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Ten Things You Should Know About Water Before Going to High School: Incorporating Local Water-Resources Issues Into the Albuquerque, New Mexico Public School System Science Curriculum

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**Ten Things You Should Know About Water before
Going to High School: Incorporating Local Water-
Resources Issues Into the Albuquerque, New Mexico
Public School System Science Curriculum**

By

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Committee

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A Professional Project Proposal Submitted in Partial Fulfillment of the
Requirements
For the Degree of
Master of Water Resources
Water Resources Program
The University of New Mexico
Albuquerque, New Mexico

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Abstract

The desert southwest, including New Mexico (NM), has some of the most diverse water-resources issues in the country, ranging from severe drought to sustainability concerns to interstate compact violations. Water conservation is rapidly becoming an integral component in water-resources management, yet some middle-school (MS) students in Albuquerque, New Mexico do not know the definition of water conservation, let alone where their water comes from. This is disturbing, as today's students will be making tomorrow's decisions regarding our water. Therefore, science teachers need to ensure these crucial concepts get incorporated into the curriculum, beginning at an early age.

The purpose of this quantitative study is to assess the basic water knowledge of the following population samples: middle-school science students, prospective middle-school science teachers, and current middle-school science teachers, by utilizing surveying and statistical methods to collect and interpret the survey data. The study sites where the surveying took place included Jackson MS and the University of New Mexico, College of Education, both in Albuquerque, NM, in which 287 MS students and 61 teachers were surveyed. This study presents the results from a thirty (30)-item questionnaire administered to the three population samples, and focuses on ten water concepts and results with either low percentages associated with correct answers, high percentages associated with incorrect answers, high percentages for the response "I don't know," or mixed results, indicating possibly some sort of misunderstanding. These deficiencies include not knowing the definitions of the following: sustainability, watershed, aquifer, spray irrigation, water right, and interstate compact. In addition, many students do not know the source of their household water, or where their water will come from if this source is depleted. Also, students are unable to describe and breakdown New Mexico's water use by sector; are unaware of local, industrial water use; and are unaware of New Mexico's surface-water delivery requirements to Texas per the Rio Grande Compact. To address these critical, local water concepts, this study also provides recommendations and resources for science teachers to develop a water-resources curriculum tailored to students' needs.

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INTRODUCTION

The desert southwest, including New Mexico, has some of the most diverse water-resources issues in the country, ranging from severe drought to sustainability concerns to interstate compact violations. Water conservation is rapidly becoming an integral component in water-resources management, yet some middle-school students in Albuquerque, New Mexico do not know the definition of water conservation, let alone where their water comes from, according to the author's experience teaching science to sixth and seventh graders. This is disturbing, as today's students will be making tomorrow's decisions regarding our water. Therefore, science teachers need to ensure that these concepts get incorporated into the early-grade level science curriculum.

The purpose of this study is to assess middle-school students' awareness of issues related to local water-resources, as well as their basic water knowledge, at one middle school in Albuquerque. This study also set out to assess the basic water knowledge of current middle-school science teachers at that school, as well as K-8 preservice teachers (i.e. college students going to school to become teachers). More specifically, with regard to students, another goal of this study is to gather data in order to recommend a water-resources curriculum tailored to their needs.

All of the subjects' attitudes toward, opinions on, and knowledge and perceptions of water, including local issues, were gathered in this quantitative study. Then, utilizing surveying and statistical methods to quantify the aforementioned, the collected data were examined for the population subsets.

This study presents the results from a thirty (30)-item questionnaire administered to the three population samples (students, K-8 preservice teachers, and current middle-school science teachers); and, it focuses on ten questions and associated results from the

student population subset. Based on this research, students in New Mexico should know at least the following concepts about water before moving on to high school, so they can make better-informed decisions regarding their own water use:

1. What sustainability is and how it relates to their community.
2. That their household water comes from a finite, underground source, and since this source is being depleted relatively quickly, their future water source will be from the city's surface-water locality, the Rio Grande.
3. That their household water costs only pennies a day.
4. The definition of a watershed.
5. The definition of an aquifer.
6. The breakdown of New Mexico's water use by sector (i.e. that over three-quarters of the state's water sources combined goes toward irrigation and agriculture).
7. What "spray irrigation" is and how much water is lost to evaporation during this particular method.
8. The definition of a water right.
9. What the Rio Grande Compact is and what it means for New Mexico.
10. What industries in Albuquerque (e.g. Intel) use the most water.

These concepts were chosen because of results from the surveys, showing either low percentages associated with correct answers, high percentages associated with incorrect answers, high percentages for the response "I don't know," or mixed results, indicating possibly some sort of misunderstanding. To address these critical water concepts, this study provides recommendations and resources for science teachers to develop a water-resources curriculum tailored to students' needs.

Literature Review

A literature review was conducted online through the University of New Mexico, Zimmerman Library, Education Research Complete database, powered by EBSCOhost (an extensive electronic literature search engine). This account is provided to convey what knowledge and ideas have been established on the topics of K-8 water-resources education, curricula, and national programs/projects, and what their strengths and weaknesses are.

The literature review revealed little with regard to K-8 water-resources curricula specific to arid localities such as New Mexico (i.e. there was some literature on curricula and associated activities for students in places like Tennessee and Louisiana, where water is more abundant). Due to the fact that the geology, hydrology, and ecology are different in more wet areas of the United States, some of these educational lessons and activities might not apply to New Mexico. Other internet research revealed some watershed-education outreach programs specific to New Mexico that are more appropriate. These programs include New Mexico Watershed Watch (NMWW) and New Mexico Project WET (Water Education for Teachers), sponsored by WERC, A Consortium for Environmental Education and Technology Development. These local programs are discussed in more detail in the Recommendations section of this paper. National programs for environmental education include the Environmental Protection Agency, the National Environmental Education Foundation, and the U.S. Bureau of Land Management, to name a few.

The literature review also revealed at least 20 works on water-resources educational materials/curricula for in and out of the classroom. However, the review of these works did not indicate whether or not these curricula are considered successful in the environmental education discipline, and thus this is something that warrants further research (please see the Future Work section of this paper).

BACKGROUND

Over the past 100 years, Albuquerque, New Mexico (shown in figure 1) has received approximately eight inches of annual precipitation, or less (NOAA, 1998). This lack of precipitation and related effects, such as wildfires, has caused millions of dollars in economic losses between insurance claims, decreased tourism, and agriculture losses

(Hernandez, 2002), in addition to several lawsuits involving Texas and Colorado. By law, New Mexico is required to deliver hundreds of thousands of acre-feet per year of water from the Rio Grande to Texas per an interstate compact that the two states signed in 1938 (New Mexico Office of the State Engineer, 2006). Due to issues like frequent drought and delivery requirements to Texas that are difficult to fulfill, New Mexico policy makers are becoming increasingly concerned about sustaining its future. Water conservation in Albuquerque has increased significantly over the past several years (since 1994, the city has reduced water usage by 33%) (City of Albuquerque, 2007).



Figure 1. Map of New Mexico showing Albuquerque in relation to other cities for reference (from <http://www.newmexico.org/explore/map.php>).

By the year 2025, 1,011,800 people are anticipated to be living in Albuquerque (Demographia, 2000), a city in the desert where there is simply not much water. They will be getting at least 70% of their water from the San Juan-Chama Drinking Water Project, which will purify and distribute surface-water sources. In addition, other projects such as water recycling, surface-water reclamation, aquifer storage and recovery,

and shallow groundwater irrigation, will have already been initiated to try to limit dependency on groundwater as the city's sole municipal source (Albuquerque Bernalillo County Water Utility Authority, 2007).

The Albuquerque Public School System (APS) is one of the largest in the country, consisting of approximately 5,000 teachers and 87,000 students (Albuquerque Public Schools, 2006). Of the more than forty "concepts" that New Mexico state standards require school teachers to cover in earth-science classes for grades 5-8, only five are related to water (see table below). Furthermore, of these five water concepts, only one is related to local or current issues (see "concept" #4 in Table 1). As you can see, sensitive issues specific to New Mexico, such as water rights, conservation, and sustainability, are not emphasized as much as physical properties of water in the state standards for earth science.

Standard and Benchmark	“Water Concept”
<p>Strand II: Content of Science Standard III (Earth & Space Science): Understand the structure of Earth, the solar system, and the universe, the interconnections among them, and the processes and interactions of Earth’s systems.</p> <p>5-8 Benchmark II: Describe the structure of Earth and its atmosphere and explain how energy, matter, and forces shape Earth’s systems.</p>	<p>#1 Understand that water and air relate to Earth’s processes, including:</p> <ul style="list-style-type: none"> • how the water cycle relates to weather • how clouds are made of tiny droplets of water, like fog/steam.
	<p>#2 Know that most of Earth’s surface is covered by water, that most of that water is salt water in oceans, and that fresh water is found in rivers, lakes, underground sources, and glaciers.</p>
	<p>#3 Understand the unique role water plays on Earth, including:</p> <ul style="list-style-type: none"> • ability to remain liquid at most Earth temperatures • properties of water related to processes in the water cycle (evaporation, condensation, precipitation, surface run-off, percolation) • dissolving of minerals and gases and transport to the oceans • fresh and salt water in oceans, rivers, lakes, and glaciers • reactant in photosynthesis.
Standard and Benchmark	“Water Concept”
<p>Strand III: Science & Society Standard I: Understand how scientific discoveries, inventions, practices, and knowledge influence, and are influenced by, individuals and societies.</p> <p>5-8 Benchmark I: Explain how scientific discoveries and inventions have changed individuals and societies.</p>	<p>#4 Describe the contributions of science to understanding local or current issues (e.g., watershed and community decisions regarding water use).</p>
	<p>#5 Describe how scientific information can help to explain environmental phenomena (e.g., floods, earthquakes, volcanoes, fire, and extreme weather).</p>

Table 1. New Mexico state standards, benchmarks and associated concepts (from <http://www.ped.state.nm.us/standards/index.html>)

These state standards are intended for students in fifth through eighth grades, and are categorized according to specific grade levels. Three of the five standards listed above are for fifth graders and the other two are for eighth graders. Because this study focuses on middle-school aged students (which in Albuquerque is defined as sixth, seventh and eighth grade), it is important to note that the fifth-grade standards were included because some middle-school teachers in Albuquerque include these standards in their science classes. This occurs because some teachers feel it is necessary to cover lower grade-level standards, in order to teach their appropriate grade-level standards,

either as somewhat of a review, or to deal with certain deficiencies that may be present. This study did not attempt to determine exactly how many middle-school teachers in Albuquerque include these fifth grade standards into their curriculums; but, this study did determine that this phenomenon occurs at the study site (a middle school in Albuquerque), which is later described.

METHODS

The main goals of this project were to: 1) quantify students' basic water knowledge; 2) quantify the K-8 preservice and current science teachers' basic water knowledge; 3) determine how/how much science teachers are addressing water-resources issues in the classroom; and 4) based on these findings, provide recommendations for a water-resources curriculum for earth-science classes. Methods used to accomplish these goals include data collection (surveys), data interpretation (statistical analyses) and curriculum development research.

Data Collection

Surveys

Surveys were designed and administered to current (APS) science teachers from one middle school in Albuquerque, as well as K-8 preservice teachers from the University of New Mexico (UNM) College of Education (COE) in Albuquerque to determine the following: 1) their basic water knowledge, and 2) how much time/how many lessons they devote (or plan to devote) to local water-resources issues in the science classroom (see Appendix "A"). Secondly, surveys were designed and distributed to science students at one middle school in Albuquerque (name not included for confidentiality purposes) to determine their basic water knowledge (see Appendix "B").

Current and K-8 preservice teachers (i.e. adults) represented one sample of the population, and students (i.e. children) represented another. Eight current APS science teachers from one Albuquerque middle school (i.e. sixth through eighth grade) were surveyed, and 53 K-8 preservice teachers from two UNM COE classes were surveyed. 287 students total (52 sixth graders, 144 seventh graders, and 91 eighth graders) at the Albuquerque middle school (MS) were surveyed.

The survey questionnaires were administered in person (via written medium) to both population samples. Both survey instruments were in multiple-choice format and consisted of 30 “closed” questions. Closed questions give the respondents a finite (usually small) number of choices from which they can select one or more (Goodman, 1995).

Permission was obtained from both population samples. More specifically, both the adults and children were required to provide signatures in order to participate, and with the children, parental/guardian permission was required. Prior to the surveying, student assent and parental consent forms (i.e. permission slips) were sent home with students to inform them and their family that surveying about water resources would be taking place in the near future. Student assent and parental consent forms were developed in conjunction with the UNM Institute for Research and Development Department. Students were encouraged to show their parents/guardians copies of the questionnaires.

The frequency of the surveying activities for both adults and children was once. The individual participants filled out the survey form one time, but survey activities in general occurred multiple times, as there are seven class periods in a day, in addition to the two UNM COE classes that were surveyed. The duration of each surveying event

(including introduction/explanation time) was no more than 35 minutes. Surveying was conducted on Tuesday through Friday, during the week of March 12th, 2007, between the hours of 8:45 am and 3:05 pm. The field sites where the surveying took place were the science classrooms (earth science for sixth graders, life science for seventh graders, and physical science for eighth graders) at the middle-school campus, and UNM for the COE students, both in Albuquerque, New Mexico. These field sites were chosen because of their convenience and because permission had been granted to conduct research there.

Once the surveying was complete, data were processed by doing the following: identifying errors; pre-processing (e.g. elimination of unusable data); tallying; and data storage (EXCEL spreadsheets – See Appendix C). Then, utilizing the survey results and statistical methods (discussed below) to quantify the aforementioned, the collected data were examined for the middle-school students and their grade-level population subsets, as well as the current and K-8 preservice teachers.

Participants

The middle-school students surveyed are between the ages of eleven and fourteen, and have had elementary-level science at the least, and are currently either taking earth, life, or physical science at the mid-school level. Students at the study site are distributed among the following races: 7.8% are African American; 4.6% are Asian/Pacific; 48.7% are Caucasian; 32.7% are Hispanic; and 6.2% are Native American. In addition, 46% of students qualify for free or reduced-price meal rates. These socioeconomic factors may play a role in student academic performance in the sciences.

The K-8 preservice teachers are seniors in the UNM COE, meaning these participants have all had a minimum of twelve credit hours of college-level science courses, per UNM requirements. Some of these participants will receive (or are currently

working on) their teaching endorsement in science, which requires a minimum of 24 credit hours of college-level science courses. However, most of these K-8 preservice teachers are endorsing in other, various disciplines besides science, such as math, language arts/literature, social studies, etc. Thus, it is important to note that although these participants will have (or have had) some science background, their level of knowledge is not the same as middle-school science teachers that are considered highly qualified, which is further discussed below.

The current, APS science teachers that were surveyed are all considered highly qualified, meaning they were required to do one of the following: 1) Pass the appropriate New Mexico Teacher Assessments test for their situation; 2) If teaching in a middle school or high school, have at least 24 credit hours of coursework or an advanced degree in each subject the teacher teaches from a regionally accredited college or university; 3) Hold certification from the National Board of Professional Teaching Standards in the area in which they are teaching; or 4) Successfully complete New Mexico's High Objective Uniform Standard of Evaluation (HOUSSE) in the core academic subjects(s) the teacher teaches. In addition, participants in this sample have at least seven years experience teaching science.

Response Rates

Of the approximately 728 students that attend the middle school in Albuquerque (Albuquerque Public Schools, 2006), 287 or ~40% were surveyed. The reasons the entire student- enrollment sample of 728 was not able to be obtained via surveying can be attributed to several factors. First of all, only regular education (i.e. no special-education) classes were surveyed (~150 students are enrolled in special-education classes at this particular middle school). Secondly, attendance rates affected survey numbers, as

approximately 10% of all classes surveyed were absent those days due to illness, medical appointments, school activities, etc. The response rate was 100%, as every student surveyed completed their questionnaire (i.e. there were not any students that were present during the surveying that chose not to participate, even though they were told that participation was voluntary).

Data Interpretation

Statistical Analysis

Simple statistical relationships, such as mean (i.e. average) and standard deviation (i.e. how spread out the data are) were drawn from the sample data. In addition, confidence intervals and sampling errors were determined.

Sampling Error

Throughout this report, findings are reported at a 95% confidence interval. For the sample of middle-school students, the sampling error is at most $\pm 5.74\%$. For the sample of K-8 preservice teachers from the UNM COE, the sampling error is at most $\pm 10.40\%$. For the sample of current MS science teachers, the sampling error is relatively high because only eight teachers were surveyed. The previous means that if the survey were administered 100 times to different samples that were selected in the same fashion, 95 of the 100 surveys' findings would fall within the the corresponding sampling errors stated above (Responsive Management, 2001).

Population data gathered for calculating sampling errors were derived from APS and UNM and were further analyzed in the following ways: enrollment numbers for each middle school in Albuquerque were added (excluding alternative schools) totaling 19,776 students (Albuquerque Public Schools, 2006). The assumption was made that there are

approximately five science teachers at each MS (multiplied by 26 total MS's in Albuquerque) yielding a population size of 130 science teachers (Albuquerque Public Schools, 2006). This number was also used for the population size of the K-8 preservice teachers. Sampling errors were calculated by plugging the sample and population sizes described above into the formula below:

$$B = \sqrt{\frac{\frac{N_p(.25)}{N_s} - .25}{N_p - 1}} (1.96)$$

Where: B = maximum sampling error (as decimal)
 N_p = population size (e.g. total pop. of state)
 N_s = sample size

Derived from formula, p. 206 in Dillman, D. A. 2000. Mail and Internet Surveys. John Wiley & Sons, NY.

Note: This is a simplified version of the formula that calculates the maximum sampling error using a 50:50 split (the most conservative calculation since a 50:50 split would give maximum variation).

Figure 2. Formula used to calculate sampling errors (from Responsive Management, 2001).

The term “estimated” is used to indicate that projections are based on a sample. The actual value of each variable studied is likely to be the value indicated. The actual value will fall within the confidence intervals indicated 95 times out of 100. Due to rounding, percentages depicted in graphs and tables may vary slightly ($\pm 0.5\%$) from actual data and therefore may not total exactly 100% (Responsive Management, 2001).

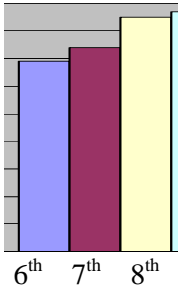
When survey questions were worded similarly for all population samples, graphical data were combined. Alternatively, when survey questions themselves were worded differently among sample populations, or the possible answers to choose from were worded differently among sample populations, graphical data were presented

separately. This method is used throughout this report, as it was sometimes necessary to word questions differently according to whether the survey questions were administered to adults or children.

RESULTS AND DISCUSSION

The following table combines and summarizes results regarding basic water knowledge of students (overall and by grade level), K-8 preservice teachers (i.e. students in the UNM COE), and current APS science teachers. These particular results are not presented with graphs (as is the case throughout the rest of this paper), because it was deemed unnecessary. Definitions were obtained from online dictionary sources and cross-referenced with a Webster's dictionary, when applicable.

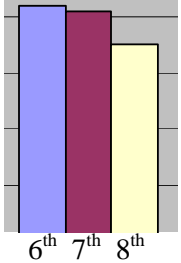
The sampling numbers (n) for each survey sample, as well as standard deviation values for the samples (S) are presented throughout the following tables.

SUMMARY – BASIC WATER KNOWLEDGE				
Question	Students (Overall)	Students (Specific Grade Level Information)	K-8 preservice Teachers (COE)	Current Science Teachers (APS)
<p>Q. What does the term “Water Resources” mean?</p> <p>A. Location, accessibility, & quality of water. OR Network of rivers, lakes, & other surface waters that supply water for food production & other necessary human needs.</p>	<p>On average, students have a good grasp on this concept (with ~92% choosing some form of the correct answer).</p>	<p>More 6th graders (compared to 7th and 8th) chose the incorrect answer, as well as “I don’t know.”</p> <p>6th Grade: n=52; Std. Dev. = 2.51. 7th Grade: n=144; Std. Dev. = 6.17. 8th Grade: n=91; Std. Dev. = 3.95.</p>	<p>Unlike the students, no one chose the wrong answer, or chose “I don’t know.”</p>	<p>Unlike the students, no one chose the wrong answer, or chose “I don’t know.”</p>
			<p>This sample has a good grasp on the term.</p> <p>COE: n=53; Std. Dev. = 3.85.</p>	<p>This sample has a good grasp on the term.</p> <p>APS: n=8; Std. Dev. = 0.72.</p>
<p>Q. Do we have enough water in Albuquerque for everyone if lots* of people keep moving here?</p> <p>A. No</p> <p>6th Grade: n=52; Std. Dev. = 3.20. 7th Grade: n=144; Std. Dev. = 5.96. 8th Grade: n=91; Std. Dev. = 6.03.</p>	<p>More than three-quarters (76%) said “No.”</p>	<p>The ability to choose “No” increases with grade level:</p>  <p>6th 7th 8th</p>	<p>87% said “No.”</p>	<p>87% said “No.”</p>
			<p>Unlike the students, none chose “Yes.”</p>	<p>Unlike the students, none chose “Yes.”</p>
			<p>13% responded with “I don’t know.”</p> <p>COE: n=53; Std. Dev. = 4.86.</p>	<p>*Due to the fact that “lots” was not defined in this question, 13% responded with “I don’t know.”</p> <p>APS: n=8; Std. Dev. = 0.74.</p>

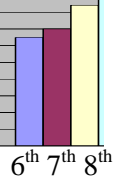
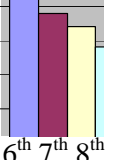
SUMMARY – BASIC WATER KNOWLEDGE CONT.

Question	Students (Overall)	Students (Specific Grade Level Information)	K-8 preservice Teachers (COE)	Current Science Teachers (APS)
<p><i>Q. What is a drought?</i> <i>A. A long period of below-average rain and snow.</i></p> <p>6th Grade: n=52; Std. Dev. = 2.23. 7th Grade: n=144; Std. Dev. = 5.82. 8th Grade: n=91; Std. Dev. = 5.78.</p>	<p>More than two-thirds (68%) correctly identified the proper definition.</p>	<p>Again, the ability to choose the right definition increases with grade level (similar to above), in which the clear majority (81%) of 8th graders knew the right definition (not a single 8th grader chose “I don’t know” for this question).</p>	<p>100% chose the correct definition.</p> <p>COE: n=53; Std. Dev. = 6.37.</p>	<p>100% chose the correct definition.</p> <p>APS: n=8; Std. Dev. = 0.96.</p>
<p><i>Q. What is water conservation?</i> <i>A. Saving water OR Practices which reduce water use.</i></p>	<p>On average, students have a good grasp on this concept (with ~89% choosing some form of the correct answer).</p>	<p>More 7th graders chose the best-fit answer compared to any other grade level.</p> <p>6th Grade: n=52; Std. Dev. = 3.05. 7th Grade: n=144; Std. Dev. = 5.68. 8th Grade: n=91; Std. Dev. = 4.05.</p>	<p>Unlike the students, no one chose the wrong answer, or chose “I don’t know.”</p> <p>This sample has a good grasp on the term.</p> <p>COE: n=53; Std. Dev. = 4.82.</p>	<p>Unlike the students, no one chose the wrong answer, or chose “I don’t know.”</p> <p>This sample has a good grasp on the term.</p> <p>APS: n=8; Std. Dev. = 0.70.</p>
<p><i>Q. Give an example of water conservation.</i> <i>A. Turning off the faucet while you brush your teeth.</i></p>	<p>The clear majority (87% on average) were able to correctly identify the best-fit choice.</p>	<p>The distribution of graphical results for this question is relatively equal for all grade levels.</p> <p>6th Grade: n=52; Std. Dev. = 5.19. 7th Grade: n=144; Std. Dev. = 8.31. 8th Grade: n=91; Std. Dev. = 7.09.</p>	<p>100% of this sample identified the correct choice.</p> <p>COE: n=53; Std. Dev. = 6.37.</p>	<p>100% of this sample identified the correct choice.</p> <p>APS: n=8; Std. Dev. = 0.96.</p>

SUMMARY – BASIC WATER KNOWLEDGE CONT.

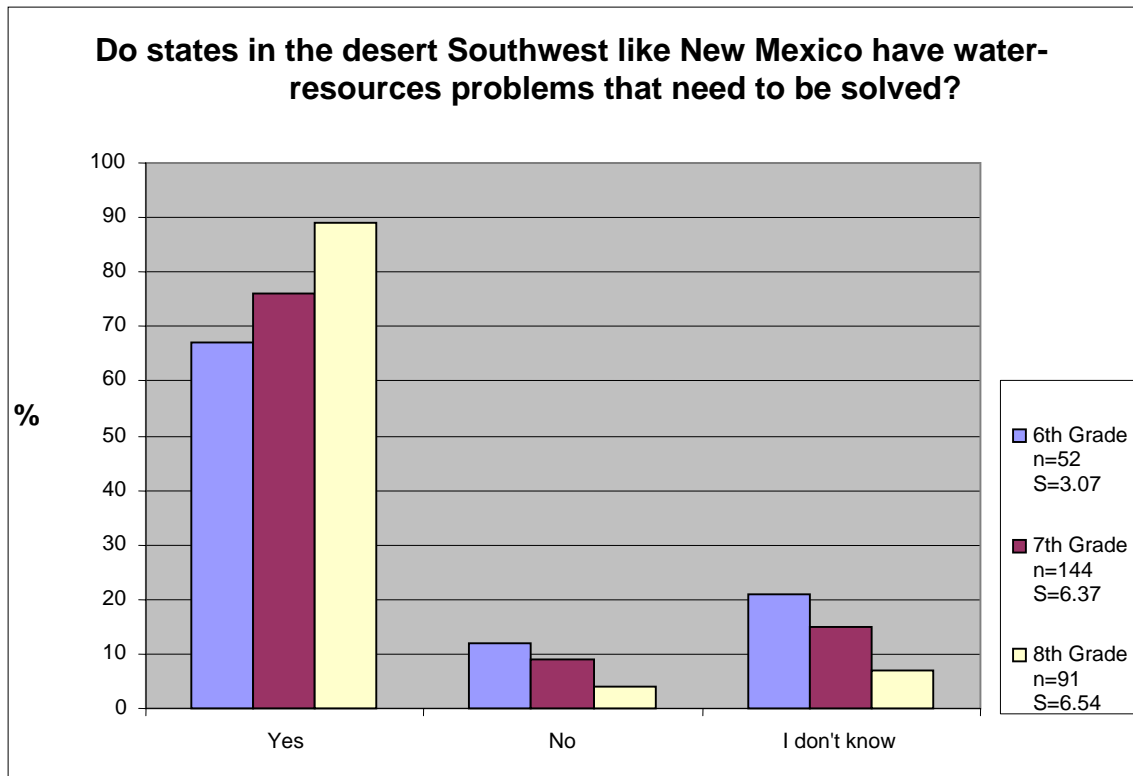
Question	Students (Overall)	Students (Specific Grade Level Information)	K-8 preservice Teachers (COE)	Current Science Teachers (APS)								
<p><i>Q. What is groundwater?</i> <i>A. Water below ground surface.</i></p> <p>6th Grade: n=52; Std. Dev. = 5.66. 7th Grade: n=144; Std. Dev. = 9.17. 8th Grade: n=91; Std. Dev. = 6.63.</p>	<p>The overwhelming majority, (~90%), chose the correct definition.</p>	<p>A characteristic of the graphical results that is inconsistent with many of the other results, is the fact that the ability to choose the right answer to this question decreases with grade level.</p>  <table border="1" data-bbox="797 716 976 976"> <caption>Bar Chart Data</caption> <thead> <tr> <th>Grade</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>6th</td> <td>~90%</td> </tr> <tr> <td>7th</td> <td>~80%</td> </tr> <tr> <td>8th</td> <td>~70%</td> </tr> </tbody> </table>	Grade	Percentage	6 th	~90%	7 th	~80%	8 th	~70%	<p>This question was not presented to this sample, as obvious results were anticipated, and thus considered unnecessary.</p>	<p>This question was not presented to this sample, as obvious results were anticipated, and thus considered unnecessary.</p>
Grade	Percentage											
6 th	~90%											
7 th	~80%											
8 th	~70%											
<p><i>Q. What does Bosque mean?</i> <i>A. Areas of forest along the floodplains of a river in the southwestern U.S., OR Spanish word for woodlands, OR Cottonwoods along the Rio Grande.</i></p> <p>6th Grade: n=52; Std. Dev. = 2.65. 7th Grade: n=144; Std. Dev. = 3.62. 8th Grade: n=91; Std. Dev. = 3.20.</p>	<p>On average, students have a good grasp on this concept (with ~70% choosing some form of the correct answer).</p>	<p>40% of 6th graders chose “I don’t know.” 35% of 7th graders chose “I don’t know.” 15% of 8th graders chose “I don’t know.”</p>	<p>This sample has a descent grasp on the term, with just 9% responding with “I don’t know.”</p> <p>COE: n=53; Std. Dev. = 3.94.</p>	<p>This sample has a good grasp on the term, with all respondents choosing some form of the correct answer.</p> <p>APS: n=8; Std. Dev. = 0.58.</p>								

SUMMARY – BASIC WATER KNOWLEDGE CONT.

Question	Students (Overall)	Students (Specific Grade Level Information)	K-8 preservice Teachers (COE)	Current Science Teachers (APS)
<p><i>Q. What are some of the crops farmers grow in the Rio Grande Valley here in New Mexico?</i> <i>A. Alfalfa & green chile.</i></p> <p>6th Grade: n=52; Std. Dev. = 3.50. 7th Grade: n=144; Std. Dev. = 6.32. 8th Grade: n=91; Std. Dev. = 6.51.</p>	<p>On average, almost three-quarters (73%) chose the best-fit response.</p>	<p>The ability to identify the best-fit response increases with grade level:</p> 	<p>91% chose the best-fit response. 9% responded with “I don’t know.”</p> <p>COE: n=53; Std. Dev. = 5.59.</p>	<p>100% of this sample chose the best-fit response.</p> <p>APS: n=8; Std. Dev. = 0.96.</p>
<p><i>Q. Do crops like alfalfa need a lot of water?</i> <i>A. Yes</i></p> <p>6th Grade: n=52; Std. Dev. = 1.00. 7th Grade: n=144; Std. Dev. = 1.75. 8th Grade: n=91; Std. Dev. = 3.13.</p>	<p>44% said “No.”</p> <p>18% said “Yes.”</p> <p>38% chose “I don’t know.”</p>	<p>The act of answering “I don’t know” decreases as grade level increases:</p> 	<p>26% said “No”</p> <p>46% said “Yes”</p> <p>28% chose “I don’t know.”</p> <p>COE: n=53; Std. Dev. = 1.08.</p>	<p>88% said “Yes” and 12% chose “I don’t know”.</p> <p>APS: n=8; Std. Dev. = 0.74.</p>
<p><i>Q. What is the best time of day to water your grass if using spray irrigation (like sprinklers)?</i> <i>A. Either early morning or at night.</i></p>	<p>On average, students have a good grasp on this subject (71% chose the correct answer).</p>	<p>Again, the ability to correctly identify the answer increases with grade level (similar to above).</p> <p>6th Grade: n=52; Std. Dev. = 3.20. 7th Grade: n=144; Std. Dev. = 6.40. 8th Grade: n=91; Std. Dev. = 6.15.</p>	<p>92% chose the best-fit response. 8% responded with “I don’t know.”</p> <p>COE: n=53; Std. Dev. = 5.74.</p>	<p>100% of this sample identified the correct answer.</p> <p>APS: n=8; Std. Dev. = 0.96.</p>
<p><i>Q. What is surface water?</i> <i>A. Water on the Earth’s surface like rivers and lakes.</i></p>	<p>The clear majority (72%) responded with the correct response.</p>	<p>The seventh graders knew this definition the most.</p> <p>6th Grade: n=52; Std. Dev. = 3.12. 7th Grade: n=144; Std. Dev. = 7.56. 8th Grade: n=91; Std. Dev. = 5.55.</p>	<p>85% chose the correct response. 15% said “I don’t know.”</p> <p>COE: n=53; Std. Dev. = 5.16.</p>	<p>100% of this sample identified the correct response.</p> <p>APS: n=8; Std. Dev. = 0.96.</p>

The remaining questions and results are graphically presented and discussed below individually, rather than combined and summarized in the tables above. This was done either because these results had more interesting graphical characteristics, and/or needed more detailed discussions for some reason. It is also worth noting that “best fit” answers are indicated on each graph with an arrow (arrows are absent on questions in which the answers are considered opinions or specific to an individual), in which correct definitions were obtained from online dictionary sources and cross-referenced with a Webster’s dictionary, when applicable. In addition, sampling numbers (n) for each survey sample, as well as standard deviation values for the samples (S) are displayed on each graph.

Lastly, the results and discussion of results for the K-8 preservice teachers and current science teachers were combined in one section for each graph. It is important to note, however, that the two samples are quite different. As previously discussed, the K-8 preservice teachers mostly have only had 12 college credit-hours of science, and only a few will be endorsing in science, whereas the current science teachers either have a degree in science, have had at least 24 college credit-hours of science, and/or have experience teaching a science curriculum.

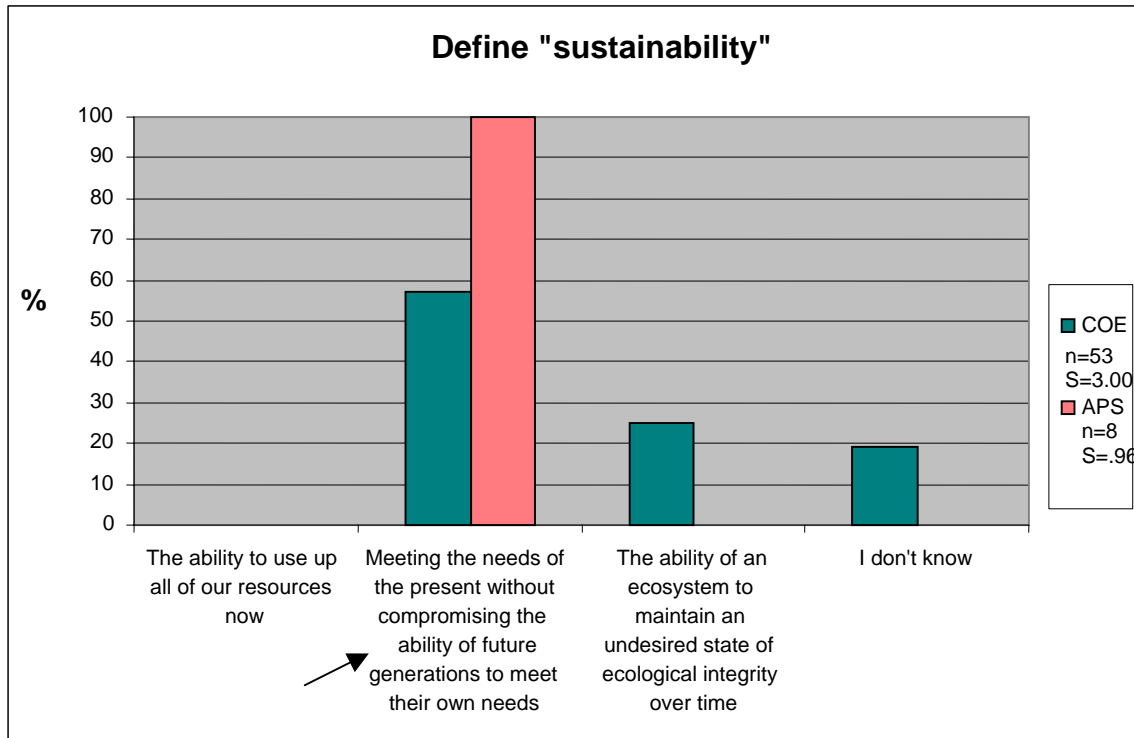
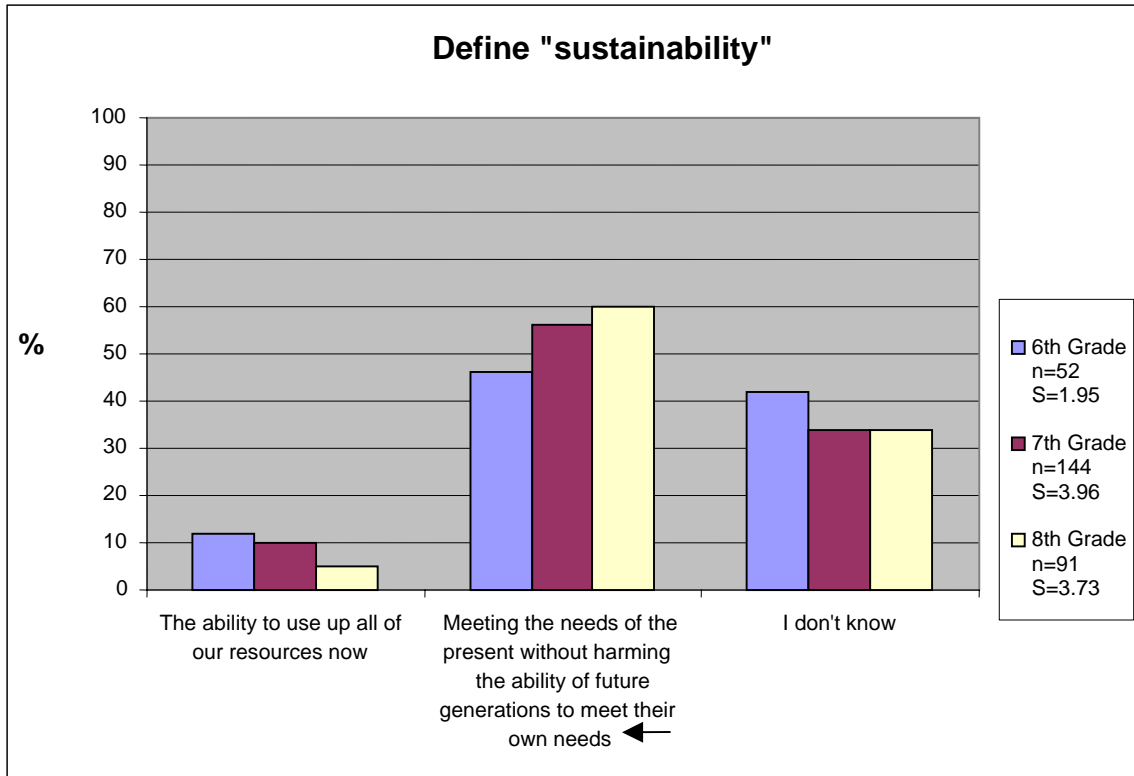


Students

Overall, a majority (more than 77%) of students think that states in the desert southwest like New Mexico have water-resources problems that need to be solved. Only 8% of students answered “No” to this question, and 14% responded with “I don’t know.” Student awareness of the state’s water-resources problems increases as grade level increases (the reason for this is unknown, but may simply be related to age factors). About two-thirds of sixth graders feel that the state has problems that need addressing. Over three-quarters of seventh graders agree, and an overwhelming population (almost 90%), of eighth graders concur.

Teachers (Preservice and Current)

This question was not presented to the K-8 preservice and current science teachers, as obvious results were anticipated, and thus considered unnecessary.

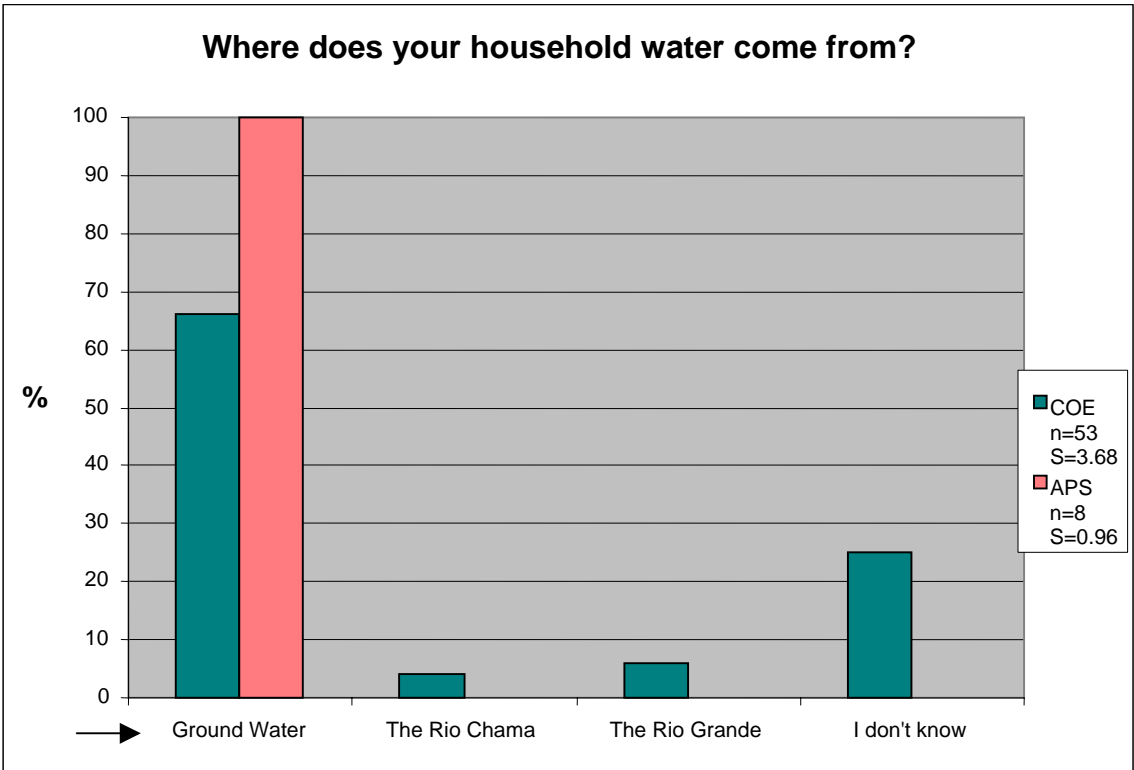
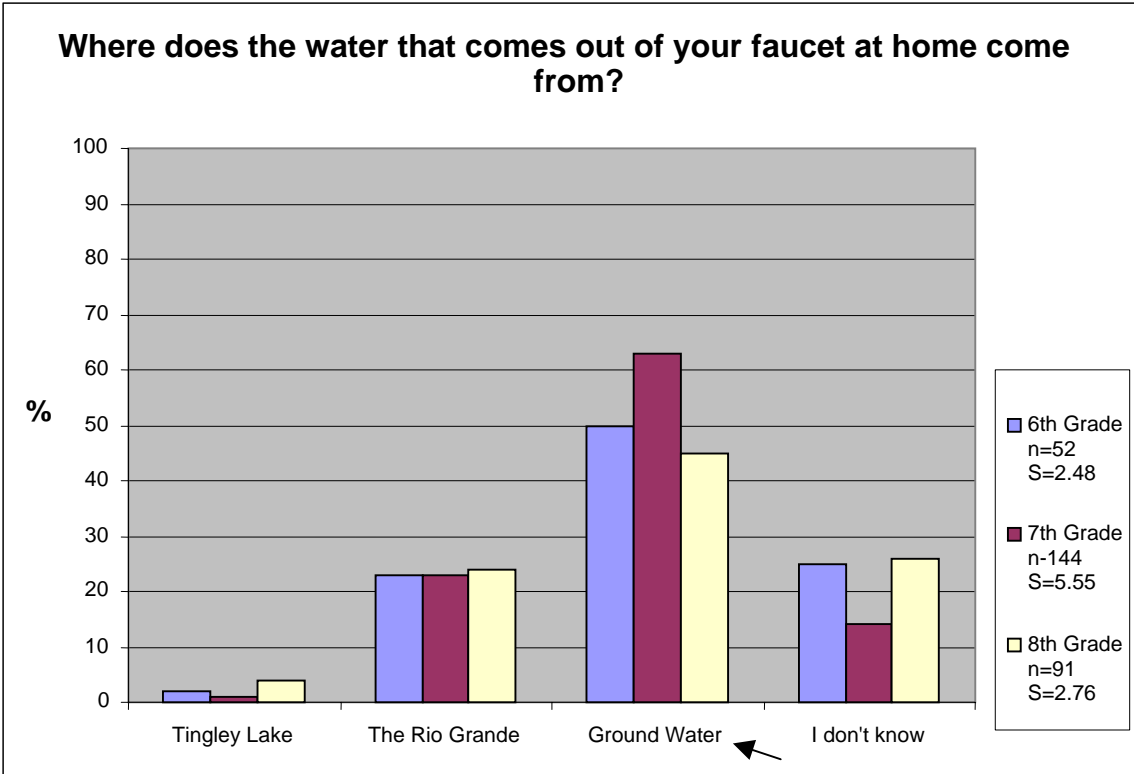


Students

For the most part, students chose the more appropriate response when asked to define “sustainability” in this question. On average, 54% of students defined it as “meeting the needs of the present without harming the ability of future generations to meet their own needs.” Alternatively, a fair majority (over 36%) indicated that they did not know. Again, the ability to correctly identify the proper definition of sustainability increases with grade level.

Teachers (Preservice and Current)

Over half (57%) of K-8 preservice teachers were able to correctly identify the best definition for “sustainability” in this question. On the other hand, a surprising one-quarter incorrectly chose “the ability of an ecosystem to maintain an *undesired* state of ecological integrity over time.” Another surprising result is that almost 20% (19%) of the COE students indicated that they do not know what sustainability is. On the other hand, all of the current science teachers surveyed know the definition of sustainability.



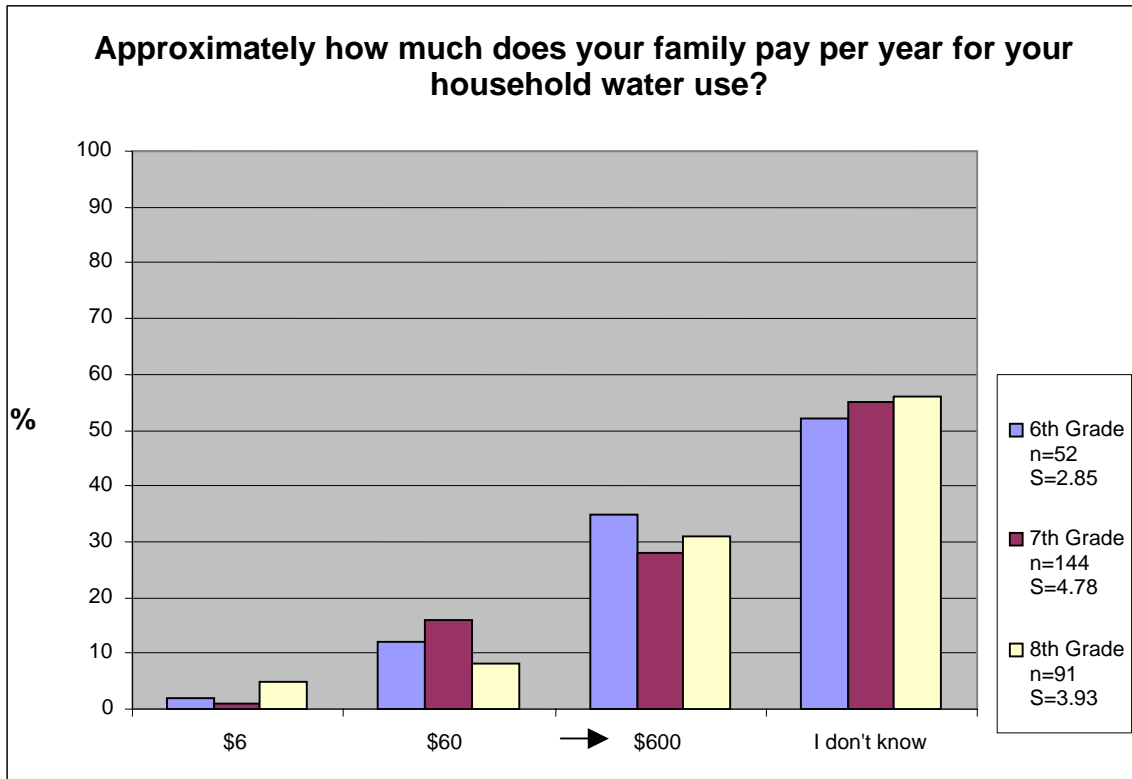
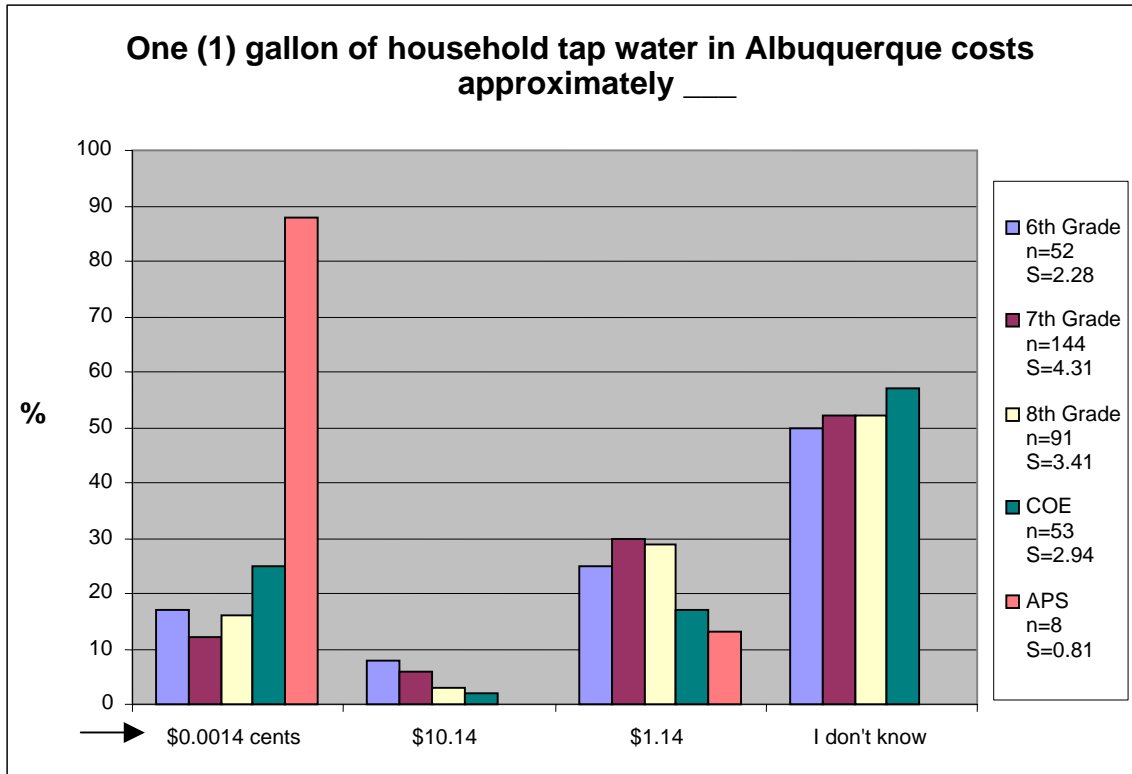
Students

Just over half (52%) of students correctly identified groundwater as the source of their household water. Almost one-quarter (around 24%) of surveyed students chose the option “the Rio Grande” as the answer to this question, and the remaining one-quarter of students (excluding seventh graders) said “I don’t know.” Dissecting this question and associated results reveals that seventh graders are more knowledgeable about where their water comes from. It is also interesting to note that almost exactly the same number of all grade levels identified the Rio Grande as their source of household water.

Recent, local efforts to filter and purify water from the Rio Grande for drinking and household purposes have been initiated. However, the project is in middle stages of development and had not officially begun at the time of surveying. This most likely does *not* account for such a large response to this part of the question, as discussion about this question after the surveying revealed that a majority of students were completely unaware that surface water is going to be a significant source of the city’s household water in the near future.

Teachers (Preservice and Current)

As expected, a larger percentage of the K-8 preservice teachers (66%) than students correctly identified groundwater as the source of their household water. On the other hand, a surprising one-quarter do not know where their household water comes from. Like the students, the K-8 preservice teachers incorrectly chose other sources of water. As previously stated, new surface-water projects involving the Rio Grande and the Rio Chama may have contributed to the minor confusion. Alternatively, 100% of the current science teachers surveyed know that groundwater supplies their household needs.



Students

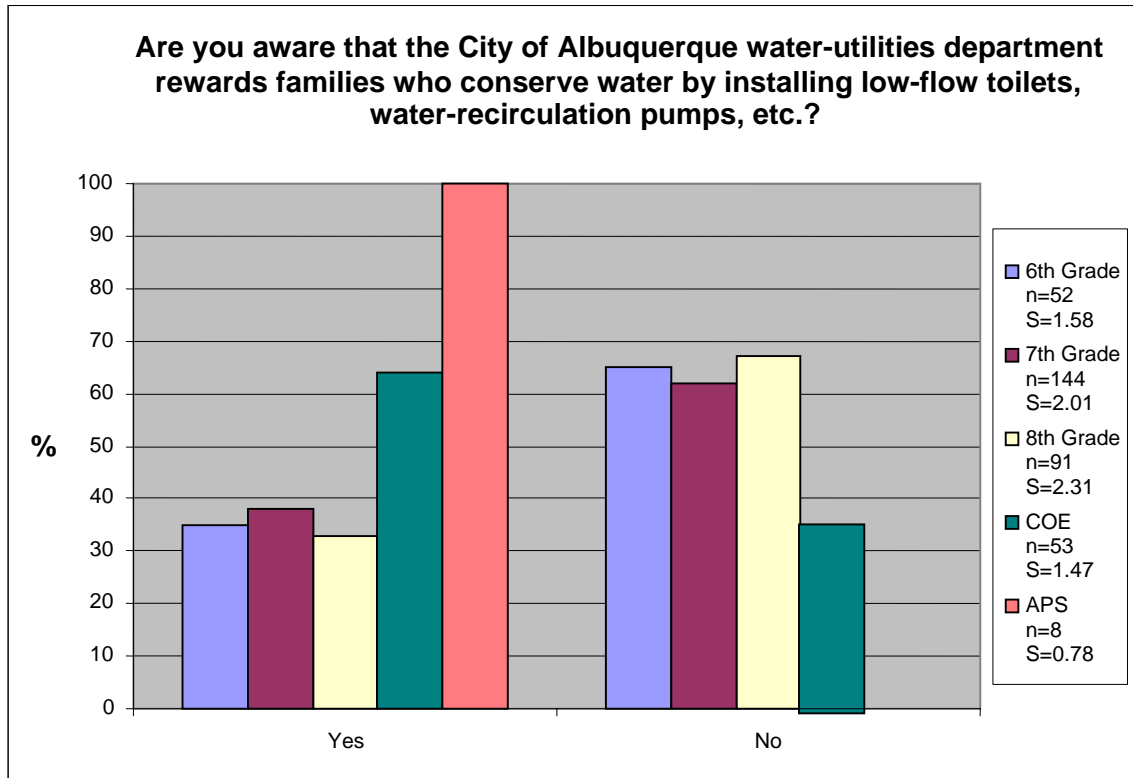
On average, half of students (51%) do not know how much municipal water costs in Albuquerque (which is understandable, since they do not pay the utility bills). Next to responding with “I don’t know” when asked “how much do your parents pay for one (1) gallon of tap water” for this question, 28% of students chose “\$1.14,” which is not the correct response (based on average, monthly-water usage for families, this value would yield a water bill of over \$6,000/month!). Next to responding with “I don’t know” when asked “how much does your family pay per year for your household water” for the question above, 31% of students chose “\$600,” which is the best-fit answer.

More specifically, all grade levels responded relatively equal with “I don’t know” for both questions relating to this topic. Correct answers to the two questions are \$0.0014 cents and \$600, respectively, and fewer seventh graders in comparison to sixth and eighth graders chose this option. The correct values associated with this question were calculated from a 2006 Albuquerque utility bill for a family of three, and are very conservative. Water costs as of this month are most likely significantly different, due to the fact that the Albuquerque-Bernalillo County Water Utility Authority calculates each residential account individually, based on certain commodity charges and surcharges that are tied to seasonal averages (www.cabq.gov/water).

Teachers (Preservice and Current)

Like most of the students, a majority of K-8 preservice teachers do not know how much their household water costs either (57%). One-quarter correctly identified the best response, and 17% chose “\$1.14,” which (as stated earlier) would add up to over \$6,000 per month, based on average rates obtained from the Albuquerque-Bernalillo County

Water Utility Authority. The adults do know, however, that one gallon of tap water does not cost over \$10, unlike some students. A clear majority (88%) of the current science teachers chose the best-fit answer to this question. The teacher samples were not questioned about the yearly cost of water, as it was considered unnecessary.

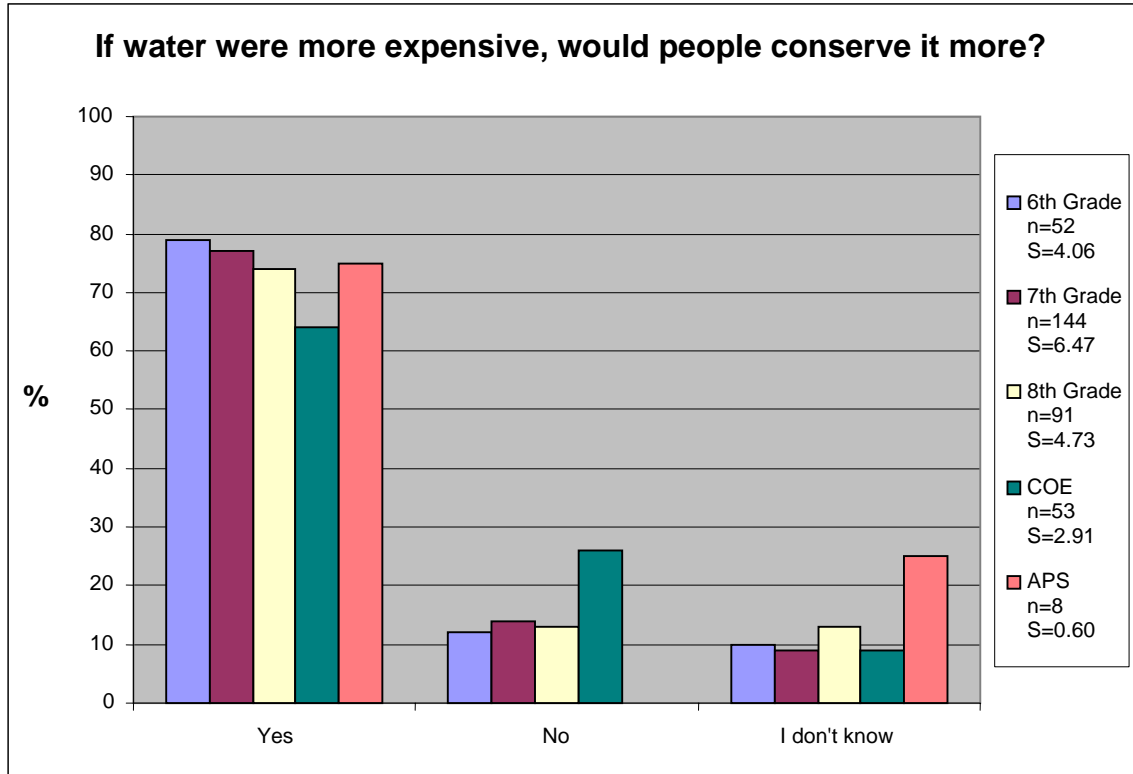


Students

This question asked students: “are you aware that the City of Albuquerque water-utilities department rewards families for conserving water (e.g. installing low-flow toilets, water recirculation pumps, etc.)?” Approximately 35% of students replied “Yes” and 65% said “No.” There were no particular grade-level specific data that emerged.

Teachers (Preservice and Current)

Most (64%) of the K-8 preservice teachers are aware that the City of Albuquerque rewards families for conserving water, and 36% are unaware. In comparison, all of the current science teachers are aware of the issue.



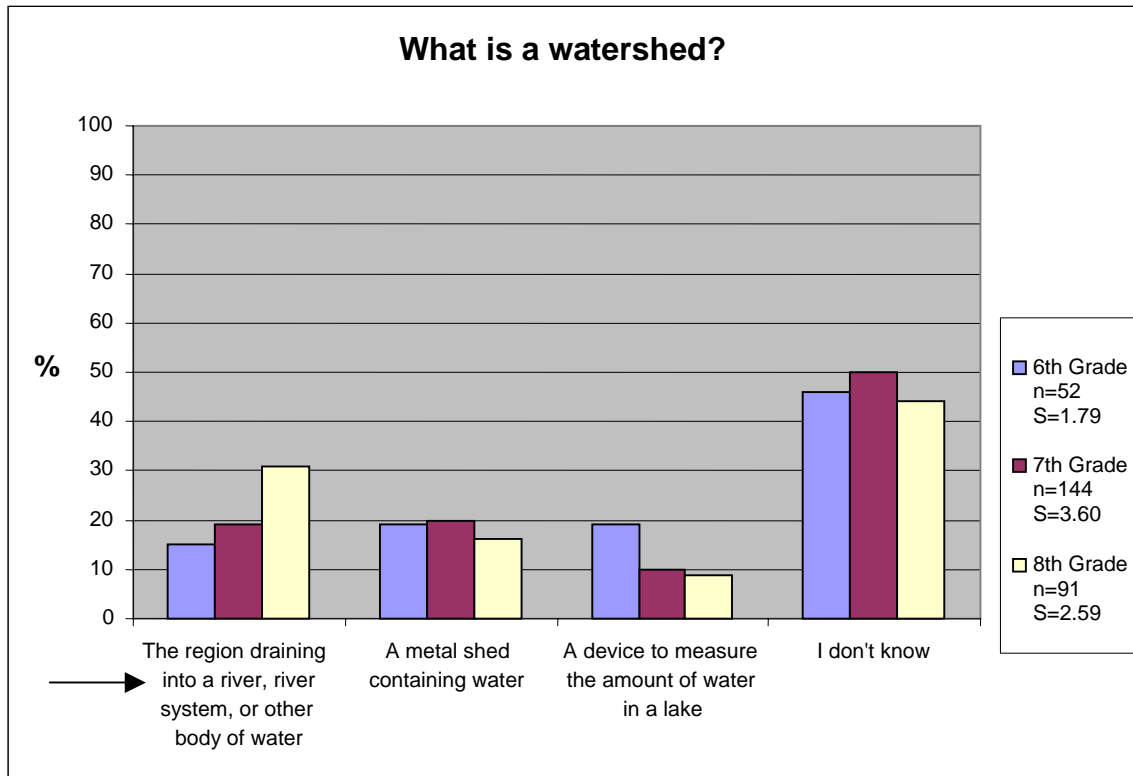
Students

Overall, more than three-quarters (76%) of students think that if water were more expensive, people would conserve it more, as worded in this question. Comparatively, 13% said “No” and 11% said “I don’t know.” The distribution of graphical results for this question is relatively equal for all grade levels.

Teachers (Preservice and Current)

K-8 preservice teachers have different views on this subject matter. This particular population sample has a higher percentage (26%) of respondents that feel that if water cost more, people would *not* conserve it more. Approximately the same

percentage (25%) of respondents from the current science teachers population sample simply said “I don’t know.”

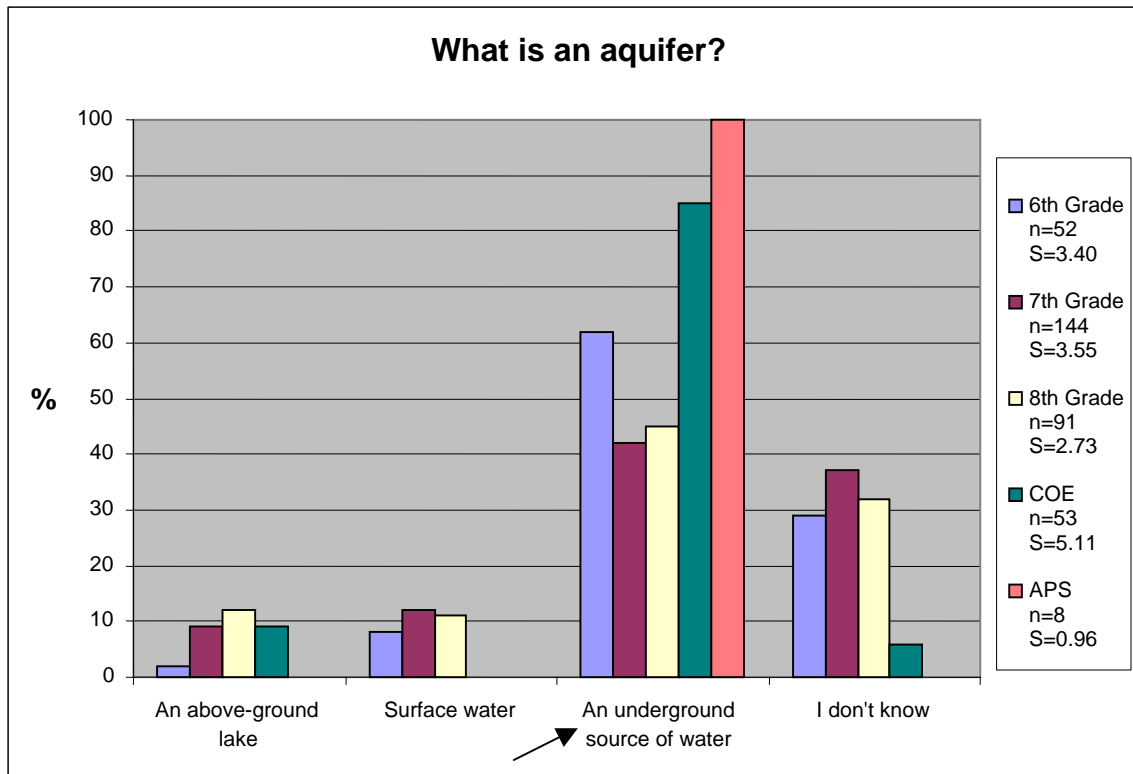


Students

When asked to define a “watershed,” only about 22% of students on average could correctly identify the answer, “the region draining into a river, river system, or other body of water.” Approximately 18% said it was a “metal shed containing water;” 13% said it was a “device to measure the amount of water in a lake;” and a majority (47%) said “I don’t know.” As observed in some previous data sets, the ability to correctly identify the answer increases as students go up in grade level.

Teachers (Preservice and Current)

Overall, both the K-8 preservice and current science teachers demonstrated a sound grasp on the definition of a watershed, and thus the need to display the results graphically was deemed unnecessary.



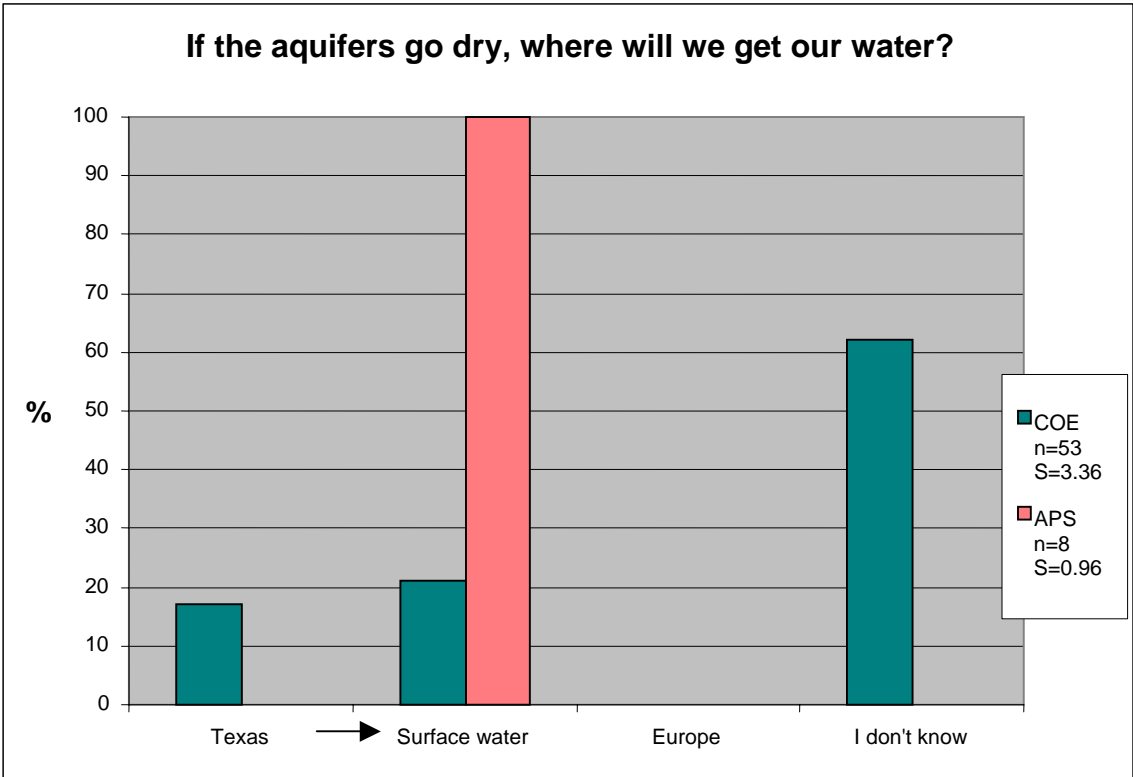
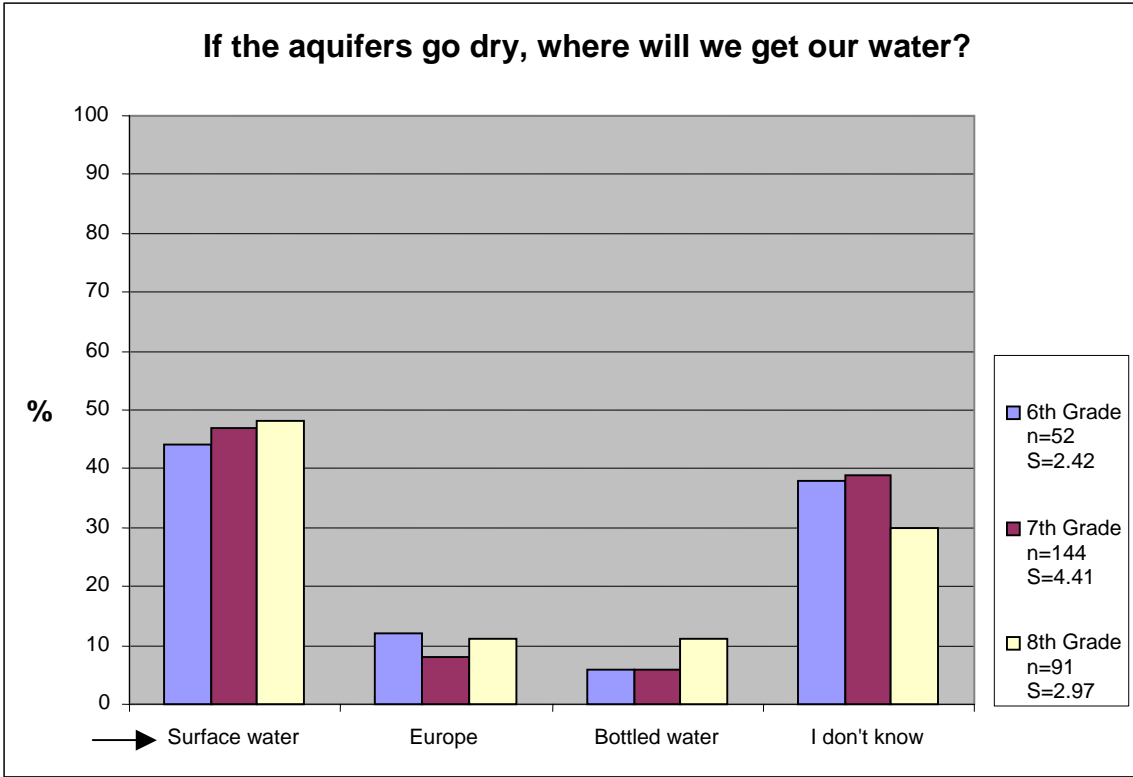
Students

With the exception of the sixth-grade students, only about 44% of the remaining students correctly defined an aquifer as an underground source of water (the sixth-grade data set was eliminated from this calculation, as it is considered an outlier). A third, or 33% of students, responded to this question with “I don’t know.”

Of the sixth-grade population, over 60% chose the right answer to this question. This increase compared to the seventh and eighth graders may be attributed to the fact that the sixth-grade science classes at the middle school are earth science.

Teachers (Preservice and Current)

Both the K-8 preservice and current science teachers know what an aquifer. More specifically, 85% of the COE students and 100% of the APS science teachers identified the correct answer.

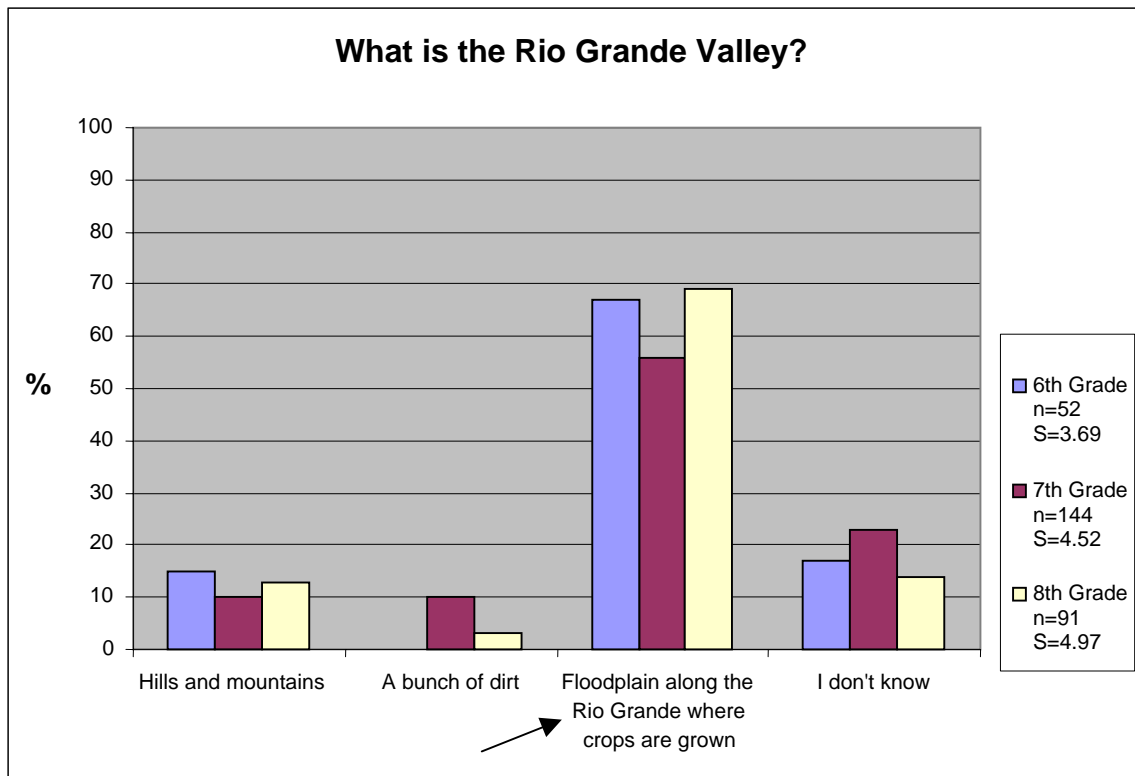


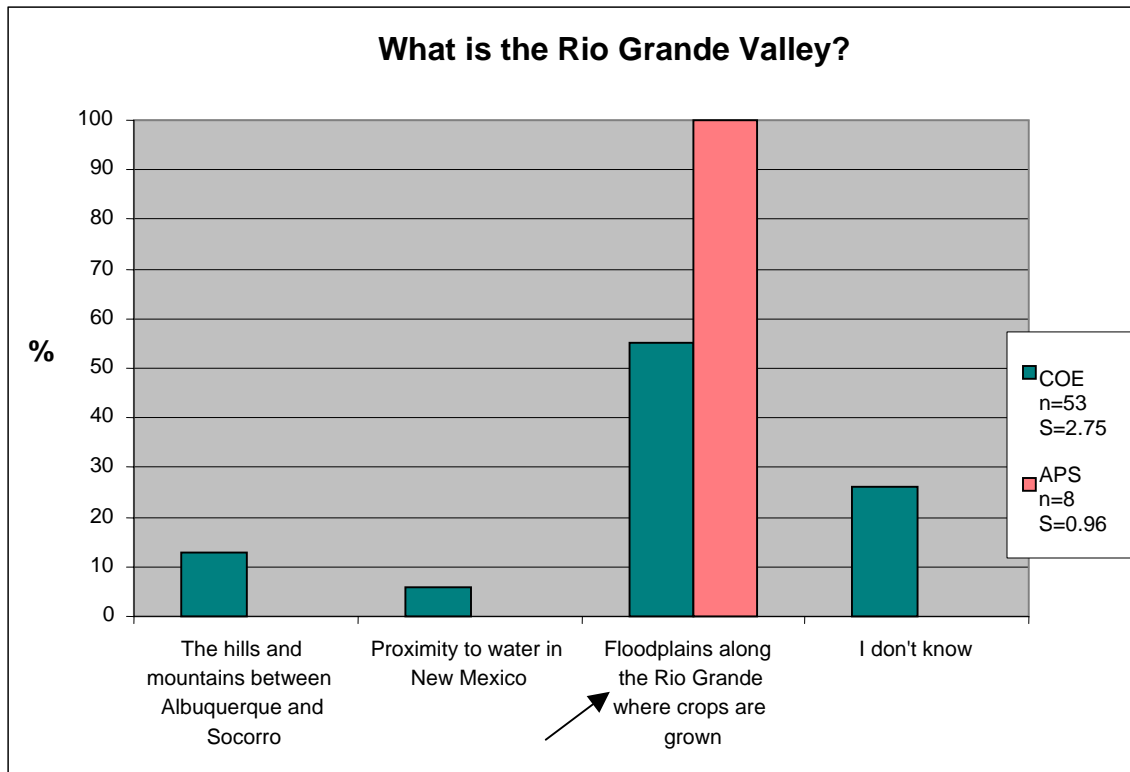
Students

The two most popular responses to the question, “if the aquifers go dry, where will we get our water?” were “surface water” at 46%, and “I don’t know” at 36%. The ability to correctly identify this response increases with grade level.

Teachers (Preservice and Current)

Only 21% of the K-8 preservice teachers correctly identified “surface water” as the city’s source of water if the aquifer is depleted, and 62% of this sample responded with “I don’t know.” On the other hand, all of the current science teachers were able to choose the best-fit answer.



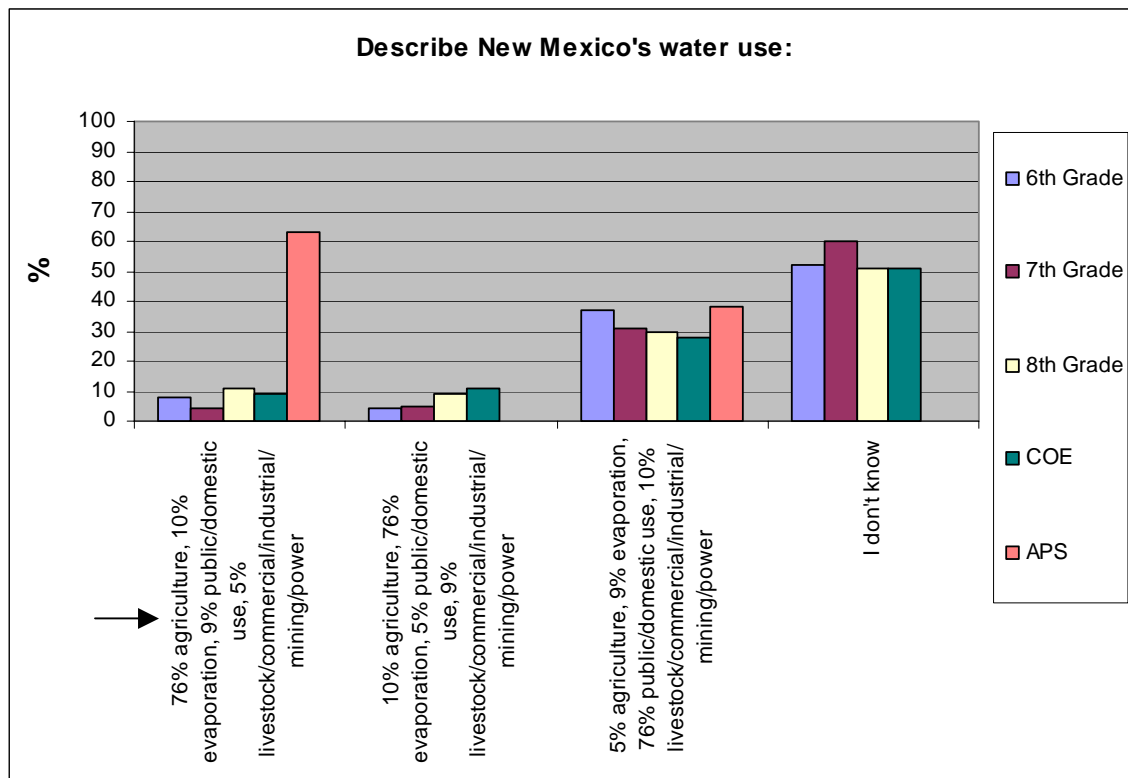


Students

Almost two-thirds (64%) chose “floodplain along the Rio Grande where crops are grown” when asked to define the Rio Grande Valley in the above question. More seventh graders were unsure about this question than any other grade level.

Teachers (Preservice and Current)

Over half (55%) of the K-8 preservice teachers (i.e. COE students) know what the Rio Grande Valley is, and over one-quarter (26%) indicated that they don’t know. More students answered it correctly, most likely because this question was worded more simply for students than it was for adults. Alternatively, 100% of the current science teachers know what the Rio Grande Valley is.

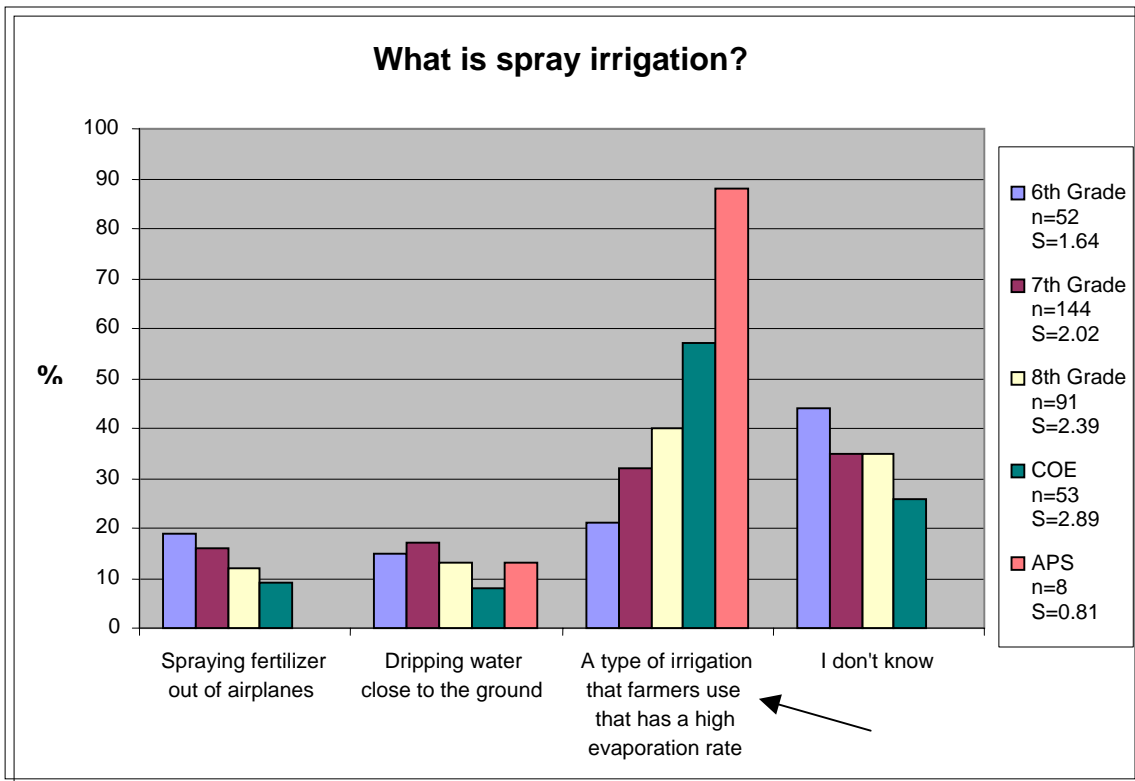


Students

Overall, more than half (54%) of students were unable to describe New Mexico’s water use, as worded in this question. The second most popular (but incorrect) answer to this question was the following: 5% agriculture, 9% evaporation, 76% public/domestic use, 10% livestock/commercial/industrial/mining/power. There are no specific grade level data that stand out on this issue.

Teachers (Preservice and Current)

Over half (51%) of the K-8 preservice teachers were unable to describe New Mexico’s water use (only 9% chose the best-fit response described above). Comparatively, two-thirds (63%) of the APS science teachers were able to correctly answer this question. Information on the breakdown of New Mexico’s water use by sector (indicated with an arrow on the above graph) was obtained from the New Mexico Office of the State Engineer (<http://www.ose.state.nm.us>).



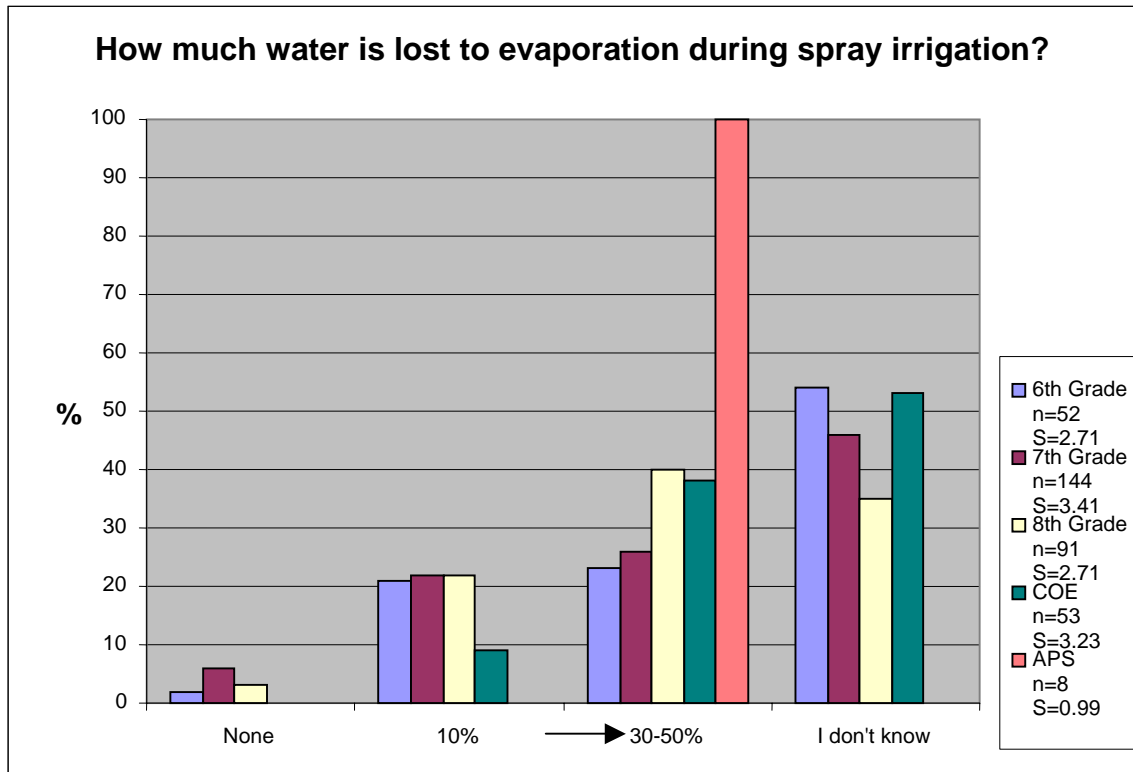
Students

Students had a difficult time choosing the right answer to the question, “What is spray irrigation?”. On average, just over 30% of students chose the correct response, “a type of irrigation that farmers use that has a high evaporation rate,” which increases with grade level. More students (38% overall) responded with “I don’t know.” The remaining approximately 30% of students incorrectly chose either “spraying fertilizer out of airplanes” or “dripping water close to the ground.”

Teachers (Preservice and Current)

57% of the K-8 preservice teachers chose the best-fit response to this question, with more than one-quarter (26%) responding with “I don’t know,” which was a little surprising. Another surprising result was that one of the current science teachers surveyed indicated that spray irrigation is dripping water close to the ground, which is

incorrect. But, for the most part, the current science teachers have a good grasp on the definition of spray irrigation (88% answered this question correctly).

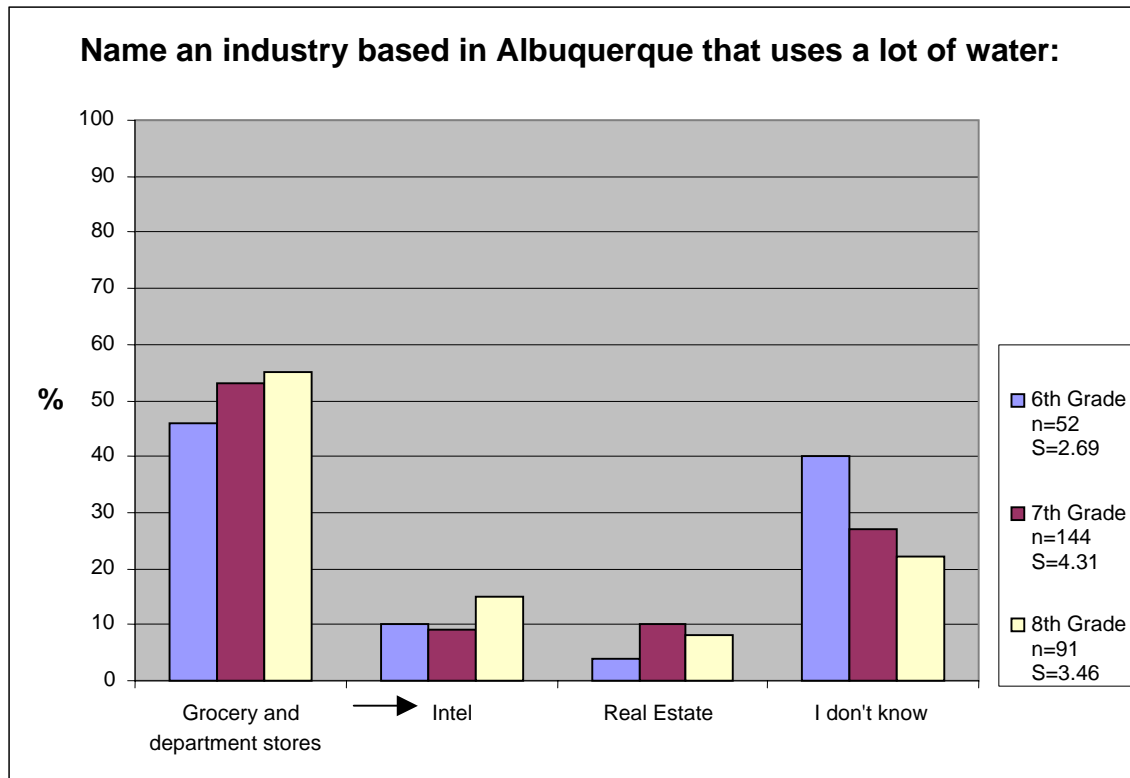


Students

The most popular response to the question: “How much water is lost to evaporation during spray irrigation?” was “I don’t know” with 45%. Just 30% of students on average chose the more appropriate answer “30-50%.” On an individual grade-level basis, significantly more eighth graders were able to correctly identify the answer compared to sixth and seventh graders. In addition, more sixth and seventh graders, in comparison to eighth graders, were unsure about this question.

Teachers (Preservice and Current)

Like the students, most (53%) of the K-8 preservice teachers (i.e. COE students) do not know how much water is lost to evaporation during spray irrigation. On the other hand, all of the current science teachers chose the most appropriate answer.

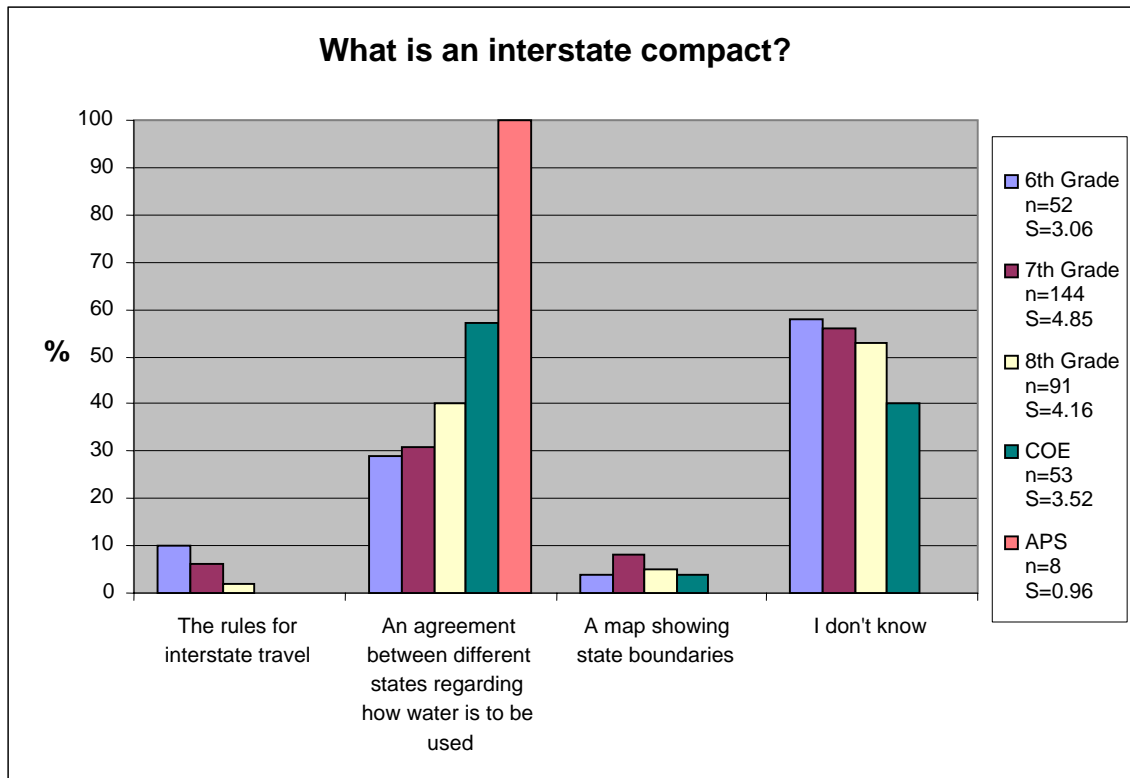


Students

On average, students were unable to identify an industry in Albuquerque that uses a lot of water, as stated in the above question. Over half (51%) of students are under the misconception that grocery and department stores use more water than Intel, which is the more appropriate answer. The second-most popular answer to this question was “I don’t know,” in which approximately 30% of students responded with. With regard to the best answer, Intel, more eighth graders than sixth and seventh graders, chose this option.

Teachers (Preservice and Current)

This question was not presented to these population samples, as obvious results were anticipated, and hence considered unnecessary.

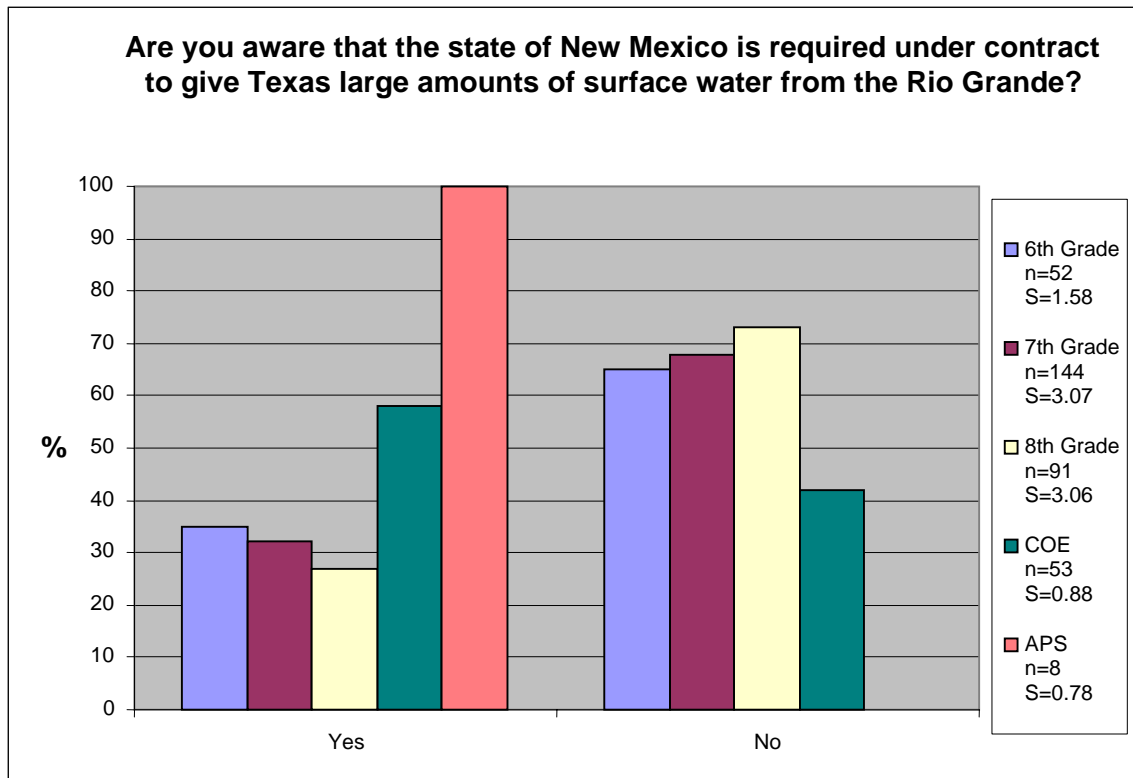


Students

Students (almost 56%) do not know what an interstate compact is, as solicited from them in the question above. Only a third of the entire student population was able to identify the correct answer, “an agreement between different states regarding how water is to be used,” and this phenomenon increases as students get older.

Teachers (Preservice and Current)

In comparison, most of the COE population sample (57%) does know the definition of an interstate compact, but 40% chose the option “I don’t know.” The entire APS population sample answered this question correctly.

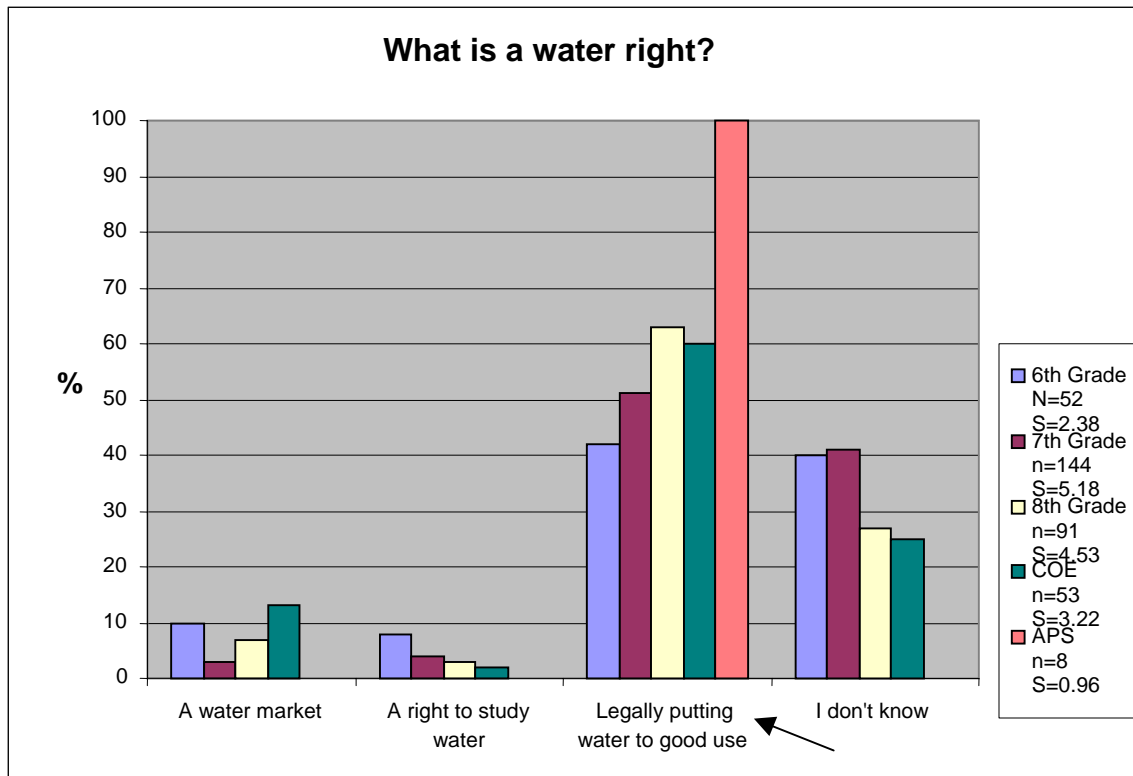


Students

The clear majority (69%) of students are unaware that the state of New Mexico is required under contract to give Texas large amounts of water from the Rio Grande. The graphical distribution with regard to this response increases with grade level. In comparison, the graphical distribution with regard to the answer “yes” to this question, decreases as grade level increases (i.e. more sixth and seventh graders answered “yes” than eighth graders).

Teachers (Preservice and Current)

The K-8 preservice teachers’ answers were more evenly split than the students’. 58% of this sample is aware that New Mexico gives Texas water, and 42% is unaware. Alternatively, 100% of the current science teachers are aware of New Mexico’s obligation to Texas.



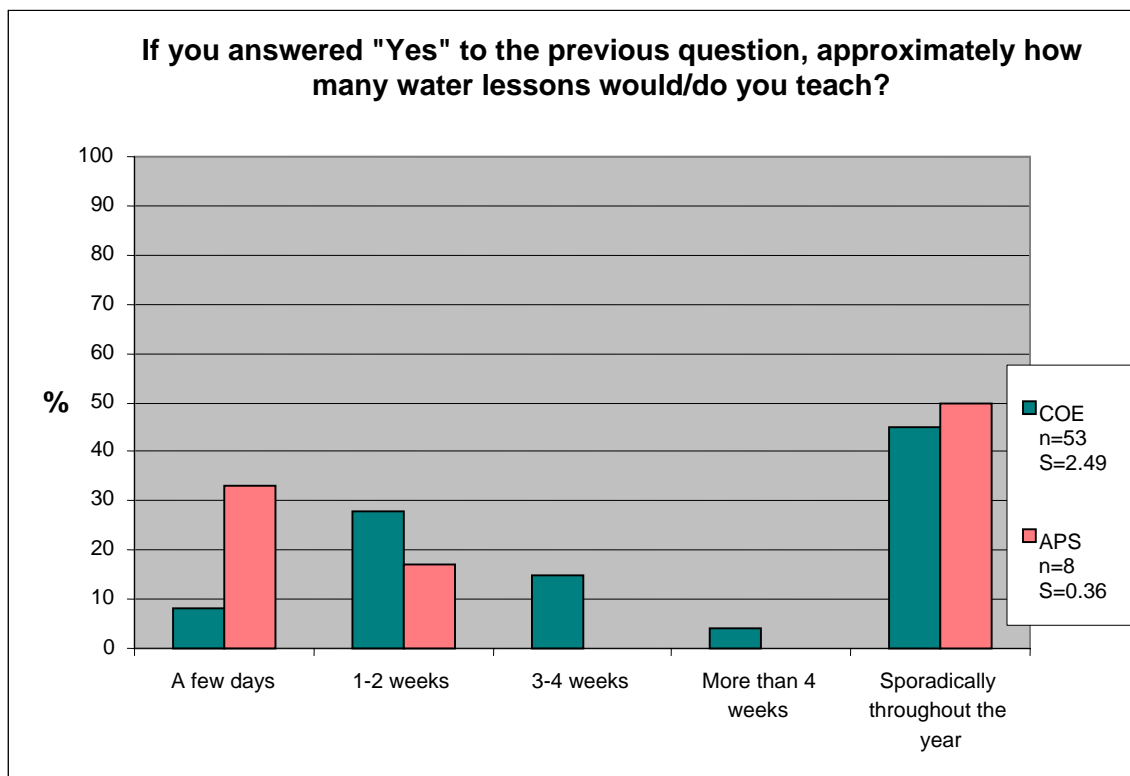
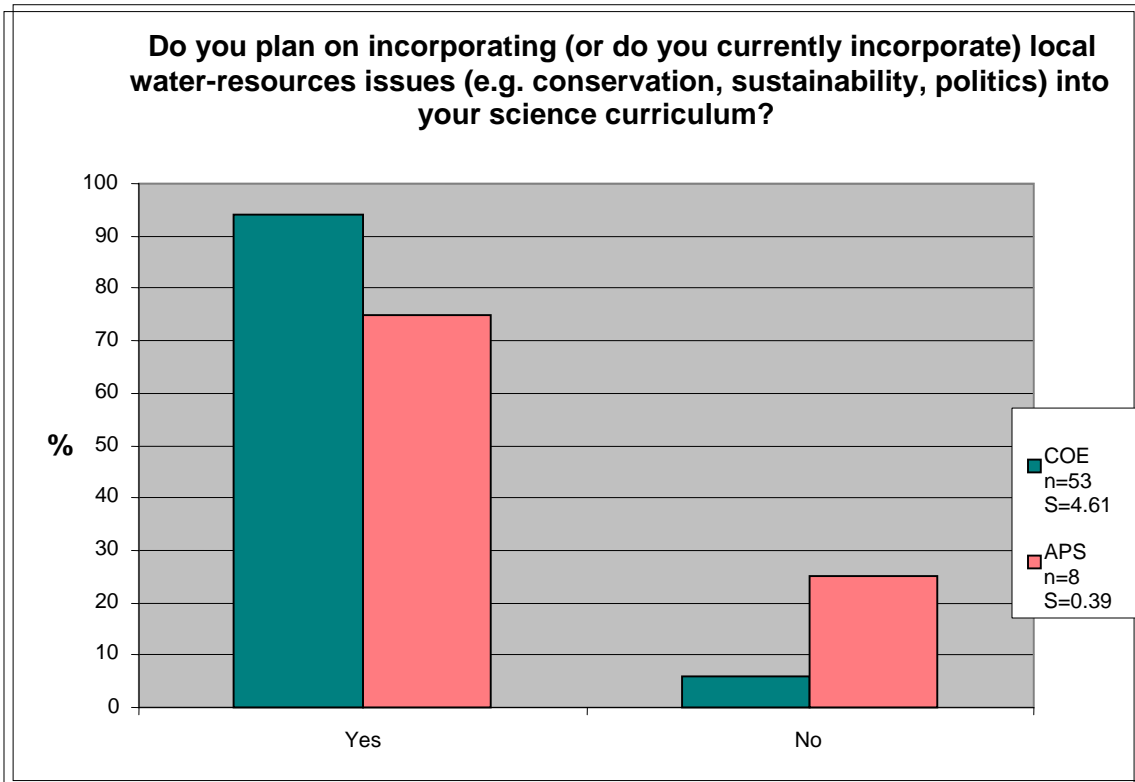
Students

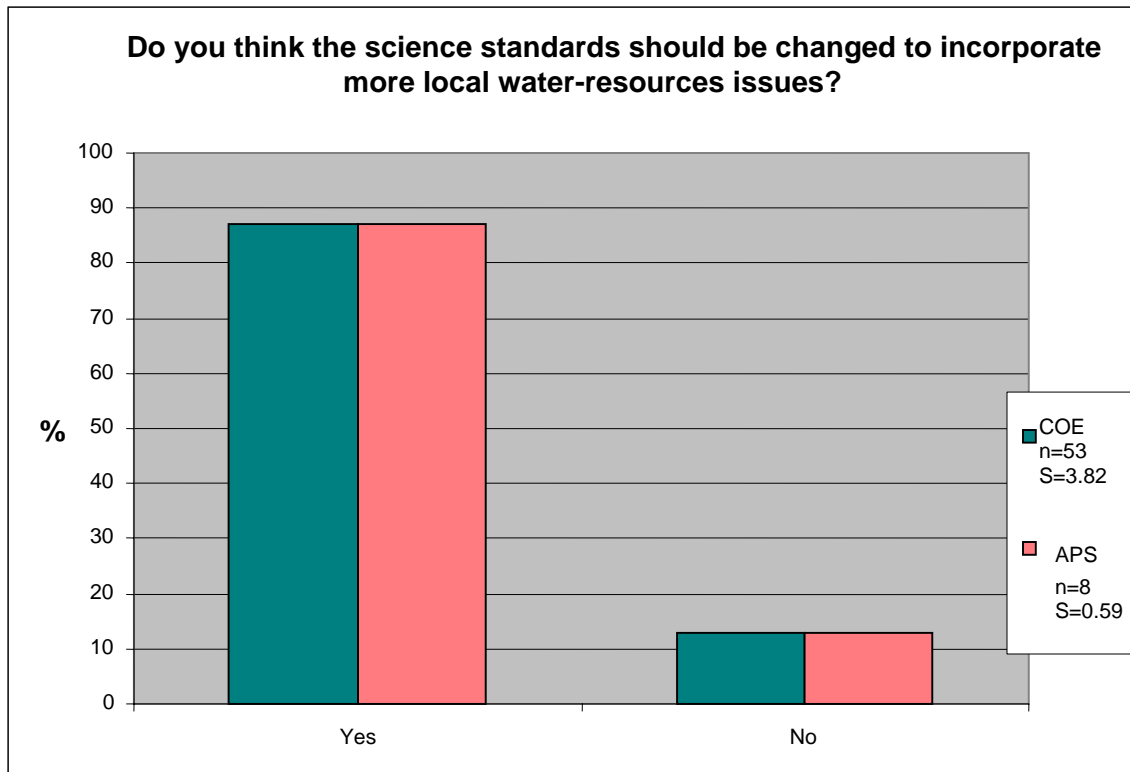
When asked to define a water right for this question, just over half of students (52% on average) were able to correctly identify “legally putting water to good use” as the proper definition. In comparison, 36% of students do not know the definition of a water right. The ability to correctly identify the definition increases with grade level, as expected.

Teachers (Preservice and Current)

For the most part, K-8 preservice teachers have a good grasp of what a water right is (60% chose the answer that fits best), but one-quarter of this population responded with “I don’t know.” Again, the current science teachers have an even better grasp on the subject (all of them got this question right).

Teacher-specific Data





Data specific to the two teaching population samples, K-8 preservice (i.e. COE students) and current (i.e. APS science teachers) indicate several key things. First, these teachers either plan on incorporating (or already do incorporate) local water-resources issues into their science curriculums. Secondly, a majority for both sets of teachers (87%) believe that the state science standards should be changed to incorporate more local water-resources issues.

CONCLUSIONS

The purpose of this study is to quantify the basic water knowledge of middle-school (MS) students, K-8 preservice teachers, and current MS science teachers in Albuquerque, New Mexico, as this part of the country deals with sensitive water-resources issues that typify life in the desert southwest. As a result, the city's future water situation may rest on the shoulders of today's youth, and a significant source of this information is the science classroom.

This study presents the results from a thirty (30)-item questionnaire administered to the populations previously described. Although a majority of students have some understanding of most of the water-resources concepts, they lack some critical knowledge. As expected, their knowledge increases with grade level. Based on the survey results, certain water concepts were associated with one or more of the following characteristics: low percentages associated with the correct answers, high percentages associated with the incorrect answers, high percentages for the response “I don’t know,” or mixed results, indicating possibly some sort of misunderstanding. Based on this research, students in New Mexico should know at least the following concepts about water before moving on to high school, so they can make better-informed decisions regarding their own water use:

1. What sustainability is and how it relates to their community.
2. That their household water comes from a finite, underground source, and since this source is being depleted relatively quickly, their future water source will be from the city’s surface-water locality, the Rio Grande.
3. That their household water costs only pennies a day.
4. The definition of a watershed.
5. The definition of an aquifer.
6. The breakdown of New Mexico’s water use by sector (i.e. that over three-quarters of the state’s water sources combined goes toward irrigation and agriculture).
7. What “spray irrigation” is and how much water is lost to evaporation during this particular method.
8. The definition of a water right.
9. What the Rio Grande Compact is and what it means for New Mexico.
10. What industries in Albuquerque (e.g. Intel) use the most water.

Most of the current APS science teachers (~75%) indicated on their questionnaires that they incorporate water-resources issues (in general) into their curriculum, but the specific issues were not defined. Therefore, the primary underlying cause of students’ performance with regard to the ten critical concepts discussed above is unknown. It is possible that teachers don’t spend enough time on the concepts (student deficiencies may result from the condensed lessons on water resources that typify local

education), or that students aren't paying enough attention. Alternatively, it is possible that some of these concepts are not being covered at all. In other words, if the teachers are sticking to the state standards with regard to local water-resources issues, which states "describe the contributions of science to understanding local or current issues (e.g., watershed and community decisions regarding water use)" (Albuquerque Public Schools, 2006), then some of these critical issues specific to Albuquerque might get overlooked. As a majority of the two teacher samples indicated, maybe the state standards should be changed to include some of these important concepts.

On the other hand, the K-8 preservice teachers have a decent grasp, and the current science teachers, have an excellent grasp, on a majority of the water-resources concepts they were questioned on, with the current science teachers possessing the most knowledge of the subject matter. The cause for these differences in knowledge between the two teaching samples is unknown, but some possibilities are discussed in the Future Work section below.

Determining student and teacher understanding of local water resources provides a reference for the preparedness of our future population. Subjects of this study had assumptions about water resources that were surprising, yet perfect abstractions of recorded misconceptions shown beyond the middle school population. The water-related needs of the future require a foundation of well-educated youth today, and this education needs to begin on the middle-school level (and preferably in elementary school), so that high-school students have a sound, working knowledge of our precious, finite resource - water.

Limitations of Study

Small sample sizes are considered a limitation to this study, because they do not represent the basic water knowledge of the actual populations very well. Also, the location of the study site (urban) might yield different survey results than a rural study site, for example. Secondly, the multiple-choice format of the survey questions may have also been a limiting factor in this study, as there are some well-known weaknesses with the multiple-choice format. According to Ballantyne, 2004, the strengths and weaknesses of multiple-choice tests are discussed below. The principal strengths of multiple-choice tests are: 1) They test a wide range of issues in a short time; 2) Assessment is not affected by a student's ability to write; 3) They can be reliably marked as all answers are predetermined.

The principal weaknesses of multiple-choice tests are: 1) They do not test the student's ability to develop and organize ideas and present them in a coherent argument; 2) Restrictions are placed on the student's answers as they must select from the test developer's alternatives; 3) Guessing may result (but plausible distractors will result in intelligent guessing); 4) Questions need to be pre-tested and items reviewed to ensure the validity of the items.

In addition, some of the questions were worded in such a way that ultimately led to: guiding participants toward the correct answer, possibly some minor confusion, and a generalization of data.

RECOMMENDATIONS

Curriculum Development

With students' basic water knowledge defined, and with the help of education resources, a water-resources curriculum that addresses students' deficiencies could be

developed. The following discusses examples of ideas that could be brought into the classroom to deal with each of these deficiencies.

To teach students about sustainability, past, present, and future population data for Albuquerque could be evaluated, and a sustainability model could even be integrated into the classroom. To teach students about where their water comes from, how much it costs, and where they might get their water in the future, collaboration with the City of Albuquerque water conservation program might be effective. They have an education department that works with schools to provide guest speakers armed with ample resources (more information can be found at www.cabq.gov).

A curriculum developed to teach students about watersheds could include a comprehensive, hands-on watershed monitoring project for example, like East Mountain High School outside of Albuquerque has done. Kerri Lathrop and her science students run the San Pedro Creek Watershed Watch Program, in collaboration with New Mexico Watershed Watch (NMWW), an educational program that takes the watershed ecosystem approach to environmental education.

The NMWW program provides teachers with instruction in methods for applying student learning to an actual, on-going monitoring effort using state-of-the-art equipment and techniques, and is a wonderful resource for science teachers (New Mexico Department of Game and Fish, 2000). The NMWW program has excellent ratings by participating teachers, as well as significant, documented academic improvement associated with the students that participated (Fleming, 2003).

Also, the New Mexico Project WET (Water Education for Teachers), sponsored by WERC, A Consortium for Environmental Education and Technology Development, is a nationally-developed, K-12 environmental education program which utilizes water as

its theme. Project WET is designed for delivery to formal and informal teachers, involving lab exercises and activities that are designed to be utilized as a supplement to existing classroom curricula. The core Project WET Curriculum and Activity Guide is a collection of more than 90 innovative, interdisciplinary activities that are hands-on, easy to use and fun, that deal with topics on conserving water, water quality, and discovering and managing watersheds (WERC, 2006). More information can be found at www.werc.net.

To teach students about the definition of an aquifer, one could use *The Water Sourcebooks*, an education resource-kit put together by the Environmental Protection Agency (EPA), which explains the water-management cycle using a balanced approach showing how it affects all aspects of the environment, including groundwater. All activities contain hands-on investigations, fact sheets, reference materials, and a glossary of terms (Environmental Protection Agency, 2006).

Lessons to teach students about how New Mexico's water is divided up between different uses; what "spray irrigation" is and how much water is lost to evaporation during this particular method; the definition of a water right; what the Rio Grande Compact is; and what industries in Albuquerque use the most water, could include guest lectures from farmers, hydrologists, representatives from the Office of the State Engineer water rights department, and industry specialists.

The following is a list of recommendations that could be utilized to maximize water-resources curriculum development efforts:

- The unit should focus on basic water knowledge and local issues, and should utilize numerous hands-on activities, inside the classroom and outside.
- The curriculum could be spread out over the course of a school year (like in the

case for a watershed-monitoring program), or could just be manifested in a short unit (approximately two weeks) that could be taught after the water-cycle unit in earth-science classes.

- If not participating in a watershed-monitoring program, one or two all-day field trips should be scheduled during the unit to maximize effectiveness of the information being presented.
- To assess student progress, as well as to determine effectiveness of teaching methods throughout the proposed water-resources unit, pre-testing and post-testing assessment methods should be used.
 - Pre and post-tests should be developed with the lesson plans and should be given at appropriate times.

Lastly, the following is a list of additional resources that could be utilized to maximize water-resources curriculum development efforts:

- North American Association for Environmental Education (NAAEE) guidelines for good and effective curriculum (www.naaee.org).
- Acorn Naturalists (www.acornnaturalists.com) (provides resources, materials, and supplies for science/nature lessons inside and outside of the classroom).
- Resources for science teachers to increase their own basic, background water knowledge:
 - The Water Atlas, A Unique Visual Analysis of the World's Most Critical Resource by Robin Clarke and Jannet King.
 - Watersheds, A Practical Handbook for Healthy Water by Clive Dobson and Gregor Gilpin Beck

FUTURE WORK

Ideally, larger samples of all of the studied populations (students, K-8 preservice teachers, and current science teachers) should be obtained, to minimize sampling error and maximize the results. But most importantly, significantly more current, APS science teachers should be surveyed to get a better idea of their basic water knowledge, as this study did not obtain a large enough sample to represent the data as accurately as possible.

[0] The cause in differences of knowledge between the K-8 preservice teachers and the current science teachers is unclear, and warrants further investigation. It would be interesting to find out if more water education needs to be addressed at the COE level, or if teachers in the classroom have more general knowledge in this content area for any particular reason. Again, possibly a larger sampling of APS and COE teachers would impact the data.

In addition, it would be interesting to find out how many middle-school teachers include the fifth grade standards displayed in Table 1 into their science classes, or if they just focus on the sixth through eighth grade requirements, expecting the fifth graders to have learned the concepts covered by the fifth grade standards, prior to entering science classes at the middle-school level. Alternatively, if the middle-school teachers are covering the entire earth-science section of the state standards, 5-8, then this might be valuable information to consider when evaluating any future data. Future work might also warrant finding out *how* teachers teach about water resources. This could also include a more in-depth literature review to determine what exactly works in environmental education.

Furthermore, it might be worth determining exactly what the elementary schools that feed into the study site, and other middle schools in Albuquerque, are teaching with

regard to water. If they are addressing their science standards in this area, then students should be coming into middle school with some prior knowledge on water and associated issues.

Lastly, a more refined survey with additional questions might provide even more, useful information. For example, it would be interesting to find out where students learned about certain local water-resources issues and what lessons/activities *they* think are most effective.

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Appendix A

**Survey Format Administered to
Current Science Teachers and K-8 Preservice Teachers**

Appendix B

Survey Format Administered to Middle-School Students

Appendix C

Survey Data and Graphs – EXCEL Spreadsheets