CRITICAL WATER RELATED CURRICULUM NEEDS AS PERCEIVED BY AGRICULTURAL SCIENCE TEACHERS IN PROGRAMS LOCATED WITHIN THE BOUNDARIES OF THE OGALLALA AQUIFER

Danielle Cox, Agricultural Science Instructor
Riverside High School
David E. Lawver, Professor
Matt Baker, Professor
David Doerfert, Associate Professor
Texas Tech University

Abstract

This study is part of a larger project pertaining to water related curriculum in agricultural science programs located in areas that are dependent upon the Ogallala Aquifer. Portions of South Dakota, Nebraska, Wyoming, Kansas, Colorado, Oklahoma, New Mexico, and Texas were included in the study. This study sought to determine critical needs in curriculum and professional development related to teaching water related topics. Forty-five topics, as identified in the literature, comprising four factors were presented to 356 agricultural science teachers to determine perceived importance and the degree to which the topics were included in their programs. Using Witkin's (1984) need assessment matrix analysis, three topics were found to be critical needs, one topic was found to be a low-level successful ability, 18 were found to be low-level needs, and 23 were found to be high-level successful abilities. Recommendations concerning practice and future research were made as a result of this study.

Introduction

The Ogallala Aquifer

The Ogallala Aquifer was named in 1898 after Ogallala, Nebraska, a town which is located above the aquifer (North Plains Groundwater District, n.d.). The Ogallala Aquifer is one of the largest aquifers in the country and began developing over one million years ago. The Ogallala covers approximately 200,000 square miles in the eight states of South Dakota, Nebraska, Wyoming, Kansas, Colorado, Oklahoma, New Mexico, and Texas. The Ogallala Aquifer is the primary water source to more than two million people, many of whom make their living from the agricultural economy. Over 170,000 wells tap into the Ogallala Aquifer (McCray, 1982). This water is used to irrigate corn, cotton, sorghum, alfalfa, wheat, peanuts, milo, sugar beets, and soybeans (McCray, 1982). "The total farm value of crops produced on the irrigated acreage of the Ogallala area is now in excess of $2 billion annually, or 10 percent of the U.S. value of the crops," states Dr. Herbert W. Grubb (McCray, 1982, p. 54). In addition to crops, the aquifer also serves as a necessity to millions of head of livestock in eight different states. Approximately 40 % of United States beef production comes from the High Plains area, beef that is fattened on grain irrigated with Ogallala water (Bittinger, 1981).

Experts now estimate that 11% of the Ogallala Aquifer has been pumped since the 1930s and 25% of its once vast reserves will be gone by the year 2020 (Lewis, 1990). With low natural recharge rates and dramatic increases in the use of groundwater throughout the region, declining water levels were noticed in parts of the region as early as the 1940s and 1950s. By the 1970s, farmers and officials at all levels of government were expressing a need to more closely examine the issue of aquifer depletion (Guru & Horn, 2000). The Great Plains area is very prone to drought.

Unfortunately, rainfall restores only 10% of the groundwater in the High Plains Aquifer that pumping at the same time depletes. Given the basic aridity of the High Plains region, it would take hundreds of years of heavier than normal rainfall to replenish what 70 years of undisciplined pumping has depleted (Lewis, 1990).

Ignorance and carelessness are the main factors behind the increasing water quality deterioration (Guru & Horne, 2000). Areas of confined feeding operations for cattle, hogs, and chickens are becoming a major source of water pollution. In fact, agriculture runoff is the greatest non-point source of water pollution in the United States (Guru & Horne, 2000). Only a small fraction of the Ogallala groundwater is known to be contaminated such that it fails to meet drinking water standards (Guru & Horne, 2000).

Water has become a political issue because of its locality. Concern over depletion and contamination of the Ogallala Aquifer has prompted several states to take regulatory action (Lewis, 1990). Recently, the U. S. House of Representatives appointed an Ogallala study group. The problem is that the states all have different interests and independent legal systems encourage officials to pretend as if the Ogallala were bounded by their state borders (Verchick, 1999). One conclusion that can be drawn from analyzing the results of the future situation is that the aquifer can continue to be a source of substantial amounts of water for several decades if we can learn to conserve this valuable resource (Knowles, 1985). We can learn to get along on less, but not without water (Bittinger, 1981).

Theoretical Framework

Curriculum is defined as the sum of the learning activities and experiences that a student has under the direction of the school (Finch & Crunkilton, 1984). Curriculum development focuses primarily on content and experiences related to the content. The *Carl D. Perkins Vocational and Technical Education Act* of 1998 called for an integrated curriculum of technical and academic competencies and that all students be taught the same challenging academic

proficiencies (Davis & Knobloch, 2002).

Educators agree that curriculum should be based on the learners' needs (Pratt, 1984). Finch and Crunkilton (1984) suggested that curriculum development may be viewed as a broad based activity that deals extensively with content identification and organization. Therefore a needs assessment should be the centerpiece for this planning process and should be conducted to achieve the goal or vision of curriculum development (Pratt, 1994). Needs assessments are conducted to identify problems or skills and justify decisions implemented in a development process. Needs assessments are a systematic approach to analyzing people's needs and determining the best ways to meet them (Witkin, 1984).

The term need, can be defined as a gap or discrepancy between existing conditions and desired conditions. When applied to the educational setting, a need is the gap or discrepancy between existing knowledge or skills and desired knowledge or skills (Knowles, 1980). Suarez (1991) defined needs assessment as an information gathering and analysis process that results in the identification of the needs of individuals, groups, institutions, communities, or societies.

The Witkin Model (Witkin, 1984) is a calculation of the grand mean scores for importance and a mean score for inclusion. The calculations are then plotted on the "X" and "Y" axis as a point. The "X" and "Y" axis indicates the different quadrants. For each of the individual areas, the mean of importance and the mean for inclusion are plotted. These points will fall into the categories of critical need, low-level need, high-level successful ability, or low-level successful ability. Items that fall into the critical need group are those of high importance but have low inclusion. Items that fall into the low-level needs are those of low importance and low inclusion. Items that fall into the low-level successful ability group are those of low importance but high inclusion. Finally, items that fall into the high-level successful ability are those with high importance and high inclusion.

Such graphs are helpful to needs assessment committees making

recommendations about priorities. Furthermore, they are also used in making decisions about allocation of program efforts. Items in the critical need area should be given priority for program development or specific interventions. Items in the low-level need area should be given a secondary priority, perhaps for later action. Items in the high-level successful ability area should be monitored for maintaining excellence. Finally, items in the low-level successful ability area should be reexamined for possible deletion from the curriculum (Witkin, 1984).

Water Education

Throughout the eight Ogallala states, agricultural educators teach a number of different curricular topics in agricultural science classrooms. This curricular topic information comes from state standards that were developed by teachers, administrators, and State Departments of Education.

In Wyoming, the Wyoming Vocational Agricultural Teachers Association (n.d.), has recommended the following topics to be included in curriculum: (a) conducting water quality tests and identifying contaminants, (b) discussing water as a non-renewable resource, (c) supply versus demand, (d) aquifer mining, and (e) interactions between federal, state, and local acts that effect water, such as the National Clean Water Act.

Texas requires the implementation of essential knowledge and skills to be taught in the classroom. Curricular standards that address natural resources included: (a) determining the importance and scope of natural resources, (b) defining the impact that natural or water resources have on the agricultural industry, (c) analyzing conservation and environmental water policies related to the local, state, and national levels, and (d) developing management skills for natural resources (Texas Education Agency, 1998).

The Nebraska Department of Education (1999) suggests that the following standards addressing natural resources be included: (a) identifying and suggesting strategies to properly manage water resources, b) distinguishing local and state water supplies for domestic, commercial, and industrial

use, and (c) describing the various elements, which can affect water quality and quantity.

The Colorado Department of Education (CDE) (2001), suggests these standards be included in curriculum: (a) conducting water quality tests, and determining what contaminants are present, (b) demonstrating knowledge of legal and administrative structures, which affect water resources and management, and (c) dealing with water regulations at the local, state, and federal levels.

The Kansas Department of Education (KDE) (1999) includes the following issues related to natural resources to be taught in the classroom: (a) identifying the roles and interactions between humans and the environment, (b) understanding that groups hold different views on environmental issues, (c) describing ways that economics and politics can affect decisions about the environment, (d) explaining human rights, economic development, public health, resource allocation, and environmental quality, (e) describing the short and long-term costs and benefits of addressing local, state, and national environmental issues, (f) illustrating how technological advances have changed the way people interact with the environment, and (g) identifying ways in which various resources can be reused and recycled.

The Oklahoma Department of Career and Technology Education (n.d.) suggests that agricultural education emphasize the principles and processes involved in conserving and/or improving natural resources, such as air, water, land, wildlife, habitat, forestry, and energy for economic and recreational purposes. Broadly speaking competencies include the establishment, management, and operation of land and water.

According to Career Clusters (2002), the topics to be taught in New Mexico in agriculture, food, and natural resources include: (a) identifying the components of each agriculture, natural resource, and environmental system to address their maintenance requirements, (b) recognizing the importance of resources and human interrelations, (c) using effective venues to communicate natural resources to the public, (d) communicating natural resource

information to the general public, (e) using the science concept processes and research techniques to examine natural resource topics, (f) practicing responsible conduct to protect natural resources, and (g) identifying policies and regulations impacting the environment.

Important issues to be taught in South Dakota classrooms include: (a) identifying surface and groundwater supplies, (b) calculating water needs on farms and in rural communities, (c) interpreting water use laws and rights, (d) determining water quality standards, and (e) conducting water quality tests (South Dakota Agricultural Education/FFA/PAS, n.d.).

Purpose and Research Objective

The purpose of this study was to gather information that would give insight to curriculum and professional development decisions related to water issues present in locations that are dependent upon the Ogallala Aquifer. The objective of this study was to determine the critical curriculum development needs for agricultural education teachers in the eight states serviced by the Ogallala Aquifer concerning water management and sustainability, water policy, water quality, and water conservation and technology. This paper is part of a larger study that assessed demographic data and agricultural science teacher perceptions as to the importance of selected water related topics. This paper focuses only on critical curricular needs portion of the larger study.

Methods and Procedures

Population
A map of the Ogallala Aquifer (Gutentag, Heimes, Krothe, Luckey, & Weeks, 2001) was used to determine counties in the states of Texas, New Mexico, Oklahoma, Colorado, Kansas, Nebraska, Wyoming, and South Dakota to be included in the population. After determining counties in the Ogallala states, a list of agricultural science teachers for those counties was compiled. The population for the study included: 28 teachers from

Colorado, 52 teachers from Kansas, 101 teachers from Nebraska, 23 teachers from New Mexico, 18 teachers from Oklahoma, four teachers from South Dakota, 120 teachers from Texas, and 10 teachers from Wyoming. A census was conducted including all the 356 agricultural education teachers in all eight states.

Instrumentation
The first section of the instrument included questions that determined how important agricultural science teachers felt water quality, quantity, and policy issues were and to what extent they included them in their curriculum. Forty-five water content areas were selected based on the review of state education standard topics. The agricultural science teachers rated the topics on a Likert-type scale with perceived importance of the topics and degree to which the topics were included in their curriculum. The importance scale was set up as follows*: 1=Very Low Importance, 2=Low Importance, 3=Moderate Importance, 4=High Importance, and 5=Very High Importance.* The inclusion scale was set up as follows*: 1=Hardly Ever, 2=Occasionally, 3=Sometimes, 4=Frequently, and 5=Almost Always.*

The validity of the instrument's content was reviewed and analyzed by a panel of experts. To further ensure validity and reliability the questionnaire was field tested with 43 agricultural science teachers from the Edwards Aquifer region located near San Antonio, Texas. The subjects involved in the field test received a cover letter with a link to the online questionnaire. The agricultural science teachers were encouraged to complete the questionnaire and provide any information that was needed to improve or clarify the questionnaire. Eighteen (42%) agriculture educators completed the online questionnaire.

Data collected from the pilot study were analyzed using SPSS. The importance scale had a .97 Cronbach's alpha reliability coefficient. Comments were collected and considered in making changes to the questionnaire instructions. No changes were made to the 45 items assessing teacher perceptions of importance of the topics nor

to teacher perceptions of inclusion of the topics.

Data Collection Procedure

The bi-modal process, as described by Fraze, Hardin, Brashears, Smith, and Lockaby (2002), was used as the collection procedure for this study. The bi-modal process included electronic as well as mailed questionnaires and reminders that were distributed to the population. Data collection began in May 2003. An e-mail pre-notice was sent out on May 2, 2003 to all participants. The pre-notice explained the purpose and objectives of the study, as well as an encouragement to participate. On May 5, 2003, an e-mail with a link to the questionnaire was distributed to the participants. Reminder e-mails were sent out on May 8, 2003 in the form of a thank you and reminder to reply to the questionnaire if they had not already done so. On May 13, 2003, a paper packet was mailed to the participants that had not responded to the questionnaire through e-mail. On May 16, 2003, a final e-mail thank you and reminder was sent out. Responses were accepted through June 13, 2003. A total of 356 teachers were contacted about filling out the questionnaire and a final response rate of 62.61% (n=223) was achieved.

Non-response error was a concern because the response rate for this study was 62.61%. An analysis of variance (ANOVA) was utilized to determine statistically significant differences between early e-mail respondents and late e-mail respondents and between early United States Postal Service (USPS) respondents and late USPS respondents. The dependent variables were the factor scores for each of the four factors extracted by the principal components factor analysis with Equamax rotation. There were no statistically significant differences between any of the respondent groups. Therefore, according to Miller and Smith (1983), it is acceptable to assume that there are no differences between respondents and non-respondents.

Data Analysis Procedure

The 45 water issue topics were collapsed into four factors as noted in the previous paragraph. These factors were utilized in the portion of the study reported in this paper. To accomplish the objective for this paper, needs assessment matrices as described by Witkin (1984) were used. The matrices were used for determining the critical content area needs for water management and sustainability, water quantity, water policy, and water conservation and technology issues. Each topic was classified as high-level successful ability, low-level successful ability, low-level need, or critical need as shown in Figure 1.
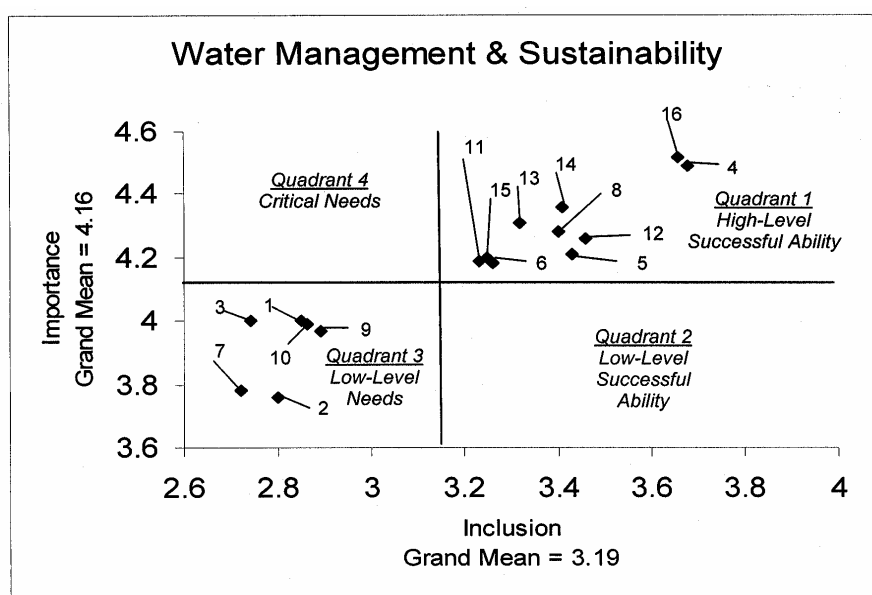

Figure 1. Needs Assessment Matrix (Witkin, 1984).

Findings

*Factor 1– Water Management and
Sustainability Needs Assessment*

Figure 2 shows the results of the Witkin Needs Assessment Matrix Analysis for water management and sustainability related topics. The 16 topics where plotted on the matrix with 10 being classified as High-Level Successful Abilities and six classified as Low-Level Needs. The High-Level Successful Abilities were: agriculture use of groundwater, water as a non-renewable resource, local groundwater issues, selecting proper irrigation techniques, water demand, center pivot irrigation systems, groundwater impact in the future, groundwater depletion, responsible water use by households, and responsible water use by agriculture. The Low-Level Needs were: producing crops that require less water, soil moisture monitoring, water quantity research, municipal demands for agriculture water, groundwater recharge, and groundwater reserves.

(1) producing crops that require less water
(2) soil moisture monitoring
(3) water quantity research
(4) agriculture use of groundwater
(5) water as a non-renewable resource
(6) local groundwater issues
(7) municipal demands for agriculture water
(8) selecting proper irrigation techniques
(9) groundwater recharge
(10) groundwater reserves
(11) water demand
(12) center pivot irrigation systems
(13) groundwater impact in the future
(14) groundwater depletion
(15) responsible water use by households
(16) responsible water use by agriculture

Figure 2. Needs Assessment Matrix – Water Management and Sustainability

Factor 2 – Water Policy Needs Assessment

Figure 3 shows the matrix analysis for water policy related topics. There were nine water policy related topics with five being classified as High-Level Successful Abilities. Those five topics were: state water laws, local water laws, water ownership, local water policy, and state water policy. Four topics were classified as Low-Level Needs: regulatory agency water use monitoring, water policy research, exportation of groundwater from one region to another, and water permits.
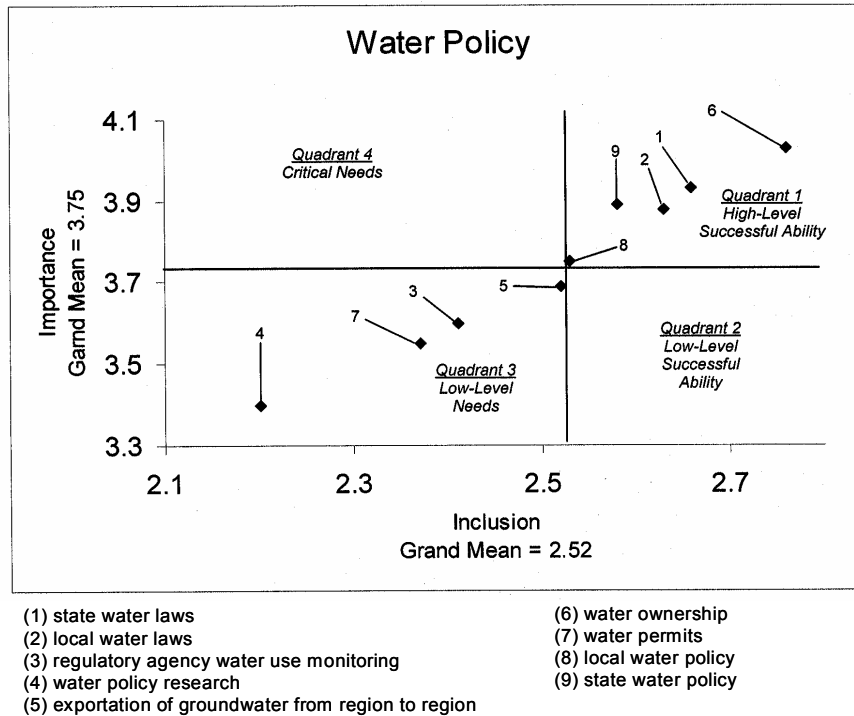
Water Policy

Importance
Garnd Mean = 3.75

4.1

Quadrant 4
Critical Needs

3.9

Quadrant 1
High-Level
Successful Ability

3.7

Quadrant 2
Low-Level
Successful
Ability

3.5

Quadrant 3
Low-Level
Needs

3.3

2.1   2.3   2.5   2.7

Inclusion
Grand Mean = 2.52

(1) state water laws
(2) local water laws
(3) regulatory agency water use monitoring
(4) water policy research
(5) exportation of groundwater from region to region

(6) water ownership
(7) water permits
(8) local water policy
(9) state water policy

Figure 3. Needs Assessment Matrix – Water Policy

Factor 3 – Water Quality Needs Assessment

There were 10 topics that comprised the Water Quality related factor (Figure 4). One topic was classified Critical Need: water quality research. Point water contamination was classified as a Low-Level Successful Ability. Four topics were classified as High-Level Successful Ability: water quality testing, water quality improvement, water contamination caused by nitrated from agriculture, and watershed management. Low-Level Needs were: industry use of groundwater, key indicators to water quality, non-point water contamination, and water contamination caused by water discharge.
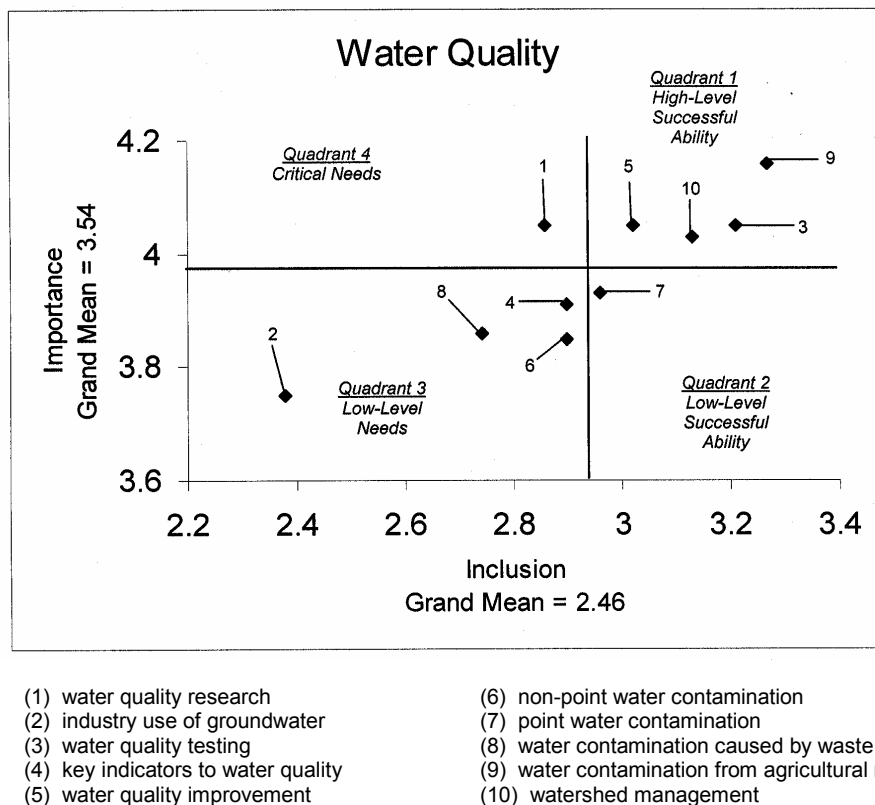
Water Quality

(1) water quality research
(2) industry use of groundwater
(3) water quality testing
(4) key indicators to water quality
(5) water quality improvement

(6) non-point water contamination
(7) point water contamination
(8) water contamination caused by waste water
(9) water contamination from agricultural nitrates
(10) watershed management

Figure 4. Needs Assessment Matrix – Water Quality

Factor 4 – Water Conservation and Technology Needs Assessment

Figure 5 shows the results of the Witkin Needs Assessment Matrix Analysis for water conservation and technology related topics. The ten topics where plotted on the matrix with two being classified as Critical Needs, four being classified as High-Level Successful Abilities and four classified as Low-Level Needs. The Critical Needs were:

water contamination caused by extraction of petroleum products and surge irrigation. The High-Level Successful Abilities were: drip irrigation, low-energy precision application (LEPA) systems, water price/value, and empowering youth in water conservation efforts. The Low-Level Needs were: furrow dikes, cloud seeding/weather modification, recycling tail water, and recycling gray water.
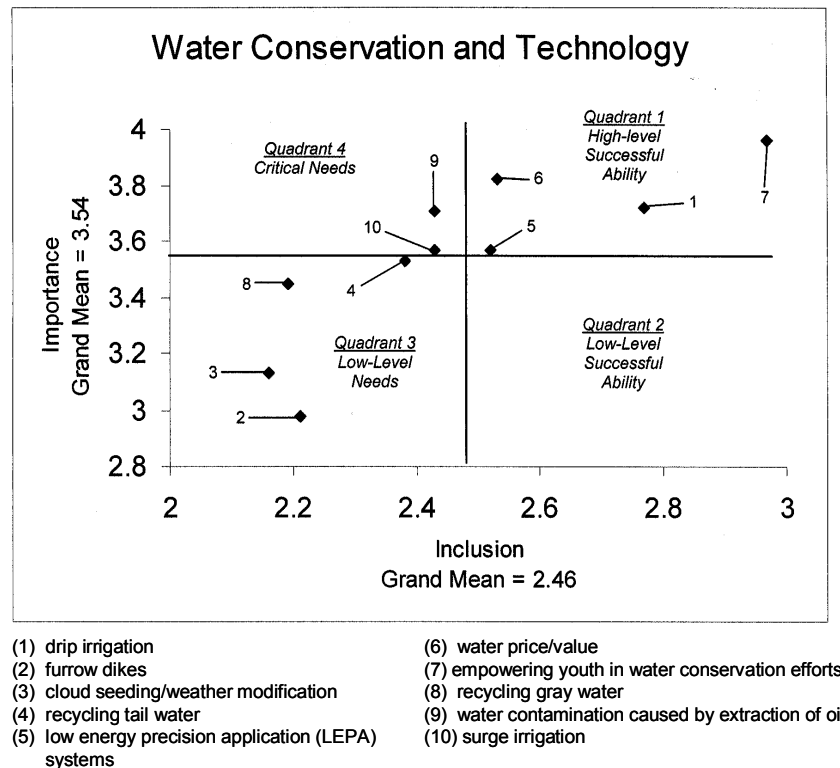
Water Conservation and Technology

(1) drip irrigation
(2) furrow dikes
(3) cloud seeding/weather modification
(4) recycling tail water
(5) low energy precision application (LEPA)
    systems

(6) water price/value
(7) empowering youth in water conservation efforts
(8) recycling gray water
(9) water contamination caused by extraction of oil
(10) surge irrigation

Figure 5. Needs Assessment Matrix – Water Conservation and Technology

Conclusions and Recommendations

Conclusions

The design of this study allowed the researcher to determine the critical concept areas as perceived by agricultural science teachers. By using the mean scores for inclusion and importance, the researchers were able to plot the individual content areas on the Witkin model and determine if it was a high-level successful ability, a low-level successful ability, a low-level need, or a critical need. The respondents identified 23 content areas as high-level successful ability. This means that agricultural science teachers believed that these components were important and that they are currently including them in their curriculum. The respondents identified 18 content areas as low-level needs. This means that agricultural science teachers do not believe these content areas are important and the rate of inclusion is lower than the mean inclusion score for the respective factors. The respondents identified only three content areas as a critical need. This means that the agricultural science teachers believe

that these are very important issues, but they are not including it in their curriculum at a rate greater than the mean inclusion rate. The respondents identified only one content area (water quality research) as a low-level successful ability. This means that the agricultural science teachers are including this topic in their curriculum; however, they do not feel that it is a very important issue.

Recommendations for Practice

There were three content areas that were identified as a critical need. The critical needs included: water quality research, water contamination caused by extraction of petroleum products, and surge irrigation. According to agricultural science teachers, these are important issues, but they are not including them in their curriculum. Witkin (1984) suggested that items in the critical needs area should be given priority for curriculum development or specific interventions. In addition, this information should be provided to leaders in education for each state so that in-service workshops can be developed to address these critical needs.

There were 18 content areas that were identified as low-level needs. These content areas included: producing crops that require less water, soil moisture monitoring, water quality research, municipal demands for agriculture water, groundwater recharge, groundwater reserves, regulatory agency water use monitoring, water policy research, exportation of groundwater from one region to another, water permits, low level needs, key indicators to water quality, non-point water contamination, water contamination caused by waste water discharge, furrow dikes, cloud seeding/weather modification, recycling tail water, and recycling gray water. These issues should be given secondary priority, perhaps for later action (Witkin, 1984).

The agricultural science teachers determined 23 content areas to be of high level successful ability. These items include: agricultural use of groundwater, water as a non-renewable resource, local groundwater issues, selecting proper irrigation techniques, water demand, center pivot irrigation systems, groundwater impact in the future, groundwater depletion, responsible water use by households, responsible water use by agriculture, state water laws, local water laws, water ownership, local water policy, state water policy, water quality testing, water quality improvement, water contamination caused by nitrates from agriculture, watershed management, drip irrigation, low energy precision application (LEPA) systems, water price/value, and empowering youth in water conservation efforts. These items should be monitored in order to maintain excellence in a program (Witkin, 1984).

The teachers only identified one content area as being a low-level successful ability. The one content area was water quality research. According to Witkin (1984), this content area should be reexamined for possible reduction or deletion.

Recommendations for Further Research

It is recommend that this study be replicated with water experts to determine if there is an agreement between agricultural teachers and experts as to the importance in each of the 45 content areas.

Additional research should be conducted placing more emphasis on how the material is being taught in the agricultural classrooms instead of the content that is being taught.

Due to the fact that the Ogallala Aquifer is so large, further analysis of this same data needs to be done on a state-by-state basis to determine if there are different view points of teachers based on importance and inclusion. This will allow researchers to determine if curriculum needs to be developed on a state-by-state basis or on the Ogallala as a whole.

Finally, additional research needs to be conducted in the areas of water management and sustainability, water policy, water quality, and water conservation and technology. This information needs to be available to teachers so they have additional teaching resources. With these resources, teachers will be able to increase the amount of water-related topics taught in their curriculums.

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DANIELLE COX is an Agricultural Science Instructor at Riverside High School, P.O. Box 159, Basin, Wyoming 82410 E-mail: danielle_cox@hotmail.com.

DAVID E. LAWVER is a Professor in the Department of Agricultural Education and Communication at Texas Tech University, Box 42131, Lubbock, TX 79409. E-mail: david.lawver@ttu.edu.

MATT BAKER is a Professor in the Department of Agricultural Education and Communication at Texas Tech University, Box 42131, Lubbock, TX 79409. E-mail: matt.baker@ttu.edu.

DAVID DOERFERT is an Associate Professor in the Department of Agricultural Education and Communication at Texas Tech University, Box 42131, Lubbock, TX 79409. E-mail: david.doerfert@ttu.edu.