	.208

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Current availability of recycled water in the community

Hypothesis Test Summary

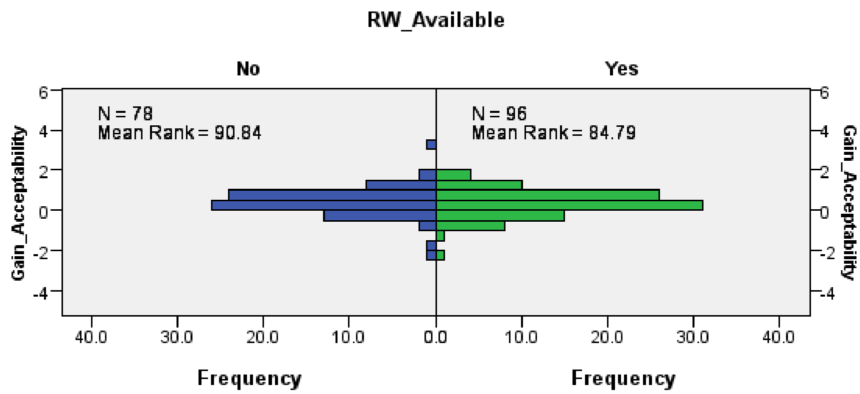
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Gain_Acceptability is the same across categories of RW_Available.	Independent-Samples Mann-Whitney U Test	.427	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Median Report

RW_Available	Gain_Acceptance
No	.2500
Yes	.2500
Total	.2500

Independent-Samples Mann-Whitney U Test



Total N	174
Mann-Whitney U	3,483.500
Wilcoxon W	8,139.500
Test Statistic	3,483.500
Standard Error	328.242
Standardized Test Statistic	-.794
Asymptotic Sig. (2-sided test)	.427

$H_{5:}$ The belief in the need for a new water supply will have the greatest effect on acceptance of potable reuse.

Descriptive Statistics

	Mean	Std. Deviation	N
Gain_Acceptability	.2585	.68261	174
Gain_K_WW	.6072	.57828	174
Gain_LWS	.8233	.70199	174
Gain_Trust	.3909	.91856	174
Gain_Need	.1818	.63078	174

Correlations

		Gain_Acceptability	Gain_K_WW	Gain_LWS	Gain_Trust	Gain_Need
Pearson Correlation	Gain_Acceptability	1.000	.069	.128	.079	.323
	Gain_K_WW	.069	1.000	.441	.177	.069
	Gain_LWS	.128	.441	1.000	.192	.028
	Gain_Trust	.079	.177	.192	1.000	.296
	Gain_Need	.323	.069	.028	.296	1.000
Sig. (1-tailed)	Gain_Acceptability	.	.184	.047	.149	.000
	Gain_K_WW	.184	.	.000	.010	.182
	Gain_LWS	.047	.000	.	.006	.355
	Gain_Trust	.149	.010	.006	.	.000
	Gain_Need	.000	.182	.355	.000	.
N	Gain_Acceptability	174	174	174	174	174
	Gain_K_WW	174	174	174	174	174
	Gain_LWS	174	174	174	174	174
	Gain_Trust	174	174	174	174	174
	Gain_Need	174	174	174	174	174

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.670	4	2.418	5.759	.000[b]
	Residual	70.940	169	.420		
	Total	80.610	173			

a. Dependent Variable: Gain_Acceptability

b. Predictors: (Constant), Gain_Need, Gain_LWS, Gain_Trust, Gain_K_WW

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.346[a]	.120	.099	.64789	1.845

a. Predictors: (Constant), Gain_Need, Gain_LWS, Gain_Trust, Gain_K_WW

b. Dependent Variable: Gain_Acceptability

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions				
				(Constant)	Gain_K_WW	Gain_LWS	Gain_Trust	Gain_Need
1	1	2.918	1.000	.03	.03	.03	.04	.02
	2	.976	1.729	.02	.02	.03	.15	.52
	3	.600	2.205	.01	.01	.00	.80	.44
	4	.276	3.254	.48	.82	.03	.00	.00
	5	.230	3.560	.45	.11	.91	.01	.02

a. Dependent Variable: Gain_Acceptability

Casewise Diagnostics[a]

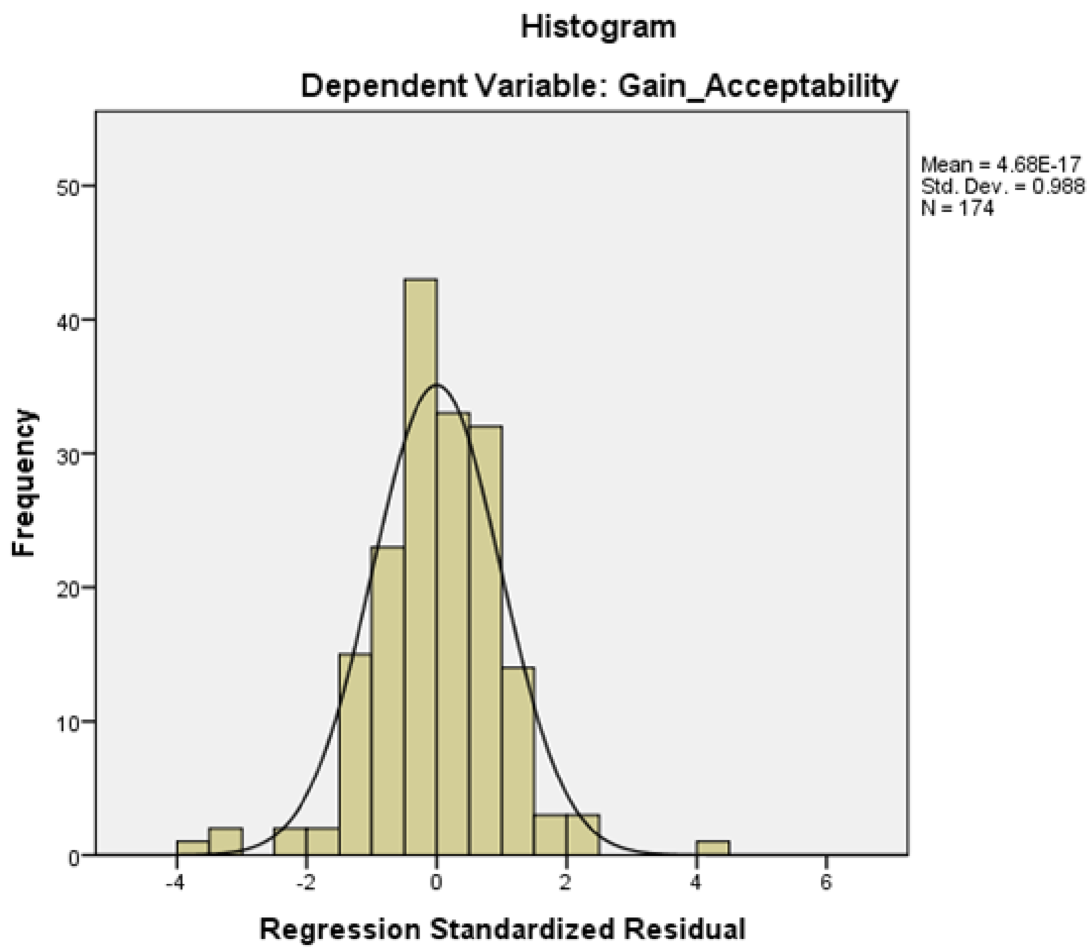
Case Number	Std. Residual	Gain_Acceptability	Predicted Value	Residual
15	4.370	3.00	.1686	2.83136
39	-3.155	-2.25	-.2060	-2.04398
98	-3.698	-2.25	.1457	-2.39574
99	-3.459	-2.00	.2412	-2.24116

a. Dependent Variable: Gain_Acceptability

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-.6002	1.2025	.2585	.23643	174
Std. Predicted Value	-3.632	3.993	.000	1.000	174
Standard Error of Predicted Value	.053	.281	.102	.041	174
Adjusted Predicted Value	-.7024	1.1641	.2601	.23698	174
Residual	-2.39574	2.83136	.00000	.64036	174
Std. Residual	-3.698	4.370	.000	.988	174
Stud. Residual	-3.756	4.421	-.001	1.003	174
Deleted Residual	-2.47209	2.89768	-.00164	.65957	174
Stud. Deleted Residual	-3.912	4.687	-.002	1.020	174
Mahal. Distance	.159	31.595	3.977	4.723	174
Cook's Distance	.000	.172	.006	.017	174
Centered Leverage Value	.001	.183	.023	.027	174

a. Dependent Variable: Gain_Acceptability



Histogram
Dependent Variable: Gain_Acceptability
Mean = 4.68E-17
Std. Dev. = 0.988
N = 174
Frequency
Regression Standardized Residual