Perception of Alabama Science and Career Technology Teachers Concerning Teaching the Alabama Aquaculture Course of Study

by

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Abstract

The purpose of this study was to improve teachers' ability to effectively use aquaculture as a tool to teach math and science. The study population included Alabama science and career tech teachers that were certified to teach the Alabama aquaculture course of study. The teachers were electronically surveyed regarding their perceptions of the importance of the aquascience elective and aquaculture science course content standards, their knowledge of those topics and how they perceived the quality of available teaching materials.

While all of the content standards were rated above average in importance, aquaculture career awareness and safety concerns were rated the highest by teachers. Teachers were most knowledgeable about career opportunities, categorization of aquaculture species, and the adaptations of aquatic organisms. The average materials ratings were below average for all content standards. The highest rated materials were for career opportunities, categorization of species and safety topics. Using Borich's (1980) model of mean weighted discrepancy scores, the control of diseases and pests in the aquatic environment and concepts associated with health management of aquacrops were identified as top priorities for in-service teacher training. Aquaculture industry infrastructure and the effects of the fishing industry were also identified as priority training topics.

Teachers were self-divided into 3 categories those that taught science (SCI), career tech (CTE) and those that taught both (BOTH). They were further divided by their level of experience. A multitvariate analysis of variance (MANOVA) revealed a significant effect between teacher types but there was no significant interaction effect between (a) teacher type and experience level or (b) the two levels of experience. A follow-up analysis of variance (ANOVA) indicated that the science teachers thought significantly less of the available materials than either the CTE or BOTH groups.

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I would like to thank my committee members, colleagues and especially my family for their encouragement and patience in the completion of this project. My wife Tracy and son Michael were especially patient with me and my parents helped me to believe the words of author Richard Bach who said

"You're never given a dream without also being given the power to make it true."

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Parting Words:

"No matter how qualified or deserving we are, we will never reach a better life until we can imagine it for ourselves and allow ourselves to have it."
— Richard Bach

"When you have come to the edge of all the light you have
And step into the darkness of the unknown
Believe that one of the two will happen to you
Either you'll find something solid to stand on
Or you'll be taught how to fly!"
— Richard Bach

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List of Abbreviations

ALSDE	Alabama State Department of Education
NAEP	National Assessment of Educational Progress
NRC	National Research Council
RAS	Recirculating Aquaculture System
UNESCO	United Nations Educational, Scientific and Cultural Organization
K-12	Kindergarten through Grade 12
LIW	Living in Water Curricula
CBI	Computer Based Instruction
CAI	Computer Aided Instruction
FAO	The Food and Agriculture Organization of the United Nations
USDA	United State Department of Agriculture
NOAA	National Oceanic and Atmospheric Administration
CTE	Career and Technical Education
SPSS	Statistical Package for the Social Sciences
DS	Discrepancy Score
MDS	Mean Discrepancy Score
WDS	Weighted Discrepancy Score
MWDS	Mean Weighted Discrepancy Score
SCI	Science Teachers

BOTH Teachers that taught both science and career technical courses

MANOVA Multivariate Analysis of Variance

M Mean

SD Standard Deviation

CS Content Standard

IMP Importance (of aquaculture content standards)

KNOW Knowledge (of aquaculture content standards)

MAT Materials (used to teach the aquaculture content standards)

CHAPTER 1 - INTRODUCTION

Aquaculture or fish farming is the aquatic version of agriculture. Aquaculture is the reproduction and growth of aquatic organisms in a controlled or semi-controlled environment (Stickney, 1979; Lovshin, 1989). It is an important facet of agriculture and is destined to play a major role in the production of food for the earth's growing population.

The first written documents concerning aquaculture appear in 460 B.C. when Fen Li described the culture of common carp (Parker, 2001). Over time the importance and popularity of aquaculture has grown. There are two major reasons for the relatively recent surge in aquaculture growth. First, aquaculture provides a relatively inexpensive source of animal protein. Second, aquatic animals, fish in particular, have the ability to convert plant based feed to flesh in a very efficient manner. The feed conversion ratio of fish is the lowest among domestic animal protein sources such as poultry, swine and cattle. Tilapia for example can convert 1 pound of dry fish feed into fish flesh at a nearly 1:1 ratio. In some cases when there is natural food present this ratio can exceed 1:1 where the fish gains more than 1 pound of flesh for each pound of feed provided. These attributes have led scientists and economists to forecast that aquaculture will play an important role in providing protein to the world's expanding population.

Aquaculture, like agriculture, is a complex subject with numerous facets for study in educational programs. A number of university, secondary agriculture, and science teachers have realized this and integrated aquaculture into their curricula. Mengel (1999) estimated that 2,600 out of 11,000 high school programs teaching agriculture education provided more than 36,000 students with hands-on opportunities in aquaculture. He further estimates that more than 100,000 students annually are introduced to aquaculture through exposure to these programs. Aquaculture is an excellent teaching tool, because it easily integrates many disciplines including biology, chemistry, economics, math, and physics. Growing fish, aquatic plants, and other living things in the classroom creates a living laboratory and promotes daily hands-on experiences that enrich the learning environment. It makes learning practical, experimental, and enjoyable for teachers and students (Mengel, 1999). In the final evaluation of a major aquaculture curriculum initiative conducted by the National Council for Agriculture Education, the authors (Conroy & Peasley, 1998) deliver a powerful statement about the potency and potential of aquaculture education.

> Data reveal that, in the span of less than 10 years, aquaculture has gone from virtual anonymity to reaching students in over 25% of the agriculture programs in the US. This is not a mandated program, nor is it a reaction to some national fear of Russian space domination. Aquaculture has breathed new life into most of the agriculture programs into which it has been infused. Aquaculture is important to students, to communities and the environment. Future food production will, no doubt, depend on domestic aquaculture production and related activities such as

hydroponics. Secondary-postsecondary linkages and articulation programs will supply a competent workforce. To support this view, survey data reveal that high school aquaculture initiatives are positively impacting the number of students enrolling in postsecondary technical aquaculture programs.

> Aquaculture has, perhaps more than any other agriculture or academic content area, the potential for interdisciplinary and collaborative instruction. Tremendous enthusiasm and collegiality are results of integration efforts in schools and districts visited by the evaluation team. The survey data indicate that the opportunities are limitless and go beyond the traditional academic-vocational integration. Teachers have blurred the lines between academic-vocational-fine arts to create a holistic learning environment that is productive for students of all age and ability levels. (p. 22)

Among the chief reasons aquaculture has not been universally accepted as a tool to teach math, science and agriculture is that it requires additional teacher effort and in some cases substantial funding to get an aquaculture program started. To move beyond these barriers generally requires strong administrative support, and most administrators are not familiar enough with aquaculture to recognize its' potential as a cross curricular teaching tool (Conroy, 1999; Conroy & Walker, 1998; Fortner & Wildman, 1980).

Teachers already have their hands full trying to meet state and national standards and prepare students for standardized tests and exit exams. Few, if any, teachers have formal training in aquaculture and many who are trained believe that they are inadequately prepared to teach this relatively new subject (Conry& Peasley, 1997).

There also appears to be a perceived lack of quality teaching materials among teachers new to aquaculture programs. Despite these and other obstacles many teachers have decided to forge ahead and use aquaculture to try to capture student interest. Many concede that system maintenance and caring for live animals can become tiresome at times, but most aquaculture teachers feel that the educational rewards are justified.

Aquaculture's ability to reconnect students with agriculture and support the teaching of math and science is still considered an innovative concept. Teacher's reasons for initial involvement with aquaculture generally fell into three general categories

1. aquaculture could help the students learn math and science concepts and enhance the student learning experience (Conroy & Walker, 2000; Wingenbach et al., 2000; Stickney, 1979),
2. it would generate interest in their program and be a positive public relations vehicle for them (Lovett, 1999) and
3. it would create educated consumers and improve students' ability to excel in a highly technical society (Conroy & Walker, 2000).

While there is little that can be done to provide more time available for teachers to start and maintain these systems, efforts at improving teacher knowledge and gaining and understanding of teaching priorities have the potential to stimulate aquaculture program initiation and improve the chances of success of existing programs.

Problem Statement

It is now generally accepted that aquaculture education programs motivate students and assist in teaching math and science principles (Goodwin& Schaadt, 1978;

Stickney, 1979; Fortner, 1983; 2001; Trent 1983, Picker, 1985, Moore, 1987; Brody & Patterson, 1992; Walsh, 1992; El Ghmrini, 1996; Conroy & Peasley, 1998; Wingenbach et al., 1998; 1999; 2000; Davis-Hodgkins, 1999; Lovett, 1999; Mengel, 1999; Cline, 2000; 2004; 2005; Conroy & Walker, 2000; Reese, 2001; Parker, 2002; Frederick 2005; Roy, 2005), but little research has been conducted on how to make these programs more successful and sustainable. Much of the work to date focused on why and how the programs got started along with the barriers to their use and success (Lovett, 1999; Mengel, 1999; Chankook & Fortner, 2006).

There appears to be a void in the available data related to how instructors perceive aquaculture and their ability to teach the various facets of aquaculture science (Wingenbach et al., 1998; 2000). Likewise, while some data has been collected on how teachers rate the importance of the various content areas under the subject of aquaculture (Lovett, 1999) and marine science (Milkent et al., 1979; Fornter & Meyer, 2000), this data has not been collected from Alabama teachers who are considered qualified by the Alabama State Department of Education (ALSDE), to teach the aquaculture curricula. Without this information it is difficult for teachers and administrators alike to determine what topic areas should be emphasized within the aquaculture courses. The problem, therefore, is if (a) instructors do not consider the various aspects of aquaculture subject matter to be important, (b) do not have confidence in their ability to teach aquaculture and (c) teaching materials of high quality are not readily available, they are unlikely to take on this excellent teaching opportunity or be able to maximize its' potential impact and effectiveness.

Purpose of the Study

The purpose of this study is to improve teachers' ability to effectively use aquaculture as a tool to teach math and science. To accomplish this task the researcher explored how Alabama science and career tech teachers perceive the importance of aquaculture related topics, their knowledge of those topics and how they perceive the quality and quantity of available teaching materials. This information will make it possible to determine the greatest areas of need with regard to aquaculture training and curriculum development (or identification). This knowledge should prove valuable to schools in scheduling in-service training, pre-service teacher training and in the long run, create more aquaculturally literate citizens with an improved ability to prosper in a technology advanced society and help feed our ever-growing population.

Research Questions

1. <u>Importance of Content Standards</u>. How do teachers certified to teach the aquaculture curricula perceive the importance of various content standards of the Alabama aquaculture science course of study?
2. <u>Abilities</u>. What are teachers', certified to teach the aquaculture curricula, perceived abilities, indicated by their current knowledge, to teach the content standards of the Alabama aquaculture science course of study?
3. <u>Teaching Materials</u>. How do Alabama teachers, certified to teach the aquaculture curricula, perceive of the quality of aquaculture teaching materials?

Significance of the Study

Teachers' and administrators' perceptions about aquaculture curriculum may influence the level of support, funding, resource allocation, and access to continuing education opportunities for potential, new, or existing aquaculture programs. By examining teachers' perceived abilities to teach the content standards and relative importance of the Alabama Aquascience Course of Study content standards it will be possible to identify and prioritize teacher training needs. This information should be very helpful to in-service training planners and university outreach (Cooperative Extension) personnel in developing and delivering appropriate and constructive education opportunities. It will also help identify areas that need strengthening in teacher pre-service education programs.

The examination of the way teachers view the importance of various content standards of the Alabama Aquascience Course of Study will help provide information to enhance future revisions of the course offerings and help them determine the appropriate time and emphasis to spend in each of the various areas. In addition by increasing teacher exposure to the learning opportunities that aquaculture provides it may also enable them to identify areas for cross-curricular collaboration and may improve the odds of successfully initiating or operating an aquaculture program.

Ascertaining the teachers' perception of the availability of quality teaching materials in each of the content areas will enable content providers to, 1) develop more or better materials for that area or 2) demonstrate the need to make teachers aware of the materials that are available. In either case this will improve the resources available to teachers and allow them to dedicate more time to the students.

There is a growing body of evidence to suggest the significant capacity of aquaculture as an area of study to improve agriscience programs and serve as a cross-curricular mechanism to improve students' competency in math and science. Teachers and administrators overcoming barriers to the initiation or success of such a program is a significant and worthwhile effort.

Definitions

Definitions of terms are furnished to provide the reader with the meaning, as clearly as possible, of the terms used in this study include:

a. Aquaculture – The production and culture of aquatic organisms in a controlled or semi-controlled environment.

b. Agriculture – The science, art, and business of cultivating the soil, producing crops, and raising livestock useful to man: farming (Morris, 1982). Agriculture also encompasses the study of economics, technology, politics, sociology, international relations and trade, and environmental problems, in addition to biology (Moore, 1987)

c. "Agriscience – The notion of identifying and using concepts of biological, chemical, and physical science in the teaching of agriculture, and using agricultural examples to relate these concepts to the student." (Conroy and Walker, 1998, p. 3)

d. Marine – of or pertaining to the sea: saltwater.

e. Aquatic – of or pertaining to water. "In common use, although such use is not extensive, aquatic generally refers to water in the generic sense…. The word most often is applied to fresh water." (Goodwin & Schaadt, 1978, p.5)

f. Environment - "Environment refers to the totality of physical, chemical, biological, social, economic, political, cultural, aesthetic, and structural surroundings of organisms, including ourselves and other people" (Goodwin & Schaadt, 1978, p.6) .

g. Education – "…the entire variety of experiences though which people learn: formal and informal educational activities from kindergarten to graduate school and continuing education; recreational, work, and life experiences, and all forms of communication from personal to mass media" (Goodwin & Schaadt, 1978, p.6).

h. Scientific literacy - "…the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity" (Lambert, 2006, p. 633).

i. Alabama Course of Study – A document that contains minimum required content and specifies WHAT students should know and be able to do in a particular subject area by the end of each course or grade-level (K-12).

j. Content Standard – A clearly defined statement of the knowledge, concepts and skills that a student is expected to acquire by taking a given class.

k. Competency – In the most general sense, a competency has come to stand for a skill, behavior, or performance expected of a trainee at the completion of the training (Borich, 1979).

l. Attitude – A learned predisposition to respond in a consistent manner in different situations.

Assumptions

The following assumptions are made:

a. Teachers answer the survey instrument honestly.

b. Teachers in states outside of Alabama will readily understand the Alabama Content Standards and be able to relate them to their teaching activities.

c. The respondents to the survey (187 out of an estimated 2300, 8.1%) were representative of the total population of Alabama science and career tech teachers. Even the state level administrators could not provide a definitive answer to how many science (SCI) and career and technical education (CTE) teachers there were in the total population. However, the numbers of Alabama biology, chemistry, earth science and physics teachers reported in the State Indicators of Science and Mathematics Education report suggests that the total number is 1268 in grades 7-8 and 1103 in grades 9-12 (Council of Chief State School Officers, 2007).

Organization of the Study

This dissertation consists of five chapters. Chapter I introduces the study and provides some background information. It also indicates the problem, its significance and the proposed research questions. Chapter II provides a review of the relevant literature related to aquaculture, aquaculture education, and several related educational models. Chapter III outlines the methods and procedures used to carry out the study. The results of the study are presented in Chapter IV. Chapter V provides a summary of the study and empirical findings, with discussions of implications, some limitations of the study and directions for future research.

CHAPTER 2 - LITERATURE REVIEW

The purpose of this study is to improve teachers' ability to effectively use aquaculture as a tool to teach math and science. To accomplish this task we will explore how Alabama science and career tech teachers perceive the importance of aquaculture related topics, their ability to teach those topics and how they perceive the quality and quantity of available teaching materials. This information will make it possible to determine the greatest areas of need with regard to aquaculture training and curriculum development (or identification). This knowledge should prove valuable to schools in scheduling in-service training, pre-service teacher training and in the long run, create more aquaculturally literate citizens with an improved ability to prosper in a technology advanced society and help feed our ever-growing population. Specific research questions to be answered include,

1. Importance of Content Standards. How do teachers certified to teach the aquaculture curricula perceive the importance of various content standards of the Alabama aquaculture science course of study?
2. Abilities. What are teachers', certified to teach the aquaculture curricula, perceived abilities, indicated by their current knowledge, to teach the content standards of the Alabama aquaculture science course of study?

3. Teaching Materials. How do Alabama teachers, certified to teach the aquaculture curricula, perceive of the quality of aquaculture teaching materials?

This chapter reviews literature related to the development and current status of aquaculture education in secondary schools in the United States. An examination of teacher perceptions about aquaculture education will assist in the maximization of opportunities for students to gain skills in math, science, and problem solving. An exploratory evaluation of teacher's perceptions of (a)) relative importance of, (b their ability to teach, and (c) availability of quality teaching materials related to the various content areas within the Alabama Aquaculture Science course of study will also:

1. Allow identification and prioritization of teacher training needs,
2. Determine the appropriate time and emphasis to spend in each topic area,
3. Identify areas for cross curricular collaboration, and
4. Improve the resources available to teachers.

Among areas of literature incorporated into the review are background information on aquaculture education and the related educational models of environmental education, marine/aquatic education, outdoor classrooms, and hands-on learning. In addition to the educational models a review of world, U.S. and Alabama aquaculture will be included. This area of the review will demonstrate the economic and social significance of aquaculture both globally and locally.

Aquaculture Education

El-Ghamrini (1996) stated that aquaculture in U.S. high schools have a very short history. There are a limited number of researchers, scientists and educators working in the study of this area. A lack of research information was noticed by Conroy & Peasley (1997) as well. This situation still exists today. To date there have been relatively few research projects specifically directed at aquaculture education in schools whether at the primary or secondary level. In order to provide as broad an overview as possible it will be necessary to step back and look at the larger picture of education.

Science education including agriscience education has been under scrutiny in the United States for a number of years. School children in the United States have fallen further and further behind other nations in science and mathematics. According to the National Academy of Science the ability of the United States to remain a leader in science innovation and technology is in serious jeopardy. The study states, “The danger exists that Americans may not know enough about science, technology, or mathematics to significantly contribute to, or fully benefit from, the knowledge-based society that is already taking shape around us”(National Academy of Sciences, 2007, p. 94). The 2005 National Assessment of Educational Progress (NAEP) tests, as reported by National Academy of Science 2007, indicated that only 36% of 4^{th}-graders and 30% of the 8^{th}-graders tested, performed at or above the proficient level in mathematics. In addition, the 2000 science NAEP tests indicated that only 29% of 4^{th}-grade, 32% of 8^{th}-grade, and 18% of 12th-grade students performed at or above the proficient level in science.

Studies indicate that attitudes towards science and scientific pursuits generally rise in elementary school, peaking near the sixth grade (Osborne, Simon & Collins, 2003). From sixth grade through high school attitudes towards science steadily erode. The *Rising above the Gathering Storm* study indicates that one way to improve students' chances of success in these areas is to find ways to increase interest in relevant subject areas. Educators have found that using aquaculture to teach the principles of math and science improves student interest and motivation (Conroy, 1999; Conroy & Walker, 2000; El-Ghamrini, 1996; Leighfield, 2005; Lovitt, 1999; Mengel, 1999; Reese, 2001; Wingenbach, Gartin & Lawrence, 2000). Conroy & Walker (2000) interviewed students who participated in aquaculture class and found "…that they believe aquaculture has enhanced their academic performance in mathematics and science and made those areas more relevant for them" (p 54).

Aquaculture is an excellent teaching tool because it easily integrates many disciplines including biology, chemistry, economics, math, and physics, and can provide hands-on experiences that complement academic theory (Conroy & Peaslely, 1998; El-Ghamrini, 1996; Reese, 2001; Wingenbach, 2000). John Harbuck, an agri-technology teacher who has integrated aquaculture into his general agribusiness curriculum for six years, observed that the "practical, hands-on approach is best for keeping students interested and for assuring learning, rather than just memorization" (personal communication, June 10, 2002). Another experienced teacher, Terry Youngblood, points out that the "daily feeding and maintenance of the fish has taught the students responsibility, as well as, the integrated math and science concepts" (personal communication, June 10, 2002).

Relationship to Agriscience Education

Agriscience was first taught formally in the United States in 1733 when a specialized school was set up in Ebenezer, Georgia, to teach orphans successful farm practices. (National Research Council [NRC], 1988). Most early informal agriculture education consisted of parents teaching their children the skills necessary to maintain the family farm. The passage of the Morrill Act in 1862 set the stage for more formal education in agriculture. This act precipitated the foundation of today's Land Grant University System and provided the land, support, and maintenance funding for state colleges where citizens could be taught agricultural and mechanical arts. According to the NRC report, in 1901 Wisconsin was the first state to provide funds for country agricultural high schools or independent agricultural schools. It also reports that in 1908 Virginia was the first state to fund agriculture departments within public schools (NRC, 1988).

Early agriculture curriculum focused on the "hows" of agriculture production more than the "why", because instructors were training students to become practicing farmers (Conroy and Walker, 1998). According to Conroy and Walker, this practice began in the 1920's and continued through the mid 1980's. Changes in the content reflected new, better, and more efficient methods of production and continued the "how to" tradition. During this time, the population of the United States went through dramatic changes, shifting away from a primarily agrarian society to a more urbanized and industrialized society. When federally supported agriculture education began in 1917, more than one third of the population lived on farms. However, by the mid 1980's, less than 2.2 % of the people were involved in farming (National Research Council, 1988). In this same time span agriculture went from a hand-labor-based system to a highly mechanized and sophisticated science. However, this evolution in technology was not adequately reflected in the agriculture curriculum. This failure to update curriculum and other factors led to decreased enrollment in agriculture education classes (Conroy and Walker, 1998; Roy, 2005). This sentiment was echoed by Reese (2001) noting that the dramatically shifting demographics required a change in agriculture education opportunities to remain relevant for non-farm youth.

Although science has always been an integral part of agriculture education, slowing enrollment and a growing disconnect between curriculum and technology led to a recommendation by the National Research Council that agriculture education programs update their programs to incorporate more science content into the curriculum. This led to a redefinition of the term agriscience. Based on their review of the literature and various studies, Conroy and Walker (1998) identified the following definition of agriscience. "Agriscience – The notion of identifying and using concepts of biological, chemical, and physical science in the teaching of agriculture, and using agricultural examples to relate these concepts to the student" (p. 3).

Frederick (2005) refers to several important events in the development of aquaculture education including the National Aquaculture Act of 1980 (P.L. 96-362), the 1990 Farm Bill (P.L. 101-624), also known as the Food, Agriculture Conservation, and

Trade Act of 1990, and the efforts of the National Council for Agriculture Education (NCAE) to develop a national 'core curriculum' for aquaculture in 1990. Each of these events contributes to the development of aquaculture education. The National Aquaculture Act was designed to promote aquaculture production in the United States. One of its main purposes was to promote aquaculture in the U. S. by:

> …encouraging aquaculture activities and programs in both the public and private sectors of the economy that will result in increased aquacultural production, the coordination of domestic aquaculture efforts, the conservation and enhancement of aquatic resources, the creation of new industries and job opportunities, and other national benefits. (p.1)

By inference this statement includes aquaculture education. A push by the National Council for Agriculture Education to incorporate aquaculture into the agriculture curriculum led to the development of a core aquaculture curriculum. This core curriculum included a number of long term goals: (a) teach the principles of success in aquaculture, (b) impart scientific principles, and recognize the importance of managing aquatic resources; (c) use aquaculture to interest students in science, math, and other relevant subjects; (d) encourage the integration of aquaculture in other subjects and to augment greater cooperation among individuals, (e) inspire students to enter post-secondary study in aquaculture or environmental science, thereby, providing new talent to the industry, and (f) explore the potential of aquaculture as an alternative enterprise in rural communities (Frederick, 2005).

Science Literacy

Many efforts are underway to improve science education and science literacy among Americans. This education includes students as well as the general public. According to Lambert (2006):

> Scientific literacy is defined as the knowledge and understanding of scientific concepts and process required for personal decision–making, participation in civic and cultural affairs, and economic productivity. Being scientifically literate implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. (p. 633)

A 1980 report by the National Science Foundation and the US Department of Education characterized Americans as scientific illiterates (National Science Foundation, 1980). This report led to recommendations to increase academic standards within schools, place higher demands on both the teachers and the students and increase the level and number of science courses required for graduation. The effect on the agriculture teachers was to encourage them to integrate more math and science into their lessons to meet this goal. "Some agriculture educators were already working to incorporate more science into vocational agriculture courses, but they found it harder to attract students who had to fit more academic subjects into their school day" (National Research Council [NRC], 1988, p. 88). Some vocational agriculture teachers recognized that aquaculture had the potential to help meet another of the NRC (1988) recommendations which was to continue to stress applied learning but strengthen instruction and inclusion of agribusiness marketing and management, economics, international agriculture, public policy, science, and technology.

While the education system was undergoing reform in the 1980s, the practice and economic significance of aquaculture in the U. S. was growing rapidly. Scarpa (1999) hypothesized that the increase in aquaculture worldwide increased the educational demands of those students and technicians entering or currently working in the field. Expanding employment opportunities required the development of training programs (Davis-Hodgkins, 1999). Employers had difficulty locating personnel with the appropriate training and education. A survey of the catfish industry revealed that while only 6% of the respondents anticipated hiring college trained aquaculturists (Rouse, 1999). However, many of the skills desired by employers were those currently taught in the aquaculture education classes, particularly the hands-on experience (Landau, 2003). The subjects and skills desired by the industry included knowledge of water quality, aquaculture production, communication skills, and interpersonal skills (ability to work as part of a team).

Where it Started

Schools in Connecticut were among the first schools to infuse aquaculture into the curriculum. In 1981 the development of an aquaculture curriculum was seen as a means to strengthen interest in vocational agriculture schools, and in 1982 the State of Connecticut authorized creation of the Stamford Vocational Aquaculture Center (Roy, 2005). Roy notes that while the pilot program at the Stamford facility only lasted until 1984 and several other aquaculture initiatives came and went, the model of success for the vocational aquaculture program resides at the Sound School in New Haven, Connecticut. The Sound School was created in 1982 as a comprehensive school of choice in the New Haven Public School System. In 1994 The Sound School became a vocational agriculture center and today is the largest vocational agriculture high school aquaculture facility in the country (Roy, 2005). The mission of the school according to Roy is "…to help students become full participants in the global, multicultural society of the 21st century by involving them in a broad-based high school experience that focuses on aquaculture, marine issues and sciences" (p.226). Inclusion of aquaculture courses in the 1980's in the states of Massachusetts, Hawaii, New Jersey, West Virginia and Alabama further broadened aquaculture as a viable educational option (Lovett, 1999).

In 1990 the National Council for Agriculture Education (The Council) developed a core aquaculture curriculum (Team AgEd, 2009). Shortly after the development of this core curriculum Alabama schools, with sponsorship from the University of Alabama's program for Rural Services and Research, began teaching aquaculture and using recirculating aquaculture systems (RAS) in the classroom. What began as a basic RAS in Florala High School, in Florala, Alabama, evolved into a complex system including multiple large tanks and filters for both warm and cold water fish production and spawning, as well as, aquaponically grown herbs and vegetables. As word of the success of these early programs spread, interest in using this type of teaching technology grew. With additional funding from the National Science Foundation and other public and private funding sources the number of programs increased. Today there are more that 50 programs in Alabama alone using this equipment and technology to teach a variety of disciplines (see Table 1) in elementary, middle and high schools across the state. (Cline, 2000; 2004; 2005)

Table 1

Sample of Topics Addressed in the Secondary School Study of Aquaculture

Art	Fish Reproduction	Math
Biology	Food Sanitation and Safety	Mechanical Systems
Business	Genetics	Morphology
Carpentry	History	Nutrition
Chemistry	Home Economics	Plumbing
Computer Technology	Hydraulics	Public Relations
Construction	Hydroponics	Physics
Economics	Language Arts	Physiology
Finance	Masonry	Sales
Fish Health	Marketing	Sociology

While aquaculture in the classroom was initially limited to vocational and agriculture technology programs, it eventually spread to other academic areas. The number of aquaculture education programs experienced a rapid rise throughout the 1980's and 90's. Mengel (1999) and Conroy and Walker (2000) estimated that in 1997 there were 2,600 out of 11,000 or 23.6% U.S. secondary agriculture education programs teaching aquaculture. This correlated to 35,900 students receiving direct instruction annually. In addition to the direct instruction, they estimated that 138,120 additional students were exposed to aquaculture through tours and visits of the aquaculture facilities annually.

Benefits

The most commonly recognized benefit of aquaculture as an educational tool is that it is multifaceted and has the ability to integrate with a variety of subjects; therefore, it is not necessary to teach a course specifically about aquaculture to benefit from what aquaculture has to offer. According to Conroy and Walker (2000) aquaculture meets needs for instruction in basic biology, chemistry and mathematics and provides opportunities to examine concepts that are required of workers in technical jobs. There are aspects of aquaculture that can be incorporated into nearly every subject currently taught in schools. This is a bold statement considering that subjects include everything from Art to Zen philosophy. Examples of how to incorporate aquaculture into other areas of study are numerous (Conroy & Walker, 2000; Ericson, 1995; Scarpa, 1999; Schreibman & Zarnoch, 2005). It only requires a willingness of the instructor and a person or resource with specialized aquaculture knowledge to identify an area capable of aquaculture inclusion (Hammer, 2008). According to Ericson (1995) “Integrated curriculum takes things to levels of analysis, synthesis, and evaluation and should be used to help students understand concepts, problems or issues from multiple perspectives, applying what they learn to real-world problem solving” (p.142). He continues that this integration supports and enhances brain-based learning as a way to facilitate the brain’s search for patterns. Conroy and Walker (2000) imply that the value of integration extends beyond the classroom noting that integration is perceived as effective in improving opportunities for youth who will face technologies that demand high level skills.

Various authors and researchers have acknowledged the opportunities that aquaculture studies embody. In a survey (Wingenbach et al., 2000) examining the factors affecting the decision to teach aquaculture the top five responses were cited: 1) relates to natural resource conservation education, 2) motivates students, 3) fits into the curriculum, 4) is interesting to teachers, and 5) provides a means for inclusion of more science within the agriculture education curriculum. In a separate study by Lovett (1999) teachers responses to why they chose to include aquaculture indicated they: 1) wanted to broaden the students' horizons and interests, 2) thought it would increase interest in the agriculture education program, and 3) wanted to provide hands-on experiences for students that would combine a variety of scientific theories and methods. Conroy and Walker (2000) reported through a survey of teachers the observed or perceived benefits of teaching aquaculture 1) is interesting to teachers, 2) fits easily into curriculum, 3) education motivates students and 4) Teaching materials are readily available for agricultural educators to teach aquaculture. Among those teachers surveyed that were not currently teaching aquaculture but interested, the top 4 answers were slightly different. The responses included 1) teaching materials readily available, 2) aquaculture education motivates students, 3) can try out teaching aquaculture on a small scale before making decision to teach, and 4) aquaculture has a positive effect on the environment.

Aquaculture frequently appears in the science classes such as biology, botany, chemistry, earth science, marine and natural science, physics, physiology, water science, zoology and the host of environmental education options. Photosynthesis and the nitrogen cycle play critical roles in aquaculture operation management and involve chemical equations. These topics are required in a number of biology, chemistry, and earth science classes. Concepts associated with reproduction and general physiology rise to the top in the biological category while the physical movement of water and unique chemical and physical properties invite additional investigation. In order to understand these processes the students must be able to interpret and understand chemical equations and how some of the various elements react with water and oxygen (Stickney, 1979).

Not to be underestimated is the application of aquaculture in math classes. Examples of mathematical operations performed as part of daily aquaculture activities includes the measurement and calculation of averages, concentrations, density, displacement, feeding rates, feed conversion ratios, growth rates, percentages, samples, and volumes. The opportunities to infuse aquaculture related math are available from pre-kindergarten levels (one fish, two fish, red fish, blue fish) all the way through specialized post-secondary studies (fish acoustics and migration patterns). Conroy and Walker (2000) found that "Students who participated in interviews indicated that they believe aquaculture has enhanced their academic performance in mathematics and science, and made those areas more relevant for them" and that "math and science could not really be separated from aquaculture and vice versa" (p. 54). The students' comments and perceptions in Conroy and Walker's study lend credence to what Frykolm (1996) implies when he states, "…learners construct their own understanding of mathematics and, therefore, the content and teaching methodology of school classrooms should facilitate this process" (p. 666). The extent of the math involved in teaching aquaculture often requires teachers to revive their math skills. Walsh (1992a) states:

> One of the best ways that my life has changed is the influx of science and math concepts and principles into the agriculture curriculum (referring to aquaculture). I am being forced to re-learn certain math and science formulas, procedures, calculations and techniques, some of which I haven't used since my senior year in high school, and it's invigorating and exciting (p. 20).

Aquaculture will likely play a key role in feeding the earth's growing population, and there are numerous opportunities to integrate the social elements of its' expansion into the myriad of environmental political and social courses. Issues associated with

a) the production, processing, packaging, and distribution of food,

b) coastal and marine resource utilization,

c) environmental degradation,

d) global economics,

e) trade imbalances,

f) legal policies,

h) human health and sanitation,

i) watersheds and aquifers,

j) restoration of endangered species,

k) sport and commercial fisheries

can all be related to aquaculture and are relevant to many of today's current events. Fortner's (1983) surveys showed that students appeared to know more about scientific aspects of the water world than about related social studies or humanities concepts. However, she contends:

> While such emphasis admittedly is not vital to our understanding and use of water resources, experience in art, music and literature are life-enriching and culture building. An awareness of the impact of the water world in these areas builds awareness of water's pervasive influence in all aspects of human endeavor (Fortner, 1983, p. 9).

While the informational and contextual connections between aquaculture and the majority of school subjects are important, the physical pedagogical opportunities related to aquaculture should not be overlooked. Hands-on and experiential opportunities abound in both scope and scale (Mengel, 1999). The planning, design and implementation of an aquaculture operation whether it is a ten-gallon aquarium in a fourth grade classroom or a 50,000-pound foodfish production facility in an advanced agriculture technology curriculum requires a great deal of physical and mental dexterity. Teacher Michael Walsh (1992) who with his class designed and built their own aquaculture system, noted: "From design to construction and operation decisions, the problem-solving learning that took place was immense" (p.23). Vocational instructors and students are often enlisted to participate in the construction of aquaculture facilities, because the process nearly always involves plumbing and carpentry and often includes masonry, welding and mechanical problem solving skills. Authors and researchers suggest that incorporating kinesthetic elements in the learning process enhance the retention of information (Fortner, 1983). El-Ghamrini (1996) extends the benefits of aquaculture education beyond the classroom and suggests that the “Adoption of advanced aquaculture educational technologies may help economic development in the communities around those schools (with aquaculture programs) and provide job opportunities or (additional) educational opportunities to young people” (p.8). While we will look deeper into hands-on education in a later section, a statement from Wingenbach, Gartin and Lawrence (1998) sums up the integrative capacity of aquaculture education very succinctly: “At the most basic level, successful aquaculture production is the scientific and mathematical knowledge, as well as technological skills, needed to produce repeated crops of aquatic products” (p.11).

Related Educational Models

Environmental Education

There are numerous definitions for environmental education. The notion of environmental education were seen as early as W. Jackman, 1891, gave the first formal definition to the nature movement in his work. He identified the study of nature or environmental education as a means to educate urban dwellers who had lost touch with the natural world. Dewey (1938) integrates hands-on education into environmental education when he espouses the philosophy of learning by doing. Adams, Biddle, and Thomas, (1988) define environmental science as "a subset of science education that directly examines the political, cultural, and social impacts on ecological processes" (p.19). There are many variations on this theme but most encompass the notions of human interaction with the environment (Coyle, 2005). The 1977 *Intergovernmental Conference on Environmental Education* (the Tbilisi Declaration) organized by the United Nations Educational, Scientific and Cultural Organization (UNESCO) suggests principles to guiding the development of environmental education. Item number four in the recommended criteria indicates the complex interaction between people and the environment.

> A basic aim of environmental education is to succeed in making individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic and cultural aspects, and acquire the knowledge, values, attitudes and practical skills to participate in a responsible and effective way in anticipating and

> solving environmental problems, and the management of the quality of the environment. (UNESCO, 1977, p.25)

Humans are inextricably bound to the environment and are part of the environmental system. "Environmental education is rooted in the belief that humans can live compatibly with nature and act equitably toward each other" and that "…people can make informed decisions that consider future generations" (Simmons et al., 2004, p. 2).

Others assert that in addition to developing environmentally literacy environmental education can be very beneficial in improving academic achievement involving critical thinking, problem-solving, and effective decision-making skills (Lieberman & Hoody, 1998; National Environmental Education Partnership, 2002; Le Roux & Ferreira, 2005). The National Environmental Education Partnership study states

> A broader adoption of environmental education in the nation's schools can help produce motivated students, high-performance life-long learners, effective future workers and problem solvers, thoughtful community leaders, and people who care about the people, creatures, and places that surround them. As a proven method of achieving academic excellence, environmental education has been adopted as an effective tool for meeting and exceeding state and local educational standards… (p. 5)

For many the Belgrade Charter (UNESCO-UNET, 1976) and the Tbilisi Declaration (UNESCO, 1977) serve as the foundation of today's environmental education (Simmons et al. 2004). See a brief description in Table 2. They set a strong foundation for concepts and skills that an environmentally literate society should possess and highlighted the importance of viewing the environment within the context of human impacts.

Frederick (2005) refers to a collaborative work by Braus and Disinger (1998) that provides a comprehensive history of environmental education in the United States. Table 2 below indicates milestones in environmental education that Frederick chose to include in his abbreviated history.

Table 2

Important Events in the Development of Environmental Education

Date	Event
1891	*Nature Study for the Common Schools* (Jackman, 1891) gave the first definition to the nature study movement and aimed to educate urban dwellers who had lost touch with the natural world.
1911	*The Handbook of Nature Study* (Comstock, 1896), compiled from junior naturalist newsletters at Cornell University, was used to teach students natural history.
1930's	The conservation education movement develops an initiative by resource management agencies, such as the Soil Conservation Service, as a way to educate the public about vital natural resources in response to soil erosion, floods and dust storms.
1938	*Experience and Education* (Dewy,1938) outlines a philosophy of experience and its relation to education involving informal education and a philosophy of 'learning by doing'.

1950's	The rise of outdoor education developed from the concern that urban students were not having any contact or experience with the natural world. Teachers were encouraged to teach many subjects outdoors to increase these opportunities.
1962	*Silent Spring* by Rachel Carson challenged the practices of agricultural scientists and the government, and called for a change in the way humankind viewed the natural world.
1970	The National Environmental Education Act (P.L. 91-516) was signed into law, defining environmental education as the educational process dealing with man's relationship with his natural and man-made surroundings, and includes the relation of population, conservation, transportation, technology, and urban and regional planning to the total human environment.
1975	*The Belgrade Charter* (UNESCO-UNEP, 1976) was developed, and states: 'The goal of environmental education is to develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivation, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones.'
1977	*The Tbilisi Report* (UNESCO, 1978) built upon the Belgrade Charter and produced the following goals for environmental education: (a) to foster clear awareness of , and concern about economic, social, political and

	ecological interdependence in urban and rural areas; (b) to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment; and (c) to created new patterns of behavior of individuals, groups and society as a whole towards the environment.
1990	National Environmental Education Act (P.L. 101-619) re-enacted the National Environmental Education Act, giving the US Environmental Protection Agency (EPA) a Congressional mandate to strengthen and expand environmental education as an integral part of its mission to protect the environment.
1998	*Closing the Achievement Gap: Using the Environment as an Integrated Context for Learning* (Leiberman and Hoody, 1998) defined the first data regarding the use of the environment as a context for learning in all curricula for all students, and is the most reverenced document by environmental educators regarding the performance of students in science, literature and other content areas when the environment is used as the focal point for learning.

Source: Urban Aquaculture, Frederick (2005)

Frederick (2005) emphasized the link between environmental education and aquaculture education. He indicated that aquaculture education became popular as an outgrowth and extension of environmental education. He stated “Aquaculture holds great promise in promoting effective environmental education, the understanding of science concepts and the management of natural resources" (p. 233). He recognized that although aquaculture education began as part of vocational and agriculture education it could easily be part of nearly any school program.

Dinsinger (1989) examined the extent environmental-related topics were included in K-12 curricula. His survey indicated that infusion of environmental topics into other curricular areas was the prevalent delivery mechanism at both elementary and secondary levels. Disinger also examined which types of environmental education were commonly practiced and ways in which environmental education content was infused and found that nature study was the primary route of infusion in elementary schools. However, "When looked at across the K-12 board, energy education appears to be the most commonly employed approach to environmental education in the United States" (Disinger, 1989, p. 131). In secondary schools, science classes were most often named as the point of infusion and social studies to a lesser degree. While others (Adams et. al.,1988; Agne & Nash, 1974; Ham & Sewing, 1987; Ritz, 1977) agree that science classes are the area most environmental education is infused. Ham and Sewing (1987) note, "Efforts should be directed toward integrating environmental education into other curriculum areas besides science. While science should not be ignored, integration of environmental education into other subject areas might enhance its growth in public schools"…. "one way to promote this integration is to indoctrinate students in teacher education programs into a multidisciplinary view of environmental education" (p. 23). Both Ritz (1977) and Agne and Nash (1974) also espouse that environmental education is too important to be left exclusively to scientists and outdoor educators and insist that in-depth science training should not be considered a pre-requisite because practitioners of language arts, social studies and the other humanities will not get involved.

The State of Wisconsin initiated a number of efforts to infuse environmental education concepts into school systems in the late 1980s (Lane, Wilke, Champeau, & Sivek, 1994). In 1990 the Wisconsin legislature passed an act requiring the periodic assessment of environmental literacy of Wisconsin's teachers and students. In 1994 Lane et al. conducted a study to assess Wisconsin teachers' perceived competencies, attitudes and class time devoted to teaching about the environment. Based on the theory that environmental education concepts can be easily infused into a variety of subjects they surveyed a range that included agriculture teachers, art, business, health, home economics, language arts, math, music, science, social studies, and technical education. Results of their study implied that lack of training in environmental education is a major reason that teachers do not infuse the concepts. Teachers' overall attitude towards teaching environmental education was positive and agreed that environmental education should be considered a priority in their school system. However, one third of the teachers surveyed indicated that they did not teach about the environment. The primary reasons given were that they perceived environmental education did not relate to their content area or that they lacked the appropriate background in environmental education.

Adams et al., (1988), though studying in Texas agreed that the lack of teacher preparation and training in environmental education hindered its development stating "Many environmental science programs were developed but inadequate teacher training in the utilization of program materials, curricula, and implementation procedures made integration within the classroom problematic" (p. 19). Lane et al.(1994) further support the lack of training as barrier to incorporating environmental education noting that teachers top responses to what would help them infuse more environmental education concepts were improved (in-service) training and better access to resources.

While 95% of adult Americans (including 95% of parents) believe that environmental education should be taught in our K-12 schools (Coyle, 2005), some believe that it has not been utilized to its fullest potential. Disinger, (1989) noted that unlike early 1970s in 1989 the environment had become a second-tier issue and the political attention was more focused on the economy and national security issues. Dinsinger (1989) states: "It also appears that environment is, from a national perspective, a second-order issue in the schools as well as in the political arena, though there are clearly many state and local situations where it thrives…." (p. 136)

While it is true that a basic level of science is necessary to understand how the ecosystem operates, it is equally important to understand and appreciate the human aspect and role in the equation. Ritz (1977) offers advice on how to structure in-service training opportunities to attract all kinds of teachers, particularly teachers that are intimidated by the science aspect of environmental science. Ritz (1977) suggests that the training must first address the affective nature of environmental education. First and foremost, engage the teacher, get them emotionally involved. Once they are motivated, the science will follow. Ritz states, "it is the social sciences and the creative and language arts that enable us to discover and deal with human aspects of the ecosystem, provide means of aesthetic expression, and provide frameworks for combining knowledge, perception and imagination to give form to ideas" (p.42). Ritz suggests bringing teachers to workshops as teams of science and social studies teachers to help them understand how they can address the issues together. It provides a way for the teachers to interact outside of their normal confines and address topics with a greater insight. He provides a list of excellent guidelines for setting up in-service training efforts that will be inclusive and effective at bringing new educators into the environmental fold. The characteristics Ritz suggested include:

> (1) The program should deal with basic science as needed, but it should not be science dominate; (2) it should be appropriate for teachers with a wide variety of backgrounds and interests; (3) it should provide training in the methods of environmental education, as well as its content; (4) it should have a strong motivational impact on the participants; (5) it should encourage teachers to environmentalize their teaching; (6) it should bring teachers into direct involvement with the particular environments under consideration; and (7) it should make a serious effort to engage teachers in exploring their personal assumptions, values, and feelings about society and self, and the relationship of these to the natural world (p. 42).

Many of the issues of aquaculture education closely parallel environmental education. While aquaculture encompasses conceptual, physical, scientific, and socio-economic issues that could easily be integrated into nearly every school subject, the barriers and difficulties are similar. Barriers such as teachers' lack of preparation and teaching time, training, materials and facilities are among those commonly identified

(Adams et al., 1998; Ham, Rellegert-Taylor, & Krumpe, 1987; Ham & Sewing, 1987; Chankook & Fortner, 2006; Oguz, Fortner, Adadan, Gay, Kim, Yalcinoglu, Betasli, Cook-Hoggarth, McDonald, Mishler, & Manzo, 2004; Wingenbach, Gartin, & Lawrence, 2000). Never the less, one area of environmental education that has seen superior progress is the area of marine and aquatic education (Fortner & Wildman, 1980; Goodwin & Schaadt, 1978; Lambert, 2006; Picker, 1985; Rakow, 1993).

Marine/Aquatic Education

Marine biology and marine and aquatic education in general can be considered a subset of environmental education and a growing segment of science education (Goodwin and Schaadt, 1978, Lundie, 1989). Like aquaculture, marine and aquatic studies have tremendous potential for integration in the classroom. In a document developed over two years and multiple professional workshops Goodwin and Schaadt (1978) postulated "The celestial observation that from the perspective of the moon, serves as an obvious reminder for the need to improve peoples' marine and aquatic education. We are dwellers on a water world" (p.3). The need for this type of education refers not necessarily to a subject but "…to a fundamental that pervades all aspects of human life, one which should be woven into the total fabric of education" (Goodwin & Schaadt, 1978, p.4), and should be integrated into every subject taught in our schools and incorporated into existing educational programs.

After naming that the unifying factor of all things marine is saltiness, Goodwin and Schaadt (1978) defined the marine environment as that portion of the environment that contains or is directly influenced by salty water. While the word aquatic is defined by Parker (2002) as growing or living in or upon water Goodwin and Schaadt (1978) indicated that the word is most commonly associated with fresh water.

Goodwin and Schaadt (1978) defined education in the broadest possible sense as the "entire variety of experiences through with people learn: formal and informal educational activities from kindergarten to graduate school and continuing education; recreational, work, and life experiences, and all forms of communication from personal to mass media" (p. 6).

Given these definitions of marine, aquatic and education, Goodwin and Schaadt (1978) arrived at the definition of marine and aquatic education as the part of the total educational process which enables people to develop sensitivity to and general understating of the role of the seas and fresh water in human affairs and the impact of society on the marine and aquatic environments. They added that the goal of this education does not and should not exist in isolation but an integral part of both environmental and general education. They cited the following goals that if achieved would result in the American public becoming "literate" in marine and aquatic affairs. The goals they listed were to 1) develop a public which has a basic understanding of the marine and aquatic components as part of the whole environment and their importance to American life and society; 2) create a public with an awareness of and sense of responsibility for water; to evolve a new water ethic embracing the proper uses, protection, and conservation of the oceans, the coastal zone, and freshwater resources; and 3) motivate people to take part in decisions affecting the sea and fresh water while equipping them with principles and information necessary to evaluate problems, opportunities and events.

Fortner and Wildman (1980) provide an equally broad definition of marine education stating: “Marine education includes all formal and informal education experiences that impart information about the relationship of the global sea to all world systems and the impact of society upon that sea” (p. 717). Marine education is part of a larger movement that has been underway for some time under various banners that include conservation education, outdoor education, and most recently environmental education. Fortner and Wildman espoused that marine education is more than marine science education. Beyond the science components of biology, chemistry, geology, meteorology, and physics there is recognition that the oceans also impact economics, global culture, and politics.

To demonstrate the scope of marine education Fortner and Wildman (1980) refer to a survey of 400 marine science educators that yielded information about programs in 30 states involving approximately 20,000 students in grades 7-12. Prior to the development of stand-alone marine science or marine education classes, most of the marine studies elements were designed for infusion into existing science programs as interest blocks or as Fortner & Wildman (1980) noted;

> “Because of budget considerations, lock-step sequencing requirements, back-to-basics trends, and the general level of demands on teacher time, educators rarely attempt the establishment of new precollege marine courses. What has proven to be more acceptable to teachers is the instructional module that treats a standard

curriculum topic in a new way, in this case by using an oceanic or aquatic example of the concept. This curriculum infusion model allows marine education to become a topic for any discipline from language arrest to home economics, from physical education to physics" (p. 719).

An exemplary curriculum that demonstrates the infusion capacity of aquatic subjects was *Living in Water* (LIW) a set of 50 activities divided into six areas developed by the National Aquarium in Baltimore for grades 5-7. By 1989 the curriculum was used nationally and the aquarium was awarded a National Science Foundation grant to train master teachers to continue the national dissemination. At the LIW workshops, trainers provided a variety of hands-on activities for participants in small groups, exposing teachers to scientific principles and providing cooperative group experiences (Visconti-Phillips, 1998).

Lambert (2006) agrees that aquatic topics have great capacity for infusion and suggests that marine science provides both an excellent platform to develop scientific literacy and a means to build a truly integrated instructional approach incorporating elements of physical science, life science, earth and space science, technology, and science from personal, social and historical perspectives. Working with nine secondary teachers from seven counties in Florida she tested the scientific literacy of nearly 400 secondary students before and after taking an approved marine science course. While the course content and teaching styles varied, the results of her investigation indicated a small but statistically significant improvement in scientific literacy (based on content from the National Science Education Standards developed by the National Research

Council and Benchmarks for Science Literacy developed by the American Association for the Advancement of Sciences). Picker (1985) echoes Lambert's sentiment stating, "From an emphasis on marine science topics, aquatic education curricula have now evolved to include those nonscience aspects of the aquatic world which are considered fundamental to the overriding goal of producing and informed, aquatically literate public" (p.665). Both Lambert and Fortner (2001) agree that marine science and aquatic education activities can be used as a model for teaching integrated science as long as the curricula and instructional practices are aligned with national standards and meet teachers' needs.

To find out what teachers' needs are, researchers examined teachers knowledge of marine and aquatic topics and their perceived priorities about teaching them (Goodwin & Schaadt, 1978; Beiswnger, Milkent, Irby, & Story, 1979; Lundie, 1989; Sturges & Jones, 1992; Rakow, 1993; Fortner & Meyer, 2000). These researchers found that the majority of teachers surveyed thought marine and aquatic topics were important. Fortner (2001) suggests that from their responses it is possible to identify which topics teachers want to know more about and why they are not teaching some topics (identifies topics that do not fit the curriculum, and also points out the need for materials in some cases). Lundie's (1989) survey of nearly 300 science and social studies teachers in North Carolina found that 86% of the teachers included some marine concepts in their classroom. The studies also found that teachers' perceived importance of a topic was directly correlated with their knowledge of the topic. Topics teachers felt the most knowledgeable about included the:

1. water cycle (Lundie, 1989; Beiswenger et al., 1992; Fortner & Meyer, 2000)
2. properties of water (Rakow, 1993
3. sea as a source of food (Milkent et al., 1979)

The topic with the highest priorities included:

1. pollution of water (Lundie, 1989)
2. the water cycle (Beieswenger et al., 1991)
3. properties of water (Fortner & Meyer, 2000; Rakow, 1993)
4. marine ecology (Milkent et al., 1979).

A potential method to address the gap between teachers' knowledge and priorities is in-service training. Rakow (1993) surveyed environmental educators and six topics emerged as prime areas for in-service training and future curriculum development. These topics, which a majority of teachers rated as high or highest priority yet less than half of them considered themselves knowledgeable enough to teach included: (a) aquatic ecology, (b) the water table, (c) wetlands, (d) toxic waste dumping, (e) aquatic food webs, and (f) the influence of the aquatic environments on man. In a similar study, to maximize the potential impact of this type of training Fortner and Meyer (2000) examined the discrepancies between teachers' priorities and knowledge of various freshwater topics. Among the topics with the highest rated priorities there was the greatest discrepancy between priority and knowledge about 1) an ecosystem approach, 2) wetlands, 3) aquatic life, 4) endangered species, and 5) food webs.

Outdoor Education

Outdoor education can be interpreted in numerous ways. Outdoor education may manifest itself as science education, agricultural education, outdoor recreation, camping education, nature study, and the hows and whys of natural phenomena. (Carlson, Donaldson, Masters, & Smith, 1963; Hammerman & Hammerman, 1964; Hammerman, 1980; Gilberson, McLaughlin, & Ewart, 2006; Jelmberg, Goodman, Breunig, & McLaren, 2008). Carlson et al. (1963) define outdoor education as

> … conceived to mean learning in and for the outdoors….Outdoor education is a means of curriculum enrichment through experiences in and for the outdoors. It is not a separate discipline with prescribed objectives like science and mathematics; it is simply a learning climate which offers opportunities for direct laboratory experiences in identifying and resolving real-life problems, for acquiring skills with which to enjoy a lifetime of creative living, for attaining concepts and insights about human and natural resources and for getting us back in touch with those aspects of living where our roots were once firmly established. (p. 19)

While outdoor education may be thought by some to be simply the educative process conducted outdoors, authors stress that this process includes both the cognitive and affective aspects of learning and include sight, sound, taste, touch, and smell (Carlson et al., 1963; Gilberson, Riveken, 2000; McLaughlin, & Ewart; 2006). Priest (1986) describes outdoor education as a host of relationships that make up the experiential learning process. These relationships include interpersonal, intrapersonal, ecosystem, and ekistic relationships, which are the interactions between human society and the natural resources surrounding it. Dumouchel (2003) perceived an even broader relationship between outdoor, adventure, and environmental education indicating they would fit well into a Venn diagram of overlapping circles each with their own individual aspects but sharing John Dewey's (1938) commonality of experiential learning or learning by doing.

Historical Development of Outdoor Education

Numerous educators and philosophers such as Comenius, Dewey, Froebel, Herbart, James, Pestalozzi, Rousseau, Spencer, and Thorndike have all supported the need to reinforce abstract, or book learning, with concrete experiences (Hammerman & Hammerman 1964, Hammerman, 1980). Hammerman (1980) credits Sharp (1943) with one of the simplest statements that defines outdoor education. "that which ought and can best be taught inside the schoolrooms should there be taught, and that which can best be learned through experience dealing directly with native materials and live situations outside the school should there be learned" (p.24). Other authors (Jelmberg et al., 2008) link the outdoor classroom and its' ability to educate and inspire all people, rich or poor; educated or not; and from all cultures to the philosophy of Paulo Freire. Freire, the Brazilian educator and social visionary, felt that the education of all people, regardless of social or economic status was the key to overcoming poverty and social inequality.

Few will argue that camping, or more formally known as resident outdoor education was the forerunner of today's outdoor education/classroom. Hammerman (1980) provides a brief timeline of camping movement.

Table 3

Timeline of Camping

Date	Event
1823-4	The Round Hill School organized by George Bancroft and Joseph Cogswell sponsored outdoor education, hikes and camping.
1861	Frederick W. Gunn credited with starting the first organized camp in America at Milford-on-the-Sound
1948	The National Education Association recommended that the camping experiences should be provided to all youth as part of the public education program.
1951	Lloyd B. Sharp founded the first National Outdoor Education Association
1955	Establishment of the Outdoor Education Project by the American Table 3 (continued) Association for Health, Physical Education and Recreation
1964	Establishment of the Council on Outdoor Education with representatives from many fields, most significantly education, conservation, and recreation.

Fitzpatrick (1968) developed a statement of philosophy for outdoor education: "Outdoor education is a method which utilizes resources beyond the classroom as a stimulus for learning and a means of curriculum enrichment (p. 37). Fitzpatrick indicates that although the idea of outdoor education has been around for several generations of American education emphasis on outdoor education did not begin in earnest until the

1940s. In 1948 the National Education Association recommended that camping experiences should be provided to all youth as part of the public education program. In the 1950's camping programs had the attention of the public, and in 1955 the American Association for Health, Physical Education and Recreation initiated the Outdoor Education Project. The project aimed to expand outdoor education beyond camping and improve leadership in teaching skills and increase the understanding of the outdoors as an educational enhancement. As early as 1964, authors recognized the ability of television, an electronic resource, to bring the marvels of the outdoor world into the living room or classroom (Hammerman & Hammerman, 1964). Despite this novel new resource many children today are largely oblivious and unaware of the natural wonders unfolding around them. The daily drama of life and death that occur every day among the insects and small animals in the back yard or on the school grounds go unnoticed. When computers, iPods, and cell phones are added the distractions of daily life, chances of reversing this trend is more difficult than ever.

Functionality of Outdoor Education

Education outside of the classroom just as important as that which occurs indoors (Hammerman and Hammerman, 1964).

Jelmberg et al. (2008) suggest that the outdoors is an ideal learning environment:

> In today's confusing culture… almost all youth require authentic (outdoor) activities to build connection to real-world meaning for the value of one another and the need to protect our environment. Often lost in a make-believe world of video games and a mass-marketed culture of violence and escapism, today's

> youth need mentoring to guide them to the world of authentic experience and personal connectedness. (p. 5)

The writings of Carlson et al. (1963) suggest that urbanization, mechanization and the automation of the work environment have led to a degradation of both man's physical well-being and his connection to his original habitat (the land). They suggest that all entities associated with the educative process (home, school, church, community agencies and government) should include outdoor education components.

> Learning from and through nature is and always has been a part of the developmental process of human beings. It is not surprising, in the midst of a materialistic culture fraught with the problems created by a high degree of industrialization, that society seeks to rediscover the link between man and the earth from which he sprang. (Carlson et al. 1963, p. 14)

Outdoor education has the capacity to meet the physical, emotional, and spiritual needs of today's citizens. They go on to say that it is generally accepted that direct experience and problem solving are among the most important educational methods. It is apparent that thinking and doing cannot be separated. Outdoor classrooms enable children, as well as adults, to use all of their senses to gather information. Sight, sound, smell, taste, and feeling are all important components in learning and are abundantly available in the outdoor classroom.

Outdoor classrooms provide materials for learning and makes good use of a community resource. The outdoor classroom is a well-equipped laboratory with a variety of live, colorful and manipulative resources and opportunities. It is an easy way to extend learning beyond the four walls of the classroom and connect classroom studies to the "real world." Children often feel more comfortable outside of the classrooms' restrictive rules and procedures and are less inhibited allowing them to freely communicate and improve their communicative abilities (Carlson, 1963). Hammerman and Hammerman (1964) agree that the outdoor classroom is wide open and describe the outdoor classroom as one in which the boundaries are always changing. The floor, walls, and ceilings change by location and time and there is a limitless variety of study opportunities. The classroom is as large as the student cares to venture.

Students who have the opportunity to experience abstract concepts first hand usually learn faster and are able to retain the knowledge longer than if the information came solely from reading a book. Hammerman and Hammerman (1964) state:

> The pupil substitutes his own direct experience in the form of sights, sounds, odors, tastes and feelings for mere words in a text, and thus enhances and makes more meaningful the great mass of verbal knowledge to which he has already been exposed. (p.43)

Fitzpatrick (1968) concurs stating:

> Outdoor education is a method which utilizes resources beyond the classroom as a stimulus for learning and a means of curriculum enrichment. By extending the learning environment beyond the classroom, theoretical knowledge is enriched by practical knowledge gained through firsthand experiences with people, places, and things. The knowledge obtained through this direct approach to learning should enable the individual to better understand the unity of all life. It should

> also help him to develop a sense of pride for the historical, educational, scientific, recreational, and inspirational values that are part of his heritage. Ultimately, he should be able to play a more constructive role in the society of which he is part. (p. 37)

It is generally accepted that direct experience and problem solving are among the most important educational methods. It is also apparent that thinking and doing cannot be separated (Carson et al., 1963). As an example of the development of pride and values Carson et al. (1963) and Ryan, (1991) report that when school children actively participate in outdoor classroom conservation activities such as planting a tree, helping control soil erosion or constructing a learning facility they immediately feel a responsibility for the care and use the resource and facilities.

Referring to the outdoor classroom from a pedagogical perspective, Gilberson et al. (2006) state:

> … any educational philosophy or method must meet the needs of a particular curriculum, whether it is part of an organized school system, private business or not-for-profit organization. In other words, the setting and method of instruction must work in concert to fulfill the organizations educational mission. (p. 12)

In many cases fulfilling the educational mission includes teaching a variety of subject areas. Outdoor classrooms and outdoor activities cross all subject matter areas. Table 4 indicates some of the potential curricular areas available in the outdoor classroom.

Table 4

Potential Curricular Areas Available in the Outdoor Classroom

Subject matter area	Specific disciplines or example activities
Art	Campfire cooking, painting, rock collecting, sculpture with natural materials, wood crafting.
Physical education	Archery, casting, orienteering, shooting, skiing, running and water sports.
Humanities	Creative writing, poetry, storytelling
Sciences	Agriculture, biology, botany, entomology, geology, ornithology, and zoology.
Music	Campfire singing, nature songs, and using natural materials as instruments.
Social Studies	Anthropology, group dynamics, and history.

One of the many educational techniques commonly applied in outdoor education is problem solving. As Hammerman & Hammerman (1963) concur this techniques is the essence of learning in real life and is the way most of us learn when we are sufficiently motivated or curious about something to investigate it on our own. They add that resident outdoor education, or camping, has the added benefits of placing the students and teachers in an environment where they learn more about each other. Students see teachers as a real person eating three meals a day and performing other daily activities just like they do. The teachers also have the opportunity to view and interact with students in a more open and familial setting without the structured confines and rules associated with a classroom environment. The extended time spent together allows uninterrupted teaching and taking whatever time is necessary to fully discover experience and learn about a particular subject.

A common theme that runs through the definitions of outdoor, environmental, marine, and aquatic education is that through direct structured experiences, indoors or out, people learn about nature, themselves, and their place in the community and ecosystem. Carlson et al. (1963) identify eight similar characteristics inherent in outdoor education that expedite the learning process: (a) direct experience, (b) discovery, exploration and adventure; (c) sensory learning, (d) activities natural to childhood and youth, (e) intense interest, (f) problems are reality based, (g) problems in context, and (h) in general it is very active. Each of these areas incorporates hands-on activities that enable and enhance their educational potential. This hands-on learning is known as kinesthetic learning and will be reviewed next.

Hands-on Learning

The term hands-on learning has become a common phrase in today's education arena. Like many commonly used terms it has different meaning to different people. In this section we will examine several definitions of hands-on learning, why it is used or should be used, a brief discussion of its history and some of the barriers identified restricting its' use.

Learning takes many forms. It can be cognitive (gaining new knowledge), psychomotor (obtaining a new physical skill), or affective (learning how to communicate more effectively). There are multiple theories of learning including behaviorism, humanism, constructivism and others. Hands-on learning draws its philosophical support from theoreticians such as Pestalozzi, Friere, Lewin, Piaget, Dewey, Bruner, Kolb, and others who collectively represent a constructivist view of knowledge and learning (Kolb, 1984; Haury & Rillero, 1994; Duffy & Cunningham, 2007; Flick, 1993; Korwin & Jones, 2009; The Historical Roots, 2009). This view holds that students participate significantly in the teaching-learning process using prior knowledge to make meaning out of new experiences. “Constructivism looks at learning as an active process in which the learner builds on prior knowledge to select and transform information based on their own cognitive structure (patterns of mental action that form intellectual activity)” (Friesen & Kristjanson, 2007, p. 41). Wilson (1999) expounds on the variations in which individuals construct their own knowledge. He states:

> The human genome dictates that at the species level we are all the same, while at the individual level we are all different. How does this work? The British psychologist Henry Plotkin says it is done with what he has called “heuristics” - he means inherent, individually specific physical and mental capacities by which we tune into and react to important conditions or events in the environment (paragraph 34).

In its’ simplest form the term hands-on learning or hands-on education is as Dewy (1938) describes it learning by doing. In addition to recognizing Dewey as one of the strongest proponents of learning by doing, Richardson (1994) notes that among the United States' Cooperative Extension Systems and Land Grant universities:

> Perhaps the most well known proponent of learning by doing is indeed the person generally recognized as the "father" of Extension--Seaman A. Knapp. He stated that: "What a man hears, he may doubt; what he sees, he may possibly doubt, but what he does, he cannot doubt (paragraph 2).

The term hands-on implies that students will physically put their hands on objects as opposed to just reading about them in a book. "Students work directly with materials and manipulate physical objects to physically engage in experiencing science phenomena" (Bruder, 1993, p.23). Hands-on learning, however, requires more than just a simple definition to describe it. It is more than just a set of activities, it is a philosophy. A Chinese proverb tells us "Tell me and I'll forget; show me and I may remember; involve me and I'll understand" (Friesen& Kristjanson, 2007).

Hands-on learning can be described in many ways each of which has its own specificities. Haury and Rillero (1994) suggest that "It (hands-on learning) is engaging in in-depth investigations with objects, materials, phenomena, and ideas and drawing meaning and understanding from those experiences" (p.15). It requires students to become active participants in the learning process which has great value in improving student understanding, particularly of science topics.

> There are two ways that we find the term hands-on science in common use today. The first, uses hands-on science to refer to a general approach to instruction. Hands-on science can be thought of as a philosophy guiding when and how to use

> the broad range of teaching strategies needed to address diversity in contemporary classrooms…. The second way hands-on science is commonly used is in terms of a specific instructional strategy where students actively engage in manipulation of materials, using what is called a hands-on science activity (Flick, 1993, pp.1-2).

Korwin (2009) indicates that technology education has also been positively affected by the use of hands-on activities to relate concepts and notes that “there is a significant difference between learning with and without hands-on activities….organized psychomotor participation increase the learning of a technical concept” (p.3).

> The term hands-on is so widely used that it is hard to believe that it is something of a newcomer. It first surfaced in the late 1960s meaning to learn how to use a computer by actually using ones hands-on the keyboard, as it were. Although the computer people coined the term, the idea of learning by doing is an ancient one in the arts and crafts, and it has become a mark of good teaching in science and math (Rutherford, 1993, p. 5).

The philosophy of hands-on learning is often considered synonymous with experiential, hands-on-minds-on, and inquiry based learning (Kolb, 1984; Flick, 1993; Rutherford, 1993; Haury & Rillero, 1994; Fortner, 2001).

> This perspective on learning is called ‘experiential’ for two reasons. The first is to tie it clearly to its intellectual origins in the work of Dewy, Lewin, and Piaget. The second reason is to emphasize the central role that experience plays in the learning process. This differentiates experiential learning theory from rationalist and other cognitive theories of learning that tend to give primary emphasis to

> acquisition, manipulation, and recall of abstract symbols, and from behavioral learning theories that deny any role for consciousness and subjective experience in the learning process…. Experiential learning theory a holistic integrative perspective on learning that combines experience, perception, cognition, and behavior (Kolb, 1984, p. 20-21).

Theories of Dewey, Friere, Lewin, and Piaget all encompass at least 3 common elements of learning in what is called the learning cycle, (a) some form of concrete action, (b) reflection about that action and (c) the development of knowledge from that action/reflection to apply to new situations (Kolb, 1984). Additionally, Kolb (1984) provides other common characteristics of experiential education including: (a) Learning is best conceived as a process, not in terms of outcomes; (b) Learning is a continuous process grounded in experience; (c) The process of learning requires the resolution of conflicts between dialectically (arriving at the truth by the exchange of logical arguments) opposed modes of adaptation to the world; (d) Learning is a holistic process of adaption to the world; (e) learning involves transactions between the person and the environment and (f) learning is the process of creating knowledge.

History of hands-on Education

The history of hands-on education requires us to look into our distant past as a species. The intimate connection between the human hand and its activity and the development of creative thinking and language capacities has developed for 100,000 years. Wilson (1999) relates in fascinating detail the pivotal role of hand movements in particular in the development of thinking and language capacities and in developing deep feelings of confidence and interest in the world. These elements together are essential prerequisites for the emergence of the capable and caring individual. Wilson describes the development of the hand and how small anatomical changes in the hands structure made enormous impact on human capabilities. For instance, the development of the index and middle finger and their ability to grasp and throw objects allowed the earliest *Homo sapiens* to hunt by throwing rocks. Later development of the ability to move the third and fouth fingers across the hand towards the thumb (Ulnar opposition) greatly increased the grasping and manipulative potential of the hand. These new anatomical abilities allowed the hand to grip and manipulate larger objects in varying shapes such as a club or spear. The simultaneous development of the brain allowed the humans to manipulate the hands with ever greater control. Wilson (1999) notes:

> Since it does not seem likely that the brain's remarkable capacity to control refined movements of the hand would have predated the hand's biomechanical capacity to carry out those movements, we are left with a rather startling but inescapable conclusion: it was the biomechanics of the modern hand that set the stage for the creation of neurologic machinery needed to support a host of behaviors centered on skilled use of the hand. If the hand did not quite literally build the brain, it almost certainly provided the structural template around which an ancient brain built both a new system for hand control and a new bodily domain of experience, cognition, and imaginative life. (Wilson, 1999, paragraph 30)

Educational theory supporting psychomotor activities to aid cognitive growth had its origins in the 1700's. Though experiences were often part of personalized education, such as apprenticeships or trades passed from generation to generation, Jacque Rousseau and JoHann Heinrich Pestallozzi proposed that doing was not an end in itself, but a way of expanding learning (Barlow, 1967). Table 5 provides a list of a few of the important figures in the history of hands-on learning.

Table 5

Historical Timeline of Hands-on Education

Date	Event
1760s	Rousseau published a treatise on education in which he argued that the senses were the basis of intellectual development and that the child’s interaction with the environment was the basis for constructing understanding. Rousseau emphasized learning by doing with the teacher’s role being that of presenting problems that would stimulate curiosity and promote learning. (Duffy & Cunningham, 2007)
1780s	Pestalozzi extended Enlightenment ideas into education by having students learn from experiences and observation rather than from the authority of the textbook and the teachers. Among Pestalozzi’s most important philosophical contributions to education are (a) instructional methods that encourage harmonious intellectual, moral, and physical development; (b) his methodology of empirical sensory learning, especially through object

	lessons; and (c) his use of activities, excursions, and nature studies that advanced progressive education.
1810-30's	Froebel's *The Education of Man* (1826) had a profound effect on the approach to early childhood education. Friedrich Froebel believed in the development of intelligence and character through activities that engaged the interest of children. In 1837 Frobel established the first kindergarten based on his theories. Froebel labeled his approach to education as "self-activity". This idea allows the child to be led by his or her own interests and to freely explore them. The teacher's role, therefore, was to be a guide rather than lecturer.
1860s	Pestalozzi's ideas of using objects for teaching were spread in America in the 1860s. The Object Teaching Revolution occurred as a direct result of teacher education (Rillero, 1993). This movement challenged the dominance of the textbook in education and promoted active learning by students.
1893	The Committee of Ten (National Education Association, 1893) was instrumental in securing a permanent place for science in the American school curriculum. The science committees repeatedly stressed the importance of object manipulation by students. The Physics, Chemistry and Astronomy Committee recommended "That the study of simple natural phenomena be introduced into the elementary schools and that this study, so far as practicable, be pursued by means of experiments carried on by the

	pupil" (National Education Association, 1893, p. 118).
1900	Maria Montessori, an Italian educator and originator of the educational system that bears her name developed an education system based on the belief in the child's creative potential, his drive to learn, and his right to be treated as an individual (Montessori, 2009) As a physician, Dr. Montessori was very involved with the care of young children. Through scientific observation, she came to see how children interacted with one another, learned through the use of materials she provided, and went through specific phases of development.
1910-40s	John Dewey was perhaps the greatest proponent of situated learning and learning by doing. Dewey, like Rousseau, reacted against the traditional educational framework of memorization and recitation and argued that "education is not preparation for life, it is life itself." Also like Rousseau, Dewey was responding to the need for restructuring education to meet the changing needs of society, in this case the start of the Industrial Age in America and the demands of industrial technology. Dewey argued that life, including the vocations, should form the basic context for learning. In essence, rather than learning vocations, we learned science, math, literature, etc., through vocations (Kliebard, 1986).
1920's	Swiss psychologist, Piaget, was the first to make a systematic study of the acquisition of understanding in children. Piaget described two processes used by the individual in its attempt to adapt: assimilation and

	accommodation. Both of these processes are used throughout life as the person increasingly adapts to the environment in a more complex manner. Using mostly case studies Piaget identified 4 cognitive stages that were closely intertwined use of the hands and all of the senses to relate to the environment. The 4 cognitive stages in order of development include (a) the sensorimotor stage, (b) pre-operational stage, (c) concrete operational stage, and (d) formal operational stage (Huitt & Hummel, 2003).
1960s-70s	Like Rousseau and Dewey, Jerome Bruner saw learning in the activity of the learner. In particular he emphasized discovery learning, focusing on the process of discovery in which the learner sought understanding of some issue. Within this context, Bruner emphasized that the issues or questions that guide the discovery process must be personally and societally relevant (Bruner, 1966).
1970s ->	Experiential education has made many in-roads with the mainstream educational establishment in science and industrial arts. Industrial arts has always used various projects to stimulate interest, develop skills, and increase learning. Technology education has continued to focus on hands-on activities and modified them, helping students become technologically literate by developing problem solving adaptation skills and a positive attitude toward technology (Martin, 1985).

The advent of the computer and its' evolution into a graphically rich and interactive environment have inspired researchers to explore the possibilities of integrating it as another hands-on education tool. Using the computer as a learning tool, computer based instruction (CBI), has yielded positive results in several areas. Kulik (1994) conducted a meta analysis of computer based instruction and identified four major points emerging from the meta analyses: (a) students usually learn more in classes when they receive CBI, (b) students learn their lessons in less time with CBI, (c) students like their classes more when they receive computer help in them, and (d) students develop more positive attitudes towards computers when they receive help from them in school. Ayers and Melear (1998) showed that the use of multimedia and computer aided instruction (CAI) I was also of benefit to informal education outside of the classroom. They tested whether the use of an interactive multimedia exhibit was more effective than a traditional hands-on exhibit in teaching physical science concepts in a museum setting. While both exhibits were effective in attracting and engaging students, they found that students exhibited increased learning when they interacted with a multimedia exhibit. Swann, Branson & Talbert (2003) while working with Cooperative Extension agents found that CBI was also effective in training educators as students. They did note however that

> They [Extension Agents] prefer a variety of delivery systems when receiving in-service training. A combination of CBI, web, electronic mail, internet chat software, internet discussion groups, satellite teleconference, phone conferencing,

> small group interactions, hands-on activities, and face-to-face lecture would be preferred to the use of only one or two delivery methods. (Implications section)

Another Cooperative Extension Specialist (Richardson, 1994) concurred with Swann et al., (2003) findings indicating a preference for multimodal learning. Richardson found that both adult clientele and new county agents preferred to gain new knowledge and skills through experiential opportunities that included elements of doing, seeing and discussing.

Yaakub and Finch (2001) identified yet another positive attribute of computer assisted instruction and showed that computer-assisted instruction focusing on higher order learning in technical education was more effective than traditional instruction. These findings indicate that the computer is more than simply a hands-on tool but a means to transform these activities into higher order thinking skills such as analysis, synthesis, and evaluation. While computer based and computer-aided instruction has shown great promise in the improvement of learning, Wilson (1999), wrote the wholesale replacement of hands-on activities with computer generated images, mouse, and keyboard may be an enormous mistake for which we will not see results for 20-30 years:

> Suppose, for example, that it turns out that kids are like free-range chickens with respect to early childhood hands-on experiences. It doesn't really matter precisely what they pick up and tinker with, or pull apart and try to put back together, but they actually need to do *something* of that kind or else they will turn out later to be incapable of grasping not just a screwdriver or a wrench but an *idea* that comes easily when you can remember what such a tool feels like or behaves in your

> hand, and doesn't come to you at all if you have never had your hands on anything but a computer keyboard or a mouse or a joystick (paragraph 50)…They [computers/internet] can never replace the "human dimension" the teacher's voice telling stories that feed the child's imagination; the teacher's helping hand helping the child's to grasp the butterfly net; the teacher's eye and heart that see, as no machine will ever see, the spark of recognition in the child's face (paragraph 61).

While current research supports the notion that the brain learns best through rich, complex, and multi-sensory environments, Jensen (2000) stresses the need to place learning by doing activities into socio-cultural contexts. Lauda and McCrory (1986) noted that industrial arts evolved into a discipline oriented toward developing skills for the skills themselves rather than developing knowledge of industry. Hands-on activities included building projects that incorporated the learning of "...technical processes without conscious concern of the socio-cultural context in which they exist..." (p. 28).

Roberts (2007) agrees and states, "We must move beyond mere 'learning by doing' ….Using only the learning by doing definition, experiential education becomes nothing more than activities and events with little to no significance beyond the initial experience" (Chap 2, p.9).

Barriers

Each of the educational models examined (aquaculture, environmental education, marine/aquatic education, outdoor education, and hands-on education) were at one time considered new and innovative and as such encountered significant barriers to implementation. Often times, particularly in schools, innovativeness is met with resistance. El-Ghamrini (1996) alludes to some of the reasons for the lag in educational innovativeness. He cites the lack of economic incentives for teachers to adopt new ideas and take on additional work. Teachers are generally paid based on their tenure and level of educational attainment regardless of their innovativeness. Lovett (1999) concludes that the extra time required to develop (aquaculture) curriculum, run the aquaculture labs, and set up and maintain the systems was the first drawback to offering aquaculture classes. Other researchers concur that the shortage of time, both teaching and preparation, and the additional work load are significant barriers to implementing any of these innovative educational models (Byo, 1999; Conroy, 1999; Conroy & Walker, 1998; Fortner & Wildman, 1980; Wingenbach et al., 2000).

While Lovett (1999) found time to be the limiting factor in implementing new areas of study, most other researchers found that teacher training and education about the subject matter was the primary limitation to their implementation and inclusion with existing subject matter (Carlson et al., 1963; Fortner, 2001; Garton & Chung, 1996; Lane et al., 1994; Lundie, 1989; Milkent et al., 1979; Picker, 1985; Ritz, 1977; Schriebman & Zarnok, 2005; Wingenbach et al., 2000).

The third most commonly identified barrier to implementation was the real or perceived lack of quality curriculum materials (Adams et al., 1988; Garton & Chung, 1996; Lane et al., 1994; Picker, 1985; Wingenbach et al. 1998, 2000). Five other barriers that were identified included the high cost of equipment and new or remodeled facilities (Adams et al., 1988; Byo, 1999; Conroy, 1999; Wingenbach et al. 1998, 2000); inflexible or full curriculum (Fortner & Wildman, 1980; Conroy, 1999); the belief that the new subject matter was unrelated to the teachers disciplines (Lane et al.; Ritz, 1977; Goodwin & Shaadt, 1978); territorial issues between teachers (Conroy & Walker, 2000); and administrative support (Picker, 1985).

World Aquaculture

The Food and Agriculture Organization of the United Nations [FAO] report (2007) entitled *The State of World Fisheries and Aquaculture 2006* provides an excellent thesis statement of current aquaculture.

> Aquaculture is developing, expanding and intensifying in almost all regions of the world, except in sub-Saharan Africa. Global population demand for aquatic food products is increasing, the production from capture fisheries has leveled off, and most of the main fishing areas have reached their maximum potential. Sustaining fish supplies from capture fisheries will, therefore, not be able to meet the growing global demand for aquatic food. Aquaculture appears to have the potential to make a significant contribution to this increasing demand for aquatic food in most regions of the world…" (FAO, 2007, p.iv)

These sentiments are echoed by The World Fish Center (2008) and indicate the importance of aquaculture as a potential food supply for the world's 600 million people who do not have enough to eat. Historically, the oceans were considered a limitless source of food and fish. However, in the last 10 years total capture fisheries has leveled off to around ninety million metric tons (Carlberg, 2001) and forced people to re-evaluate their view of the ocean as an infinite food resource. The executive summary of the Pews Oceans Commission's report, *America's Living Oceans: Charting a Course for Sea Change* states that, "Thirty percent of the fish populations that have been assessed are overfished or are being fished unsustainably. An increasing number of these species are being driven toward extinction" (Pews Ocean Commission, 2003, p. vi), and that:

> We have reached a crossroads where the cumulative effect of what we take from, and put into, the ocean substantially reduces the ability of marine ecosystems to produce the economic and ecological goods and services that we desire and need. What we once considered inexhaustible and resilient is, in fact, finite and fragile (p. v).

According to the FAO (2006) world aquaculture has grown at an average annual rate of 8.8 percent from the early 1950's to 2004. In 2009 they reported that the total aquaculture production was close to 51.6 million tons in 2008, and that this production represents roughly fifty percent of the total seafood supply. While aquaculture is still considered an emerging industry compared to agriculture, the value of the global seafood trade (as measured by imports) surpassed the $100 billion mark for the first time ever (FAO, 2009). To compare these figures to growth in agriculture Ernst (2000) indicated that:

> Since 1984, global aquaculture output has increased at an average annual rate of about 10%, compared with a 3% increase for livestock meat and a 1.6% increase for capture fisheries. Aquaculture provided 8% of global fishery production (11% food fish) in 1984, increasing to 22% (29% of food fish) in 1996" (p.1).

China and the rest of Asia account for more than 90% of the production (China 69.6% and the rest of Asia 21.9%) while North America (the U.S. and Canada) account for only 1.3%. Although the production in China is very high they focus on relatively low value species such as carp and seaweed. Therefore, the total value of their production is only 45% of the global market is much less than their 69.6% production biomass.

An FAO consultant, Garibaldi (1996), identified at total of 262 aquaculture species including 151 fish, 39 crustacean and 72 mollusks. This number is increasing yearly with emphasis in recent years on developing technologies to reproduce and grow marine species with high market value.

Aquaculture is conducted in nearly all aquatic environments including freshwater, brackish, and marine utilizing a variety of production techniques and levels of intensity (Stickney 1979). Aquaculture species can be divided into numerous categories. Among the most common are: freshwater finfish (catfish, carp, tilapia); marine finfish (salmon, mullet, milkfish); freshwater crustaceans (crayfish, freshwater prawns); marine crustaceans (shrimp, lobster, crabs); marine mollusks (clams, mussels, oysters); marine gastropods (abalone, conch), and freshwater and marine algae (microscopic freshwater algae, red and brown seaweeds,) (Ernst, 2000). According to Ernst extensive, or low intensity, aquaculture can produce gross yields of fish from 50 to 3,000 kilograms per hectare (kg/ha) and generally occurs in static water ponds with primary reliance on natural foods and minimal added fertilization. Semi-intensive production includes aeration (mechanical agitation of the water to increase dissolved oxygen levels), limited water exchange, some utilization of natural foods and the addition of prepared feeds. Semi-intensive systems can yield 3,000 to 20,000 kg/ha. The U.S. catfish industry is an example of this semi-intensive technology. Intensive production systems continuously exchange water, with water flowing through or filtered and recirculated water, aerate (often with pure oxygen), and apply high rates of prepared diets. This intensive production requires a higher level of management skill but can generate yields from 20,000 to 1,000,000 plus kg/ha.

Ernst (2000) noted that in terms of global production, "Major production species were all low in the food chain, consisting of primary producers (e.g. kelp) filter feeders (e.g. bivalves and carp), or finfish that as adults are herbivores or omnivores (e.g. carp and tilapia" (p.3). He also indicates that intensive production technologies are a relatively new development and that, "Globally, almost all aquaculture production is extensive or semi-intensive, in outdoor, solar-algae pond environments which may be integrated with agricultural practices with respect to water, animal manures, and other resources" (p.3). Extensive production is most often used to produce lower value species in communities where subsistence is the primary goal, the availability of inputs is low, and where low- technology agriculture is the norm. Carp are one of the most commonly cultured species using extensive production techniques. More intensive and particularly the highly intensive production schemes usually involve higher value species that warrant the extra inputs and can generate increased revenues to cover increased production costs. While the yields from intensive production systems are very high on a kg/ha basis, only a tiny portion of global production is based on this technology (Ernst, 2000; FAO, 2009).

While aquaculture has grown rapidly over the last several decades, this growth has not been geographically uniform. It grew much more quickly in developing countries than developed areas. The developing countries, as opposed to the developed countries, needed not only a source of protein but a product for export and source of revenue. “In regions where aquaculture development has been rapid, the long-term environmental and economic sustainability of certain production practices has come into question” (Ernst, 2000, p.4). The impact of shrimp farming on coastal mangrove forests and the impact of raising salmon in sea cages on area water quality have received much public attention. In contrast FAO (2006) notes that:

> Aquaculture has continued to attract largely unsubstantiated negative publicity as an environmental polluter. The output of nitrates and phosphates from aquaculture is considered insignificant in terms of contributing to nutrient loading in most regions of the world but may have local impacts on eutrophication and algal blooms. Great strides have been made in the last decade in mitigating nutrient and organic inputs from aquaculture (FAO, 2006, p.120).

As in any industry, aquaculture has experienced growing pains and has faced many challenges. As each challenge is met new ones appear. Ernst (2000), Schwarz (2005), and FAO (2006), identify numerous constraints and impediments to aquaculture growth in both developing and developed countries. They include:

1. Probable resource use conflicts (land, water and other resources)
2. Potential and real environmental degradation
3. Shortage of available development capital

4. Lack of specialized equipment and supplies
5. Limited technical knowledge
6. Limited ability to apply knowledge
7. Restrictive environmental regulations
8. High energy costs
9. Negative public opinion

Despite these hurdles aquaculture continues to evolve move and forward. FAO (2006) identifies several general trends in global aquaculture. They include the:

1. Continued intensification of aquaculture production
2. Continued diversification of species
3. Continued diversification of production systems and practices
4. Increased influence of markets, trade and consumers
5. Enhancement of regulations and improved governance of the sector,
6. Drive towards better management of the aquaculture sector

The world population is now at six billion people and is projected to climb to 9.5 billion by 2040. Population growth has increased to the point that capture fisheries alone can only fill two thirds of the current demand for fish, thus almost all future demand will have to be met by aquaculture (Tidwell and Allen, 2002). El_Ghamrini (1996) estimated that aquaculture production would have to grow more than seven fold to meet the world demand by 2025. World average per capita consumption of seafood is approximately 18 kilograms (39.6 pounds) and is expected to rise to 20 kilograms (44 pounds) by 2030 (Carlberg, 2001). The population change combined with an increase in per capita consumption will require total seafood supply to nearly double. With a nearly fully exploited ocean catch the remaining volume, if it is to materialize, will necessarily be the result of aquaculture.

Aquaculture in the United States

The 2005 Census of Aquaculture by the United State Department of Agriculture indicated that there are 494,995 acres, owned or leased, in aquaculture production on 4,309 farms. The United States aquaculture industry generates about US $1 billion each year with 70% of that total being generated by catfish production (Timmons, 2005; USDA, 2005). While this value relegates the United States to 10th in global production, it is significant, because consumers in the United States import $13.4 billion in seafood and fisheries products (Kirkley, Ward, Moore, Hayes, Hooker & Walden., 2009).

The National Oceanic and Atmospheric Administration [NOAA] (2008) indicated that in 2007 the U.S. per capita consumption of seafood was 7.41 kilograms (16.3 pounds) which was down from the previous level of 7.5 kilograms (16.5 pounds) in 2006. They note that approximately 84% of seafood was imported in 2007. Both Parker (2001) and Timmons (2005) refer to a United States seafood trade deficit of $6.5 billion, but the latest FAO figures place this deficit at more than $9 billion (FAO, 2008). To place this numbers in perspective the seafood deficit is the highest deficit among food and agricultural products and second only to petroleum products in the natural resources category. This deficit has prompted the U.S. government to enact legislation to promote aquaculture and expand the value of U.S. domestic aquaculture to more than $5 billion in the coming years.

Aquaculture as an industry in the United States is a relatively new phenomena. Fish culture did not begin until the nineteenth century, because abundant fish in native rivers provided adequate fish for food and recreation (Perez, 2006). The first aquaculture efforts aimed to restock or increase the number of fish in the rivers for commercial capture. Most early aquaculture focused on cold and cool water species and by the 1850's fisheries scientists developed techniques to artificially propagate brown trout and carp. According to Parker (2002), the first public fish hatchery was established in Mumford, NY, in 1864. In coastal areas residents had learned to catch oyster larvae on strings and shells and move these baby oysters to protected areas that would be more easily harvestable. Perez indicated that the later 1800's industrial development and improvements in transportation provided workers with more time for leisure and prompted aquaculturists to shift emphasis from restocking for commercial fishing to restocking to enhance recreational fishing. "In 1914 the Kansas Department of Game and Fish published one of the first manuals on pond fish culture in the United States" (Perez, 2006, p. 2). In the 1920's rice farmers in Arkansas began to convert some of their rice fields into ponds. By the 1950's bait minnow farming became the first major warm water aquaculture practiced in the United States.

In 1934, Homer Swingle, an entomology professor at Auburn University who is considered by many to be the father of modern warm water aquaculture in the U.S., received funding to support research "… that would develop and improve life for the nation's rural populations (Perez, 2006). Perez notes that:

> The project aimed to investigate the production of freshwater fishes for food. The Purnell Project, later called the Farm Ponds Project, was born. The first general objectives were to find ways to (1) manage water resources productively, (2) improve sport fishing, and (3) produce fish as a source of food….In 1938 information in one of the earliest reports by Swingle and E. V. Smith summarized what had been learned about stocking, fertilization, and weed control and would later prove to be fundamental to the development of commercial catfish farming (pp. 3-4).

In 1935 the USDA Soil Conservation Service was established (currently called the Natural Resource Conservation Service) and provided technical support and funding to farmers across the county to design and build ponds. By 1960, these ponds, along with information, techniques, and technologies, produced at Auburn and other universities led to the birth of the commercial catfish industry in the southeast. Since that time catfish aquaculture has emerged as a model aquaculture industry that has drawn attention from around the world.

While early aquaculture research began in earnest during the depression years of the 1930's, the 'modern day' vision of aquaculture did not appear until the late 1960's and early 70's (Parker, 2001; Schwarz, 2005) and now focuses on a relatively few species. Catfish, trout, salmon, tilapia, and hybrid striped bass are the major food fish species; bait, and ornamental fish dominate the non-food fish category of fish; shrimp and crawfish are the main crustaceans; and oysters, clams, and mussels are the primary cultured mollusks (United States Department of Agriculture, 1995). Production is distributed throughout the country, but the bulk of the production comes from the southeastern states and is focused on pond production of catfish. The states of Alabama, Arkansas, Mississippi, and Louisiana account for more than 52% of the value of U.S. aquaculture production (USDA, 2006).

Despite its relatively brief history, aquaculture in the U.S. is a relatively mature industry and has shown slow growth in the last two decades relative to rest of the world (Schwarz, 2005). On the other hand, a production area that does show significant potential for growth is open ocean aquaculture.

Open ocean aquaculture, defined as the rearing of marine organisms in the U.S. Exclusive Economic Zone, is seen as a viable option for supplying consumer demand for marine products while avoiding inshore user conflicts and addressing the growing seafood trade deficit. However, major barriers to open ocean aquaculture include 1) difficulties in obtaining sufficient front-end capital investment; 2) a multi-agency permitting process; 3) technical challenges in the design and construction of facilities able to withstand the marine environment; and 4) the social and environmental impacts of open ocean aquaculture (Borgotti & Buck, 2004). While much interest and effort has been focused in this area and some progress has been made, the realization of open ocean aquaculture potential if it occurs is still a decade or more in the future.

Aquaculture in Alabama

In Alabama, more than 25,000 acres of water are dedicated to production of approximately 20 different species (Crews & Chappell, 2006). According to the 2005 Census of Aquaculture by the USDA Alabama (a) ranks third in value of aquaculture products sold ($102.8 million) behind Mississippi and Arkansas, (b) is the second largest producer of catfish (by value) at $99,458,000, and (c) has the fourth largest number of farms (215). Ponds are the dominant culture method, and the 3,632 ponds averaging 6.8 acres each total 24,458 acres of production. Table 6 provides additional Alabama aquaculture statistics.

Table 6

Number of Farms and Value of Aquaculture Products Sold by Type in Alabama.

Category	**Number of Farms**	**Value**
Baitfish	7	$41,000
Crustaceans	8	$933,000
Food Fish	201	$99,458,000
Ornamental	3	Not reported
Sportfish	20	$2,176,000
Total	215	$102,796,000

Source: USDA National Agricultural Statistics Service 2005 Census of Aquaculture

According to the 2005 Census of Aquaculture (USDA, 2006) and Parker (2001), aquaculture is the fastest growing segment of agriculture and an important industry in the

Southeastern United States.   While China is the leader in aquaculture production supplying nearly 70% of the world total, the United States and Alabama in particular have substantial room for growth. Crews and Chappell (2007) indicated in the *2006* Alabama Aquaculture Factsheet that "Alabama has the land/water resources to support a traditional pond industry 10 times its current size."

Crews and Chappell also stated that over the last 24 years the industry has grown by a factor of 13 in Alabama. In Alabama's black belt region so called for its dark fertile soils and one of the state's most depressed areas catfish has provided a much needed source of employment, opportunity and income.   Perez (2006), in her book *Fishing for Gold: The Story of Alabama's Catfish Industry,* chronicles the history of catfish culture and provides an excellent synopsis of the reasons for its success:

> According to John Jensen, of the Department of Fisheries and Allied Aquacultures at Auburn University, a key ingredient to the catfish industries' impressive growth in general has been a combination of natural conditions, public and private infrastructure, and people….Among them, suitable soils and terrain, adequate water resources, and a climate that is warm for much of the year are basic.
>
> …. Services provided by public infrastructure such as good transportation, a supportive legal and regulatory foundation, research, outreach and education are important parts of the mix. Private businesses providing financing, equipment, supplies, energy, and many other materials and services, as well as tradesmen and professionals, are all indispensable to modern farms and processing plants. Last,

but not least, are the producers (including farmers and processors and the consumers, both as a group and individuals (Perez, 2006, p. xii).

This important industry will need trained scientists and technicians if it is to continue to grow and flourish. These scientists, technicians and educators will require skills that allow the continued development of aquaculture is ecologically responsible, sustainable and profitable. Where will these scientists, technicians, and educators come from? With proper funding and support secondary and university aquaculture education programs will provide a solution.

CHAPTER 3 - METHODS AND PROCEDURES

The purpose of this study was to improve teachers' ability to effectively use aquaculture as a tool to teach mathematics and science. This study explored how Alabama science and career tech teachers perceived the importance of aquaculture-related topics, their ability to teach those topics and how they perceived the quality of available teaching materials. This cumulated information made it possible to determine the greatest areas of need with regard to aquaculture training and curriculum development (or identification) and to schedule in-service training and pre-service teacher training.

This chapter describes the step-by-step process used in an exploratory evaluation of teacher's perceptions of (a) the relative importance (b) their ability to teach, and (c) the quality of teaching materials related to the various aquaculture content areas within the Alabama Aquaculture Science course of study. Specific research questions answered included,

1. Importance of Content Standards. How do teachers certified to teach the aquaculture curricula perceive the importance of various content standards of the Alabama aquaculture science course of study?
2. Abilities. What are teachers', certified to teach the aquaculture curricula, perceived abilities, indicated by their current knowledge, to teach the content standards of the Alabama aquaculture science course of study?

3. Teaching Materials. How do Alabama teachers, certified to teach the aquaculture curricula, perceive of the quality of aquaculture teaching materials?

Population for the study consisted of the science and career and technical teachers, identified by the Alabama State Department of Education (ALSDE), who were qualified to teach one of the four aquaculture classes within the Alabama course of study. See Appendix B for a copy of the approval letters from the state administrators.

Administering the Survey

Communications with the teachers were directed through the state level coordinators for science curriculum and agriculture education who passed information to the teachers via their secure email lists. The agriculture education director was able to contact the career and technical education teachers but the science coordinator did not have direct contact to the science teacher so they sent the invitation via school counselors requesting that they pass it on to the appropriate science teachers. A pre-survey invitation was sent out November 8, 2010 and the invitation with the consent form (Appendix C) and a link to the survey followed one week later. Two reminders were sent at two week intervals and the survey was closed after 50 days. A total of 250 respondents started the survey and 186 (74.4%) completed all questions on the form.

The Survey Instrument

The survey instrument used in this study was adapted with permission from the survey by Fortner and Meyer (2000) that was used to identify discrepancies among teachers' priorities for and knowledge of freshwater topics. The Fortner and Meyer instrument as well as the one used in this survey were based on a model provided by Borich (1973, 1979, 1980). The Borich model has been used by numerous researchers to determine and examine discrepancies between priorities and knowledge (Barrick & Doefert, 1989; Barrick, Ladewig & Hedges, 1983; Besswenger, Sturges, & Jones, 1992; Edwards & Briers, 1999; Fortner and Corney, 2002; Fortner & Meyers, 2000; Garton and Chung, 1997; Joerger, 2002; Johnson, Schumacher, & Steward, 1990; Layfield & Dobbins, 2002; McDonald & Lawver, 1997; Milkent, Irby, & Story, 1979; Newman & Johnson, 1994; Rakow, 1993; Waters & Haskell, 1989). The Borich model was also identified as an appropriate means to identify and prioritize teacher in-service training needs (Barrick, Ladewig & Hedges, 1983; Edwards & Briers, 1999; Fortner and Corney, 2002; Garton and Chung, 1997; Joerger, 2002; Layfield & Dobbins, 2002 and Newman & Johnson, 1994). The Borich model and subsequent modifications typically consist of a list of competencies for potential in-service training along with the use of a Likert-type scale to rank perceived importance of, and/or ability to teach those competencies.

The use of the web-based survey instruments has increased in the last decade and they have several advantages over paper-based mail surveys (Archer, 2003; 2008; Couper, 2008; Dillman, 2000; Dillman and Bowker, 2008; Hair, Bush, & Ortinau, 2006; Malhortra, 2007; Presser, Rothgeb, Couper, Lessler, Martin, Martin & Singer, 2004;

Schonlau, Fricker & Elliot, 2002; Weisberg, 2005). Reduced cost, timeliness, and ease of data entry were among the advantages most often cited. The study population had sufficient technology and connection to the internet to warrant use of electronic communication via e-mail and a web-based survey instrument (Schonlau et al., 2002). The survey instrument (Appendix D) was constructed using a web survey provider, Survey Monkey. The survey consisted of 13 questions and required an average of 15 minutes to complete. The survey was constructed to be short and simple and incorporated automatic skip technology that allowed teachers to only see the questions applicable to their group.

The first question asked teachers to categorize themselves based on three teaching certifications: general science classes, career and technical education courses, or both general science and career and technical education courses. The Alabama course of study offers a total of four aquaculture related classes, one available for science credit and three available for career and technical education credit. Two of the classes; the aquascience elective, for science credit; and aquaculture science, for CTE credits are very similar and share ten content standards. Content standards evaluated in this study were based on these two classes. The aquascience elective has ten content standards:

1. Differentiate among freshwater, brackish water, and saltwater ecosystems.
2. Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.
3. Explain the importance of biogeochemical cycles in an aquatic environment.
4. Determine important properties and content of water as related to aquaculture.

5. Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding.
6. Describe adaptations that allow organisms to exist in specific aquatic environments.
7. Describe processes and environmental characteristics that affect growth rates of aquatic animals.
8. Determine effects of the fishing industry on the aquatic environment.
9. Describe various structures and equipment used in growing aquacrops.
10. Describe the control of diseases and pests in aquatic environments.

The aquaculture science course includes the same ten content standards plus 6 additional content standards specifically related to aquaculture as an industry.

11. Describe various career opportunities in the aquaculture industry.
12. Describe safety precautions for the aquaculture industry.
13. Explain the historical background of aquaculture.
14. Categorize aquaculture species as cold, cool, or warm water species.
15. Describe infrastructure necessary for aquaculture production.
16. Define concepts associated with health management of aquacrops.

Respondents who placed themselves in the first category, certified to teach general science classes, were only asked about the ten content standards associated with the aquacscience elective class. Teachers in the other two categories, certified to teach career and technical education classes and certified to teach both general science classes and career and technical education course were asked about the 16 content standards associated with the aquaculture science class.

The second through fourth questions used Likert scales. Question two asked the teachers to rate how important it was that their students knew about the topics covered in each aquaculture content standard. The survey included some additional information that helped clarify what topics might be included in that standard. The teachers indicated their choice where, 1 = very unimportant, 2 = unimportant, 3 = average importance, 4 = important and 5 = very important. The third question asked the teachers to rate their current knowledge of each content standard using the rating system 1 = no knowledge, 2 = little knowledge, 3 = average knowledge, 4 = good knowledge and 5 = excellent knowledge. The fourth question asked teachers to rate the quality of the materials they used to teach each of the content standards using the scale 1 = poor, 2 = below average, 3 = average, 4 = above average and 5 = excellent.

Questions five through eleven asked for demographic information and opinions. Questions five through eleven included, sex, age, years of teaching experience, highest academic degree earned, science classes taught, and career and technical education classes taught. Questions 12 and 13 asked about a) their interest in learning more about aquaculture and b) if their schedule allowed, interest in teaching an aquaculture course.

Survey Analysis

The survey instrument (Appendix D) was developed in concert with faculty advisors and approved for use by the Institutional Review Board for the Protection of

Human Subjects at Auburn University (10/29/2010 see Appendix A). It was constructed and administered using the web survey provider Survey Monkey. Content and face validity were evaluated by a panel of individuals including graphic designers, technical editors, science and career technology teachers and industry experts. Data were collected and entered into a statistical package for the social sciences (SPSS). A post- hoc Cronbach's alpha was calculated to determine the reliability of importance (α =0 .955 & 0.966), knowledge (α = 0.950 & 0.950) and quality of material (α = 0.965 & 0.974) for two categories of teachers. Category one was the general science teachers. Category two included career technical teachers and category three those that taught both general science and career technical classes. A mixed design analysis controlled non-response error and compared early and late responders. The mixed analysis was used in place of multiple T-tests to minimize type one error and reduce the number of required analyses. Late responders were those who entered data following the reminder notice.

To determine the areas with greatest need for continued or in-service training descriptive statistics (means, and standard deviations) were utilized to analyze the data and identify discrepancies (DS) between, importance and knowledge, Importance and quality of materials as well as between knowledge and quality of teaching materials used. The discrepancy score (DS), mean discrepancy scores (MDS), weighted discrepancy scores (WDS) and mean weighted discrepancy scores (MWDS) were calculated for each content standard using a stepwise procedure. The DS for each individual on each content standard was obtained by subtracting the knowledge rating from the importance rating. Next, the discrepancy score was multiplied by the mean importance rating to calculate the

WDS on each individual for each content standard. A MWDS for each of the content standards was then calculated by taking the sum of the WDS and dividing by the number of the observations. The content standards with the highest MWDS were those with the highest need for in-service training. The procedure was repeated to identify the discrepancy between importance of the content standards and the material available.

In addition to the three teacher categories (SCI, CTE, BOTH) the respondents were further categorized by years of experience. Category one represented teachers with less than the mean number of years of teaching experience (14) and category two were those with more than the mean experience. A 3x2 Multivariate analysis of variance (MANOVA) was used to identify differences between the different teacher categories as well as indicate interactions and differences between the experience categories with respect to importance, knowledge and materials. The final analysis performed was a chi squared test to evaluate differences between teachers a.) interest in learning more about aquaculture (question 14) and b.) interest in teaching and aquaculture class if their schedule allowed (question 15).

Summary

Using the methods and procedures described in this chapter the researcher was able to calculate the mean and standard deviation for the teacher perceptions of the importance, knowledge of, and materials available to teach each of the aquaculture content standards. Using these means it was possible to calculate a MWDS that would indicate the relative magnitude of the discrepancy between importance and knowledge of the content standards. A MANOVA, ANOVA, and Chi squared tests were then used to look for correlations between IMP, KNOW, MAT, the teacher types, and the teacher experience levels. The results of the data analyses are presented in chapter four.

CHAPTER 4 - RESULTS

The purpose of this study was to improve teachers' ability to effectively use aquaculture as a tool to teach mathematics and science. This study explored how Alabama science and career tech teachers perceived the importance of aquaculture-related topics, their ability to teach those topics and how they perceived the quality of available teaching materials. This cumulated information made it possible to determine the greatest areas of need with regard to aquaculture training and curriculum development (or identification) and to schedule in-service training and pre-service teacher training.

The purpose of this chapter is to present the results of the survey and subsequent analysis. It will describe the characteristics and demographics of the study population and present data relative to each research question. When the electronic survey closed on December 30, 2010 there were a total of 250 respondents. Of the 250 people that started the survey only 187 reached the final question, a completion rate of 74.8%.

Sample Demographics

The respondents included 164 science teachers (SCI), 63 career tech teachers (CTE) and 23 teachers that taught both science and career tech classes (BOTH). Seventy nine (42%) were male and 106 were female (57.3%) N= 185. The oldest teacher was 68 and the youngest was 25. The average age of the respondents was 42.5 years with a standard deviation (SD) of 10.8 years (N= 185). The most experienced teacher had 46 years of experience and the least experienced had not yet completed their first year. The mean level of experience was 14.6 years (N= 185, SD=10.1). The majority, 64.9% of the respondents held a master's degree, 33.5% held a bachelor's degree and only 3 (1.6%) held a PhD (N=185).

The teachers were also asked about the specific courses that they taught. There are 15 science courses listed in the Alabama Course of study. Those most commonly taught by the respondents included biology, physical science and earth science. The least commonly taught science courses included geology and genetics. The average number of courses taught by science teachers was 2.2 (N=130). Forty one of the teachers indicated teaching courses outside of the standard grade 9 through 12 course of study. These teachers included middle school and a few elementary science teachers. A complete listing of the science courses and teaching frequency is shown in the survey summary in Appendix E.

There are 43 different courses listed in the career and technical education section of the Alabama Course of Study. All courses were represented among the respondents, however, agriscience (44 out of 60), fish and wildlife management (25 of 60) and construction and framing (24 of 60) were the most common. CTE teachers taught an average of 6.9 different courses. A complete listing of the courses and teaching frequency is available in Appendix E.

Research question 1 – The Perceived Importance of Aquaculture Content Standards

This question asked the teachers to rate how important it is that their students know about the topics covered in each aquaculture content standard using the rating system 1 = very unimportant, 2 = unimportant, 3 = average importance, 4 = important and 5 = very important. The standards with the highest overall importance (N = 185) ratings were CS11- Describe the various career opportunities in the aquaculture industry (4.03, SD = 1.04), CS12 – Describe safety precautions for the aquaculture industry (4.00, SD = 1.15), CS7 - Describe processes and environmental characteristics that affect growth rates of aquatic animals (3.83, SD = 1.14) and CS15- Describe infrastructure necessary for aquaculture production (3.80, SD = 0.99). The least important standards were CS2 – Related geological and hydrological phenomena and fluid dynamics to aquatic systems (3.17, SD = 1.11) and CS5 – Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (3.47, SD = 1.19). The mean importance scores for all content standards were above average (rating of 3.0) indicating teacher considered them to be at least average importance or greater. Table 7 indicates the mean (M) importance rating and standard deviation (SD) for each of the content standards. The shaded area of the table indicates the standards that were common to both the science and CTE courses.

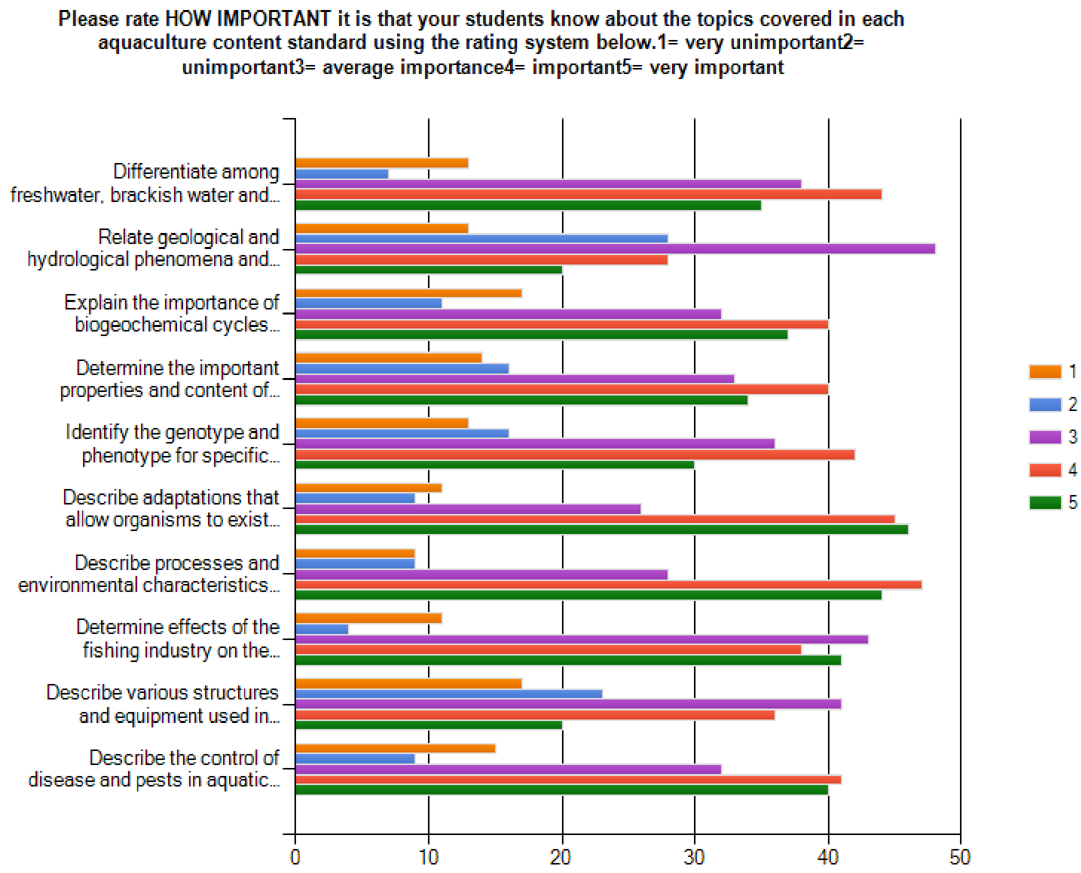
Table 7.
The importance of the aquaculture content standards as perceived by teachers

	Content Standard	M	SD
CS1	Differentiate among freshwater, brackish water, and saltwater ecosystems.	3.67	1.15
CS2	Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	3.17	1.11
CS3	Explain the importance of biogeochemical cycles in an aquatic environment.	3.60	1.24
CS4	Determine important properties and content of water as related to aquaculture.	3.64	1.25
CS5	Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding.	3.47	1.19
CS6	Describe adaptations that allow organisms to exist in specific aquatic environments.	3.77	1.13
CS7	Describe processes and environmental characteristics that affect growth rates of aquatic animals.	3.83	1.14
CS8	Determine effects of the fishing industry on the aquatic environment.	3.79	1.14
CS9	Describe various structures and equipment used in growing aquacrops.	3.39	1.23
CS10	Describe the control of diseases and pests in aquatic environments.	3.74	1.22
CS11	Describe various career opportunities in the aquaculture industry.	4.03	1.04
CS12	Describe safety precautions for the aquaculture industry.	4.00	1.15
CS13	Explain the historical background of aquaculture.	3.72	0.94
CS14	Categorize aquaculture species as cold, cool, or warm water species.	3.77	1.08
CS15	Describe infrastructure necessary for aquaculture production.	3.80	0.99
CS16	Define concepts associated with health management of aquacrops.	3.75	1.08

Note: 1 = very unimportant, 2 = unimportant, 3 = average importance, 4 = important and 5 = very important. Standards in gray are in both the aquascience elective and the aquaculture science CTE class.

Among the participants that only taught science (SCI) N = 122, and therefore only rated CS1 to CS10, the most important were CS6 – Describe adaptations that allow organisms to exist in specific aquatic environments (3.80, SD = 1.18), CS7 - Describe processes and environmental characteristics that affect growth rates of aquatic animals (3.79, SD = 1.16) and CS8 – Determine effects of the fishing industry on the aquatic environment (3.72, SD = 1.16). The content standards receiving the lowest importance ratings were CS2 – Related geological and hydrological phenomena and fluid dynamics to aquatic systems (3.17, SD = 1.11) and CS5 – Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (3.47, SD = 1.19). It should be noted that all of the content standards received ratings above 3.0 (= average) indicating that teachers felt all of the content standard were of average or greater importance. Figure 1 illustrates the level of importance identified by the science teachers.

Figure 1
Content standard importance rating among science teachers



Source: Survey Monkey Analysis Report (N=137)

The CTE teachers (N = 45) perceived the most important content standards to be CS11- Describe the various career opportunities in the aquaculture industry (4.08, SD = 1.10), CS8 – Determine effects of the fishing industry on the aquatic environment (4.02, SD = 1.06), and CS9 – Describe various structures and equipment used in growing aquacrops (3.96, SD = 1.05). The least important to the CTE group was CS2 – Relate geological and hydrological phenomena and fluid dynamics to aquatic systems (3.25, SD = 0.93).

Teachers in the BOTH group (N = 18) indicated that CS10 – Describe the control of diseases and pests in aquatic environments (4.16, SD = 1.07) and CS3 – Explain the importance of biogeochemical cycles in an aquatic environment (4.16, SD = 1.17) were the most important content standards. The lowest ranked content standard in the BOTH group was CS2 – Relate geological and hydrological phenomena and fluid dynamics to aquatic systems (3.42, SD = 1.12). Table 8 provides a summary of the means and standard deviations for all groups in the importance category.

Table 8

Mean rating and standard deviation of each content standard importance by teacher group. 1 = very unimportant, 2 = unimportant, 3 = average importance, 4 = important, and 5 = very important.

	Science		Career Tech		Both		All Teachers	
	M	SD	M	SD	M	SD	M	SD
CS1	3.59	1.20	3.79	1.05	3.95	0.97	3.67	1.15
CS2	3.10	1.17	3.25	0.93	3.42	1.12	3.17	1.11
CS3	3.50	1.31	3.63	1.03	4.16	1.17	3.60	1.24
CS4	3.47	1.27	3.98	1.16	4.00	1.11	3.64	1.25
CS5	3.44	1.22	3.48	1.13	3.63	1.16	3.47	1.19
CS6	3.77	1.21	3.69	0.98	4.00	0.88	3.77	1.13
CS7	3.79	1.16	3.94	1.09	3.84	1.21	3.83	1.14
CS8	3.69	1.17	4.02	1.06	3.95	1.13	3.79	1.14
CS9	3.14	1.23	3.96	1.05	3.68	1.16	3.39	1.23
CS10	3.60	1.27	3.94	1.09	4.16	1.07	3.74	1.22
CS11			4.08	1.10	3.89	0.88	4.03	1.04
CS12			4.06	1.14	3.84	1.17	4.00	1.15
CS13			3.75	0.97	3.63	0.90	3.72	0.94
CS14			3.88	1.08	3.47	1.07	3.77	1.08
CS15			3.90	1.00	3.53	0.96	3.80	0.99
CS16			3.79	1.07	3.63	1.12	3.75	1.08
AVG	3.51	1.22	3.82	1.06	3.80	1.07	3.70	1.13

Research question 2 – Teacher Knowledge of Aquaculture Content Standards

This question asked the teachers to rate their current knowledge of the aquaculture content standards using the rating system 1 = no knowledge, 2 = little knowledge, 3 = average knowledge, 4 = good knowledge and 5 = excellent knowledge. The standards with the highest overall knowledge (N = 185) ratings were CS11- Describe the various career opportunities in the aquaculture industry (3.55, SD = 0.96), CS14 – Categorize aquaculture species as cold, cool, or warm water species (3.49, SD = 0.88), CS6 – Describe adaptations that allow organisms to exist in specific aquatic environments (3.49, SD = 0.99) and CS12 – Describe safety precautions for the aquaculture industry (3.46, SD = 0.98). Table 10 indicates the mean (M) and standard deviation (SD) for each of the content standards.

Table 9
Teachers' knowledge of the aquaculture content standards

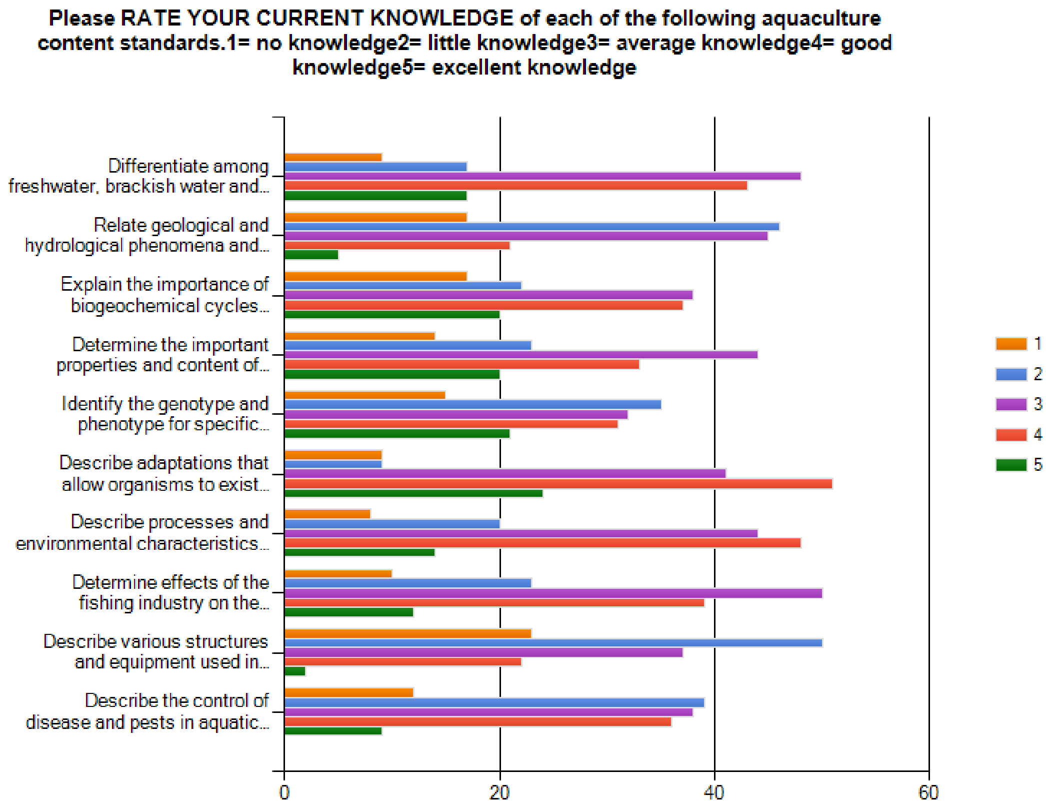
	Content Standard	M	SD
CS1	Differentiate among freshwater, brackish water, and saltwater ecosystems.	3.39	1.02
CS2	Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	2.71	0.98
CS3	Explain the importance of biogeochemical cycles in an aquatic environment.	3.23	1.13
CS4	Determine important properties and content of water as related to aquaculture.	3.32	1.13
CS5	Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding.	3.12	1.15
CS6	Describe adaptations that allow organisms to exist in specific aquatic environments.	3.49	0.99
CS7	Describe processes and environmental characteristics that affect growth rates of aquatic animals.	3.38	0.99
CS8	Determine effects of the fishing industry on the aquatic environment.	3.23	1.01
CS9	Describe various structures and equipment used in growing aquacrops.	2.80	1.13
CS10	Describe the control of diseases and pests in aquatic environments.	3.00	1.02
CS11	Describe various career opportunities in the aquaculture industry.	3.55	0.96
CS12	Describe safety precautions for the aquaculture industry.	3.46	0.98
CS13	Explain the historical background of aquaculture.	3.36	0.95
CS14	Categorize aquaculture species as cold, cool, or warm water species.	3.49	0.88
CS15	Describe infrastructure necessary for aquaculture production.	3.22	0.91
CS16	Define concepts associated with health management of aquacrops.	3.09	0.78

Note: 1 = no knowledge, 2 = little knowledge, 3 = average knowledge, 4 = good knowledge and 5 = excellent knowledge. Standards in gray are in both the aquascience elective and the aquaculture science CTE class.

Among SCI teachers (N = 122) that only rated CS1 to CS10, they were the most knowledgeable about CS6 – Describe adaptations that allow organisms to exist in specific aquatic environments (3.53, SD = 1.07), CS1 – Differentiate among freshwater, brackish water, and saltwater ecosystems (3.31, SD = 1.06) and CS7 –Describe processes and environmental characteristics that affect growth rates of aquatic animals (3.30, SD = 1.04). The content standards receiving the lowest knowledge rating was CS9 – Describe various structures and equipment used in growing aquacrops (2.48, SD = 1.01). Figure 2 indicates the SCI teachers' knowledge of the aquaculture content standards.

Figure 2

Science teacher knowledge of the aquaculture content standards



Source: Survey Monkey Analysis Report (N=134)

The CTE teachers' (N = 45) average knowledge of all the contents standards was slightly higher than the average of the SCI teachers (3.40/3.07). The CTE teachers had the most knowledge about CS11- Describe the various career opportunities in the aquaculture industry (3.50, SD = 0.88), CS9 – Describe various structures and equipment used in growing aquacrops (3.57, SD = 0.83), CS14 – Categorize aquaculture species as cold, cool, or warm water species (3.53, SD = 0.81) and CS12 – Describe safety precautions for the aquaculture industry (3.53, SD = 0.97). The content standard that the

CTE teachers were least knowledgeable about was CS2 – Relate geological and hydrological phenomena and fluid dynamics to aquatic systems (2.89, SD = 1.13).

Teachers in the BOTH group (N=18) indicated that they were most knowledgeable about CS4 – Determine important properties and content of water as related to aquaculture (3.94, SD = 1.06), CS7 –Describe processes and environmental characteristics that affect growth rates of aquatic animals (3.72, SD = 1.07), CS3 – Explain the importance of biogeochemical cycles in an aquatic environment (3.67, SD = 0.97) and CS1 – Differentiate among freshwater, brackish water, and saltwater ecosystems (3.67, SD = 1.08). The content standard that the BOTH group knew the least about was CS2 – Relate geological and hydrological phenomena and fluid dynamics to aquatic systems (2.89, SD = 1.13). Table 11 provides a summary of the means and standard deviations for all groups in the knowledge category.

Table 10

Mean rating and standard deviation of teacher knowledge of the aquaculture content standards. 1 = no knowledge, 2 = little knowledge, 3 = average knowledge, 4 = good knowledge and 5 = excellent knowledge.

	SCI		CTE		BOTH		ALL	
Standard	M	SD	M	SD	M	SD	M	SD
CS1	3.31	1.06	3.49	0.83	3.67	1.08	3.39	1.02
CS2	2.63	1.02	2.84	0.81	2.89	1.13	2.71	0.98
CS3	3.16	1.24	3.27	0.85	3.67	0.97	3.23	1.13
CS4	3.16	1.19	3.51	0.86	3.94	1.06	3.32	1.13
CS5	3.06	1.26	3.24	0.93	3.22	0.94	3.12	1.15
CS6	3.54	1.07	3.31	0.71	3.61	0.98	3.49	0.99
CS7	3.30	1.04	3.49	0.78	3.72	1.07	3.38	0.99
CS8	3.15	1.05	3.45	0.88	3.17	1.04	3.23	1.01
CS9	2.48	1.01	3.57	0.83	3.06	1.55	2.80	1.13
CS10	2.93	1.09	3.10	0.85	3.22	0.88	3.00	1.02
CS11			3.59	0.88	3.44	1.20	3.55	0.96
CS12			3.53	0.97	3.28	1.02	3.46	0.98
CS13			3.39	0.90	3.28	1.13	3.36	0.95
CS14			3.53	0.81	3.39	1.09	3.49	0.88
CS15			3.29	0.76	3.00	1.24	3.22	0.91
CS16			3.08	0.77	3.11	0.83	3.09	0.78
AVG	3.07	1.10	3.36	0.84	3.35	1.08	3.24	1.00

Research Question 3 - How do Alabama teachers, certified to teach the aquaculture curricula, perceive of the quality of aquaculture teaching materials?

This question asked the teachers to rate the quality of materials you use to teach each content standard using the rating system 1 = poor, 2 = below average, 3 = average, 4 = above average, and 5 = excellent. The standards with the highest overall materials ratings (N = 185) CS11- Describe the various career opportunities in the aquaculture industry (2.97, SD = 1.07), CS14 – Categorize aquaculture species as cold, cool, or warm water species (2.95, SD = 1.10), and CS12 – Describe safety precautions for the aquaculture industry (2.91, SD = 1.17). Table 11 indicates the mean (M) and standard deviation (SD) for each of the content standards.

Table 11

Teachers rating of the materials used to teach the aquaculture content standards.

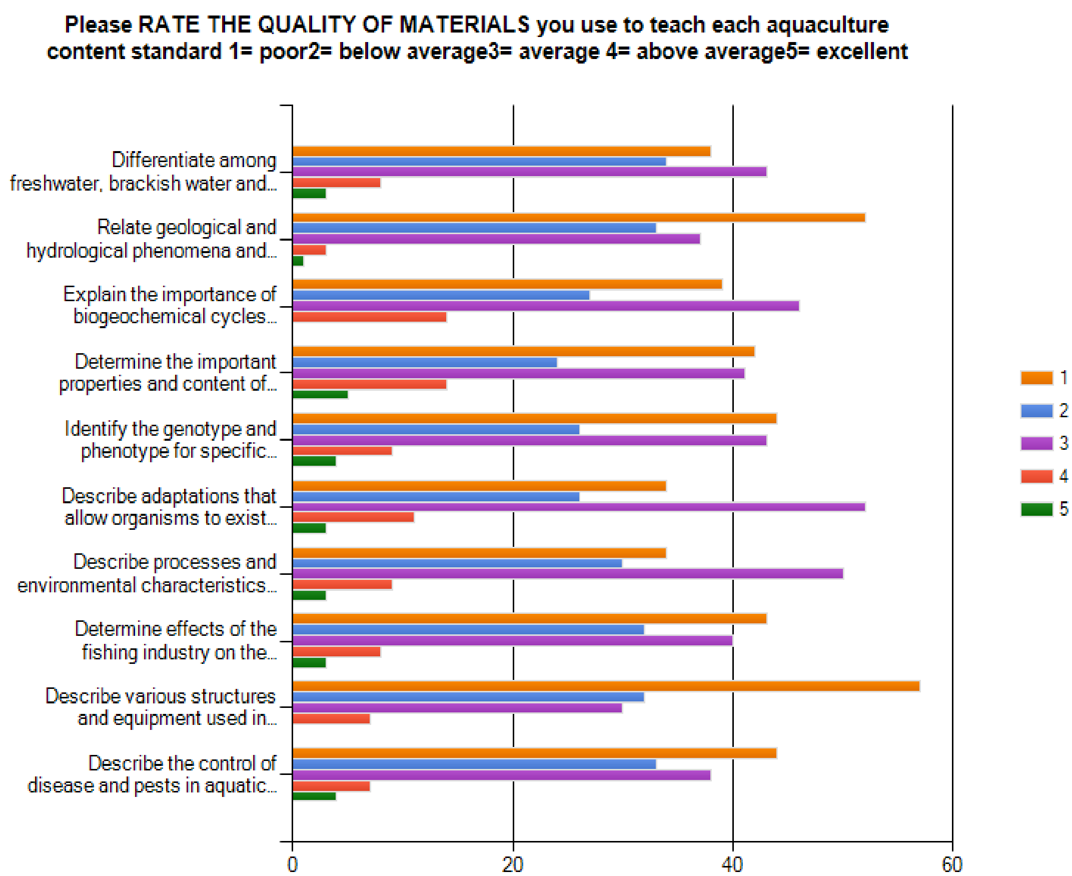
	Content Standard	M	SD
CS1	Differentiate among freshwater, brackish water, and saltwater ecosystems.	2.41	1.06
CS2	Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	2.13	0.97
CS3	Explain the importance of biogeochemical cycles in an aquatic environment.	2.47	1.08
CS4	Determine important properties and content of water as related to aquaculture.	2.58	1.21
CS5	Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding.	2.37	1.08
CS6	Describe adaptations that allow organisms to exist in specific aquatic environments.	2.53	1.04
CS7	Describe processes and environmental characteristics that affect growth rates of aquatic animals.	2.52	1.04
CS8	Determine effects of the fishing industry on the aquatic environment.	2.40	1.11
CS9	Describe various structures and equipment used in growing aquacrops.	2.23	1.09
CS10	Describe the control of diseases and pests in aquatic environments.	2.38	1.09
CS11	Describe various career opportunities in the aquaculture industry.	2.97	1.07
CS12	Describe safety precautions for the aquaculture industry.	2.91	1.17
CS13	Explain the historical background of aquaculture.	2.78	1.04
CS14	Categorize aquaculture species as cold, cool, or warm water species.	2.95	1.10
CS15	Describe infrastructure necessary for aquaculture production.	2.80	1.00
CS16	Define concepts associated with health management of aquacrops.	2.72	1.02

Note: 1 = poor, 2 = below average, 3 = average, 4 = above average and 5 = excellent. Standards in gray are in both the aquascience elective and the aquaculture science CTE class.

In general the SCI teachers (N = 137) felt that the teaching materials were below average (M = 2.20, SD = 1.04). They gave the highest material ratings to CS6 – Describe adaptations that allow organisms to exist in specific aquatic environments (2.39, SD = 1.17), CS7 –Describe processes and environmental characteristics that affect growth rates of aquatic animals (2.34, SD = 1.03) and CS4 – Determine important properties and content of water as related to aquaculture (2.33, SD = 1.17). The teaching materials receiving the lowest rating was CS9 – Describe various structures and equipment used in growing aquacrops (1.90, SD = 0.95) followed closely by CS2 - Relate geological and hydrological phenomena and fluid dynamics to aquatic systems (1.95 SD = 0.94). Figure 3 indicates how the SCI teachers' rated the materials they used to teach each of the aquaculture content standards. It is evident that many of the teachers thought the materials used were poor.

Figure 3

Science teacher ratings of the materials used to teach the content standards



Source: Survey Monkey Analysis Report (N=126)

The CTE teachers' (N = 45) rated the materials closer to average than the SCI teachers (2.84 SD = 0.94 vs. 2.20, SD = 1.04). The CTE teachers indicated that the best materials were available for CS11- Describe the various career opportunities in the aquaculture industry (3.06, SD = 1.00), CS4 - Determine important properties and content of water as related to aquaculture (3.02, SD = 1.08), and CS12 – Describe safety precautions for the aquaculture industry (3.06, SD = 1.00). The content standard with the lowest materials rating among the CTE teachers was CS2 – Relate geological and hydrological phenomena and fluid dynamics to aquatic systems (2.41, SD = 1.18).

Teachers in the BOTH group (N=18) ranked the materials average (2.75, SD = 1.30) and gave the highest rankings to CS4 – Determine important properties and content of water as related to aquaculture (3.12, SD = 1.36), CS3 – Explain the importance of biogeochemical cycles in an aquatic environment (3.06, SD = 1.25) CS6 – Describe adaptations that allow organisms to exist in specific aquatic environments (2.94, SD = 1.25), and CS14 – Categorize aquaculture species as cold, cool, or warm water species (2.94, SD = 1.48). The BOTH group ranked the materials the lowest for CS2 – Relate geological and hydrological phenomena and fluid dynamics to aquatic systems (2.41, SD = 1.18) and CS8 - Determine effects of the fishing industry on the aquatic environment (2.41, SD = 1.33). Table 12 provides a summary of the means and standard deviations for all groups in the materials category.

Table 12

Teacher ratings of the materials used to teach the aquaculture content standards. 1 = poor, 2 = below average, 3 = average, 4 = above average and 5 = excellent.

	SCI		CTE		BOTH		ALL	
Standard	M	SD	M	SD	M	SD	M	SD
CS1	2.24	1.03	2.73	0.89	2.76	1.39	2.41	1.06
CS2	1.95	0.94	2.50	0.88	2.41	1.18	2.13	0.97
CS3	2.28	1.02	2.77	1.02	3.06	1.25	2.47	1.08
CS4	2.33	1.17	3.02	1.08	3.12	1.36	2.58	1.21
CS5	2.23	1.10	2.58	0.94	2.76	1.09	2.37	1.08
CS6	2.39	1.05	2.75	0.86	2.94	1.25	2.53	1.04
CS7	2.34	1.03	2.85	0.92	2.88	1.17	2.52	1.04
CS8	2.17	1.05	2.98	0.98	2.41	1.33	2.40	1.11
CS9	1.90	0.95	2.96	0.90	2.59	1.46	2.23	1.09
CS10	2.16	1.07	2.79	0.92	2.82	1.29	2.38	1.09
CS11			3.06	1.00	2.71	1.26	2.97	1.07
CS12			3.02	1.12	2.59	1.28	2.91	1.17
CS13			2.88	0.94	2.53	1.28	2.78	1.04
CS14			2.96	0.94	2.94	1.48	2.95	1.10
CS15			2.85	0.85	2.65	1.37	2.80	1.00
CS16			2.71	0.87	2.76	1.39	2.72	1.02
AVG	2.20	1.04	2.84	0.94	2.75	1.30	2.57	1.07

Objective 1 – Determine the aquaculture related in-service training needs of Alabama science and career tech teachers

The first step in identifying the greatest areas of additional training and materials was to identify discrepancies between the three areas importance (IMP), knowledge (KNOW), and materials (MAT). The content standard with the greatest discrepancy IMP vs. KNOW was CS10 – Describe the control of diseases and pests in aquatic environments (0.74). The content standard with the greatest discrepancy IMP vs. MAT was CS8 - Determine effects of the fishing industry on the aquatic environment (1.40) and the greatest discrepancy KNOW vs. MAT was CS1 - Differentiate among freshwater, brackish water, and saltwater ecosystems (0.98). Table 13 summarizes the discrepancies for the content standards and figures 4, 5, and 6 provide a graphical representation of this data. In the case of the table the larger the discrepancy is the greater the need for improvement. In the graphical representations (Figure 4) the length of the line indicates the discrepancy, the upward mark at the right end of the lines equals the IMP rating and the downward mark at the left end of the line indicates the teachers' perception of their current knowledge of the content standards. In all cases the importance rating was greater than the knowledge rating.

Table 13

Discrepancies among and between the importance, knowledge and materials used for each of the aquaculture content standards.

	Content Standard	Importance vs. Knowledge	Importance vs. Materials	Knowledge vs. Materials
CS1	Differentiate among freshwater, brackish water, and saltwater ecosystems.	0.28	1.26	0.98
CS2	Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	0.46	1.04	0.58
CS3	Explain the importance of biogeochemical cycles in an aquatic environment.	0.36	1.12	0.76
CS4	Determine important properties and content of water as related to aquaculture.	0.32	1.07	0.74
CS5	Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding.	0.35	1.10	0.75
CS6	Describe adaptations that allow organisms to exist in specific aquatic environments.	0.29	1.25	0.96
CS7	Describe processes and environmental characteristics that affect growth rates of aquatic animals.	0.45	1.31	0.87
CS8	Determine effects of the fishing industry on the aquatic environment.	0.57	1.40	0.83
CS9	Describe various structures and equipment used in growing aquacrops.	0.59	1.17	0.58
CS10	Describe the control of diseases and pests in aquatic environments.	0.74	1.36	0.62

	Content Standard	Importance vs. Knowledge	Importance vs. Materials	Knowledge vs. Materials
CS11	Describe various career opportunities in the aquaculture industry.	0.48	1.06	0.58
CS12	Describe safety precautions for the aquaculture industry.	0.54	1.09	0.56
CS13	Explain the historical background of aquaculture.	0.36	0.93	0.58
CS14	Categorize aquaculture species as cold, cool, or warm water species.	0.28	0.82	0.54
CS15	Describe infrastructure necessary for aquaculture production.	0.59	1.00	0.42
CS16	Define concepts associated with health management of aquacrops.	0.66	1.02	0.36
AVG		**0.46**	**1.13**	**0.67**

Figure 4

Graphical representation of the discrepancy between the mean Importance rating and the mean knowledge rating.

Figure 4 Discrepancy Between Importance and Knowledge

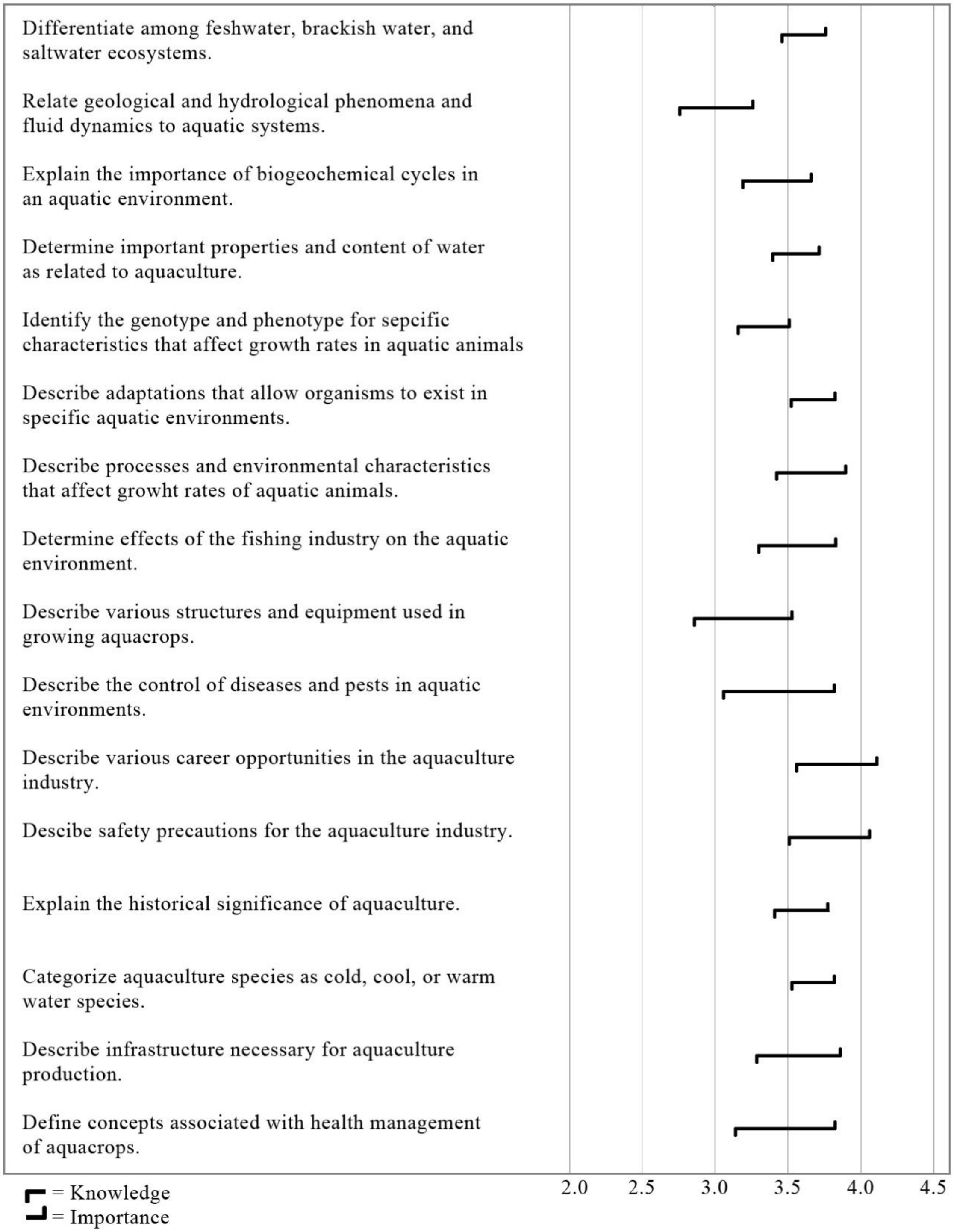


Figure 5 Discrepancy Between Importance and Materials

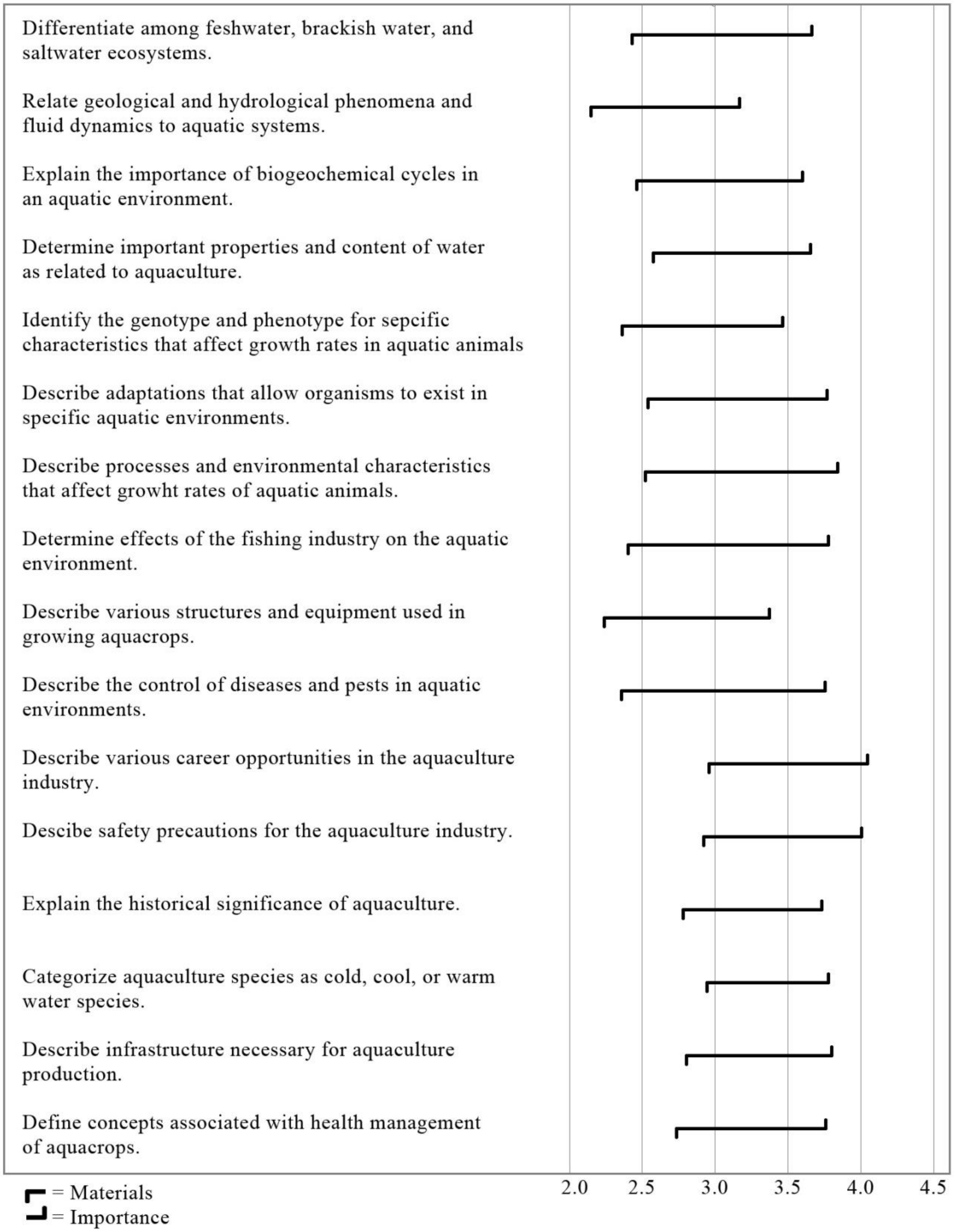
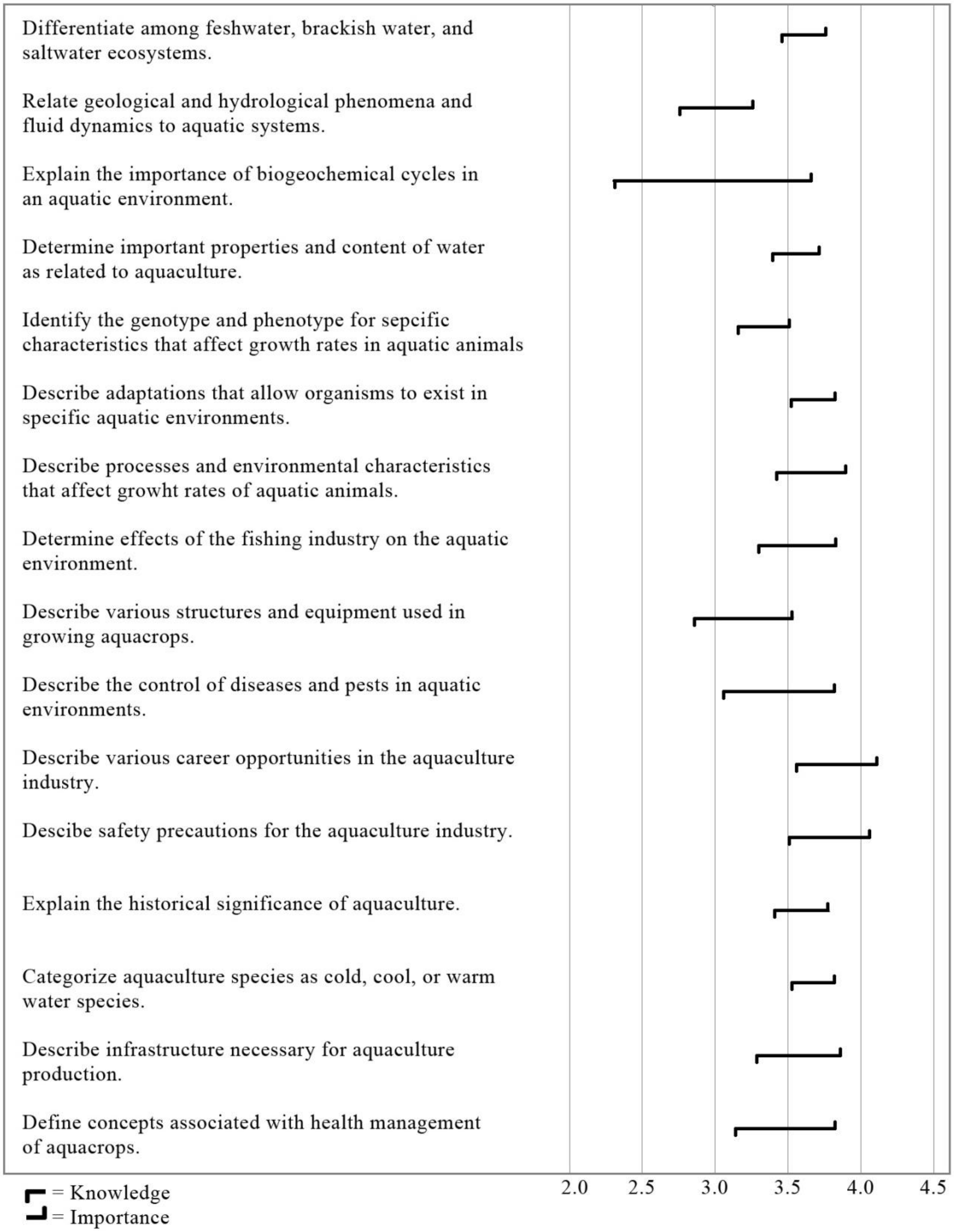


Figure 6 Discrepancy Between Knowledge and Importance



To identify the statistical significance of the discrepancies between the means of IMP, KNOW, and MAT a mixed design analysis was used. This mixed design was chosen instead of running three t-tests to reduce type I error and reduce the number of analyses. The test report showed that the data violated Mauchly's test of spericity ($p < 0.001$) indicating that the variances between IMP, KNOW, and MAT were not equal. Using the Greenhouse-Geisser equation to test for within-subject effects indicated that there was a significant difference between the discrepancy scores $F(1.674,318.053) = 129.964$, $p < 0.001$. The partial Eta squared value for this difference indicated a large effect ($\eta^2 = 0.406$). Fisher's least significant difference (LSD) test indicated significant differences in all pairwise comparisons, IMP-KNOW $p < 0.001$, IMP-MAT $p < 0.001$, and KNOW-MAT $p < 0.001$.

Mean Weighted Discrepancy Scores (MWDS)

The next step in the assessment of the need for training or improvement was to weight the scores based on their importance. The need for in-service training with respect to the various aquaculture content standards was determined by calculating the mean weighted discrepancy score (MWDS). Weighted discrepancy scores were calculated for each respondent for each of the content standards by subtracting the knowledge rating from the importance rating and multiplying the result by the importance rating (Borich, 1980). Mean weighted discrepancies were calculated for each content standard by dividing the sum of the weighted discrepancy scores for the content standard by the number of observations (Borich, 1980). This is the formula.

$$DS = (IMP - KNOW)$$

$$WMS = (DS)(IMP)$$

$$MWDS = \frac{\sum WDS}{N}$$

The content standards with the highest MWDS, and therefore the greatest need for training were, CS10 - Describe the control of diseases and pests in aquatic environments (4.19, SD = 5.47), CS16 – Define concepts associated with the health management of aquacrops (3.86, SD = 5.37), and CS12 – Describe safety precautions for the aquaculture industry (3.58, SD = 5.25). The content standards with the lowest MWDS were CS14 = Categorizes aquaculture species as cold, cool, or warm water species (2.28, SD = 4.64) and CS13 = Explain the historical background of aquaculture (2.31, SD = 4.64). Table 14 indicates the MWDS and SD for each of the content standards.

Table 14

Mean weighted discrepancy scores (MWDS) for each aquaculture content standard (IMP –KNOW)

	Content Standard	MWDS	SD
CS1	Differentiate among freshwater, brackish water, and saltwater ecosystems.	2.42	5.04
CS2	Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	2.59	4.82
CS3	Explain the importance of biogeochemical cycles in an aquatic environment.	2.63	5.05
CS4	Determine important properties and content of water as related to aquaculture.	2.55	5.19
CS5	Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding.	2.55	5.84
CS6	Describe adaptations that allow organisms to exist in specific aquatic environments.	2.52	5.18
CS7	Describe processes and environmental characteristics that affect growth rates of aquatic animals.	3.08	5.20
CS8	Determine effects of the fishing industry on the aquatic environment.	3.55	5.56
CS9	Describe various structures and equipment used in growing aquacrops.	3.24	5.28
CS10	Describe the control of diseases and pests in aquatic environments.	4.19	5.47
CS11	Describe various career opportunities in the aquaculture industry.	3.25	5.13
CS12	Describe safety precautions for the aquaculture industry.	3.58	5.25
CS13	Explain the historical background of aquaculture.	2.31	4.64
CS14	Categorize aquaculture species as cold, cool, or warm water species.	2.28	4.52

	Content Standard	MWDS	SD
CS15	Describe infrastructure necessary for aquaculture production.	3.41	5.35
CS16	Define concepts associated with health management of aquacrops.	3.86	5.37

MWDS were also calculated to identify the greatest need for improvement of educational materials used to teach the content standards using the formula.

$$DS = (IMP - MAT)$$

$$WMS = (DS)(IMP)$$

$$MWDS = \frac{\sum WDS}{N}$$

The content standards identified with the greatest MWDS for teaching material improvement were CS8 = Determine effects of the fishing industry on the aquatic environment (7.00, SD = 6.45) and CS10 = Describe the control of diseases and pests in aquatic environments (6.89, SD = 6.42). The content standard with the lowest IMP-MAT MWDS was CS2 = Relate geological and hydrological phenomena and fluid dynamics to aquatic systems (4.80, SD = 5.58). Table 15 indicates the IMP – MAT MWDS for each of the content standards.

Table 15

Mean weighted discrepancy scores between importance and materials for Alabama aquaculture content standards.

	Content Standard	MWDS	SD
CS1	Differentiate among freshwater, brackish water, and saltwater ecosystems.	6.40	6.30
CS2	Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	4.80	5.58
CS3	Explain the importance of biogeochemical cycles in an aquatic environment.	6.05	6.52
CS4	Determine important properties and content of water as related to aquaculture.	5.89	6.60
CS5	Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding.	5.64	6.53
CS6	Describe adaptations that allow organisms to exist in specific aquatic environments.	6.52	6.57
CS7	Describe processes and environmental characteristics that affect growth rates of aquatic animals.	6.81	6.23
CS8	Determine effects of the fishing industry on the aquatic environment.	7.00	6.45
CS9	Describe various structures and equipment used in growing aquacrops.	5.67	6.07
CS10	Describe the control of diseases and pests in aquatic environments.	6.89	6.42
CS11	Describe various career opportunities in the aquaculture industry.	6.07	6.37
CS12	Describe safety precautions for the aquaculture industry.	6.24	6.40
CS13	Explain the historical background of aquaculture.	4.90	5.78
CS14	Categorize aquaculture species as cold, cool, or warm water species.	5.03	6.21

	Content Standard	MWDS	SD
CS15	Describe infrastructure necessary for aquaculture production.	5.48	5.74
CS16	Define concepts associated with health management of aquacrops.	5.68	6.24

Multivariate analysis of variance (MANOVA)

A 3x2 MANOVA was conducted using the Statistical Package for Social Science (SPSS v.19) utilizing the Wilk's lambda formula to examine the data. Wilk's lambda is a statistical test used in (MANOVA) to test whether there are differences between the means of identified groups of subjects on a combination of dependent variables (Bartlett et al. 2000). The three dependent variables were importance of the content standards (IMP), knowledge of the content standards (KNOW) and materials used to teach the content standards (MAT). The two independent variables were teacher type and experience level. Teacher type was the first independent variable and had three levels, science teachers (SCI), career and technical education teachers (CTE), and those teachers that taught both (BOTH). The null hypothesis for teacher type was that there was no difference between them. Experience of the teachers was the second independent variable and was divided into two levels, teachers with less than the mean level of experience (14 years) and those with more than 14 years. The null hypothesis in this case was that there was no difference between the two levels of experience. The p-value used for the MANOVA was .05.

Analysis of the data indicated that there was no significant interaction effect between the teacher type and experience level $F(6, 320) = 1.447$, $p = 0.196$. There was also no significant main effect with respect to the two levels of experience $F(3,160) = 1.078$, $p = 0.360$. There was, however, a significant main effect with respect to teacher type $F(6,360) = 2.282$, $p = 0.036$. This means that there was a significant difference between how the teacher groups viewed either the IMP, KNOW, or MAT. The partial Eta squared value indicated that the effect size was 0.041 which is considered a small to moderate effect. A follow-up analysis of variance (ANOVA) was performed to identify which dependent variable (IMP, KNOW, MAT) was different within teacher type. The Lavene's test of equality of variance indicated that our data did not violate the equal variance assumption so we could continue ANOVA with confidence. Results of the ANOVA indicated that there was no significant differences between how the teachers viewed IMP or KNOW, $F(2,162) = 1.463$, $p = 0.235$ and $F(2,162) = 1.441$, $p = 0.24$ respectively. There was, however, a significant difference in the way the science teachers viewed the materials $F(2, 162) = 6.332$, $p = 0.002$. The size of the effect was moderate ($\eta^2 = 0.072$).

The next step in the analysis was to determine which of the teacher groups viewed the materials differently. The post-hoc Fisher's least significant difference (LSD) test indicated that the science teachers as a group thought significantly less of the materials than the CTE ($p < 0.001$) and BOTH ($p = 0.045$) teacher groups. The CTE and BOTH groups did not vary significantly from each other ($p = 0.726$).

A mixed design analysis was used to determine if there was a difference between the early and late (after December 1st) respondents to the survey. The analysis suggested that there was no difference $F(1, 189) = 1.572$, $p = 0.211$. The last statistical test used in this experiment was a Chi squared test to determine the significance of the last two questions on the survey. Question 14 was; Are you interested in aquaculture, question 15 was, if your schedule allowed would you be interested in teaching an aquaculture course. The X^2 test indicated that significantly more people answered yes to both question 14 and 15, $X^2 = 64.381$, $p < 0.001$ and 16.621, $p = 0.001$, respectively.

Summary

Through the analyses the researcher was able to successfully answer all three research questions and determine the greatest areas of need with regard to aquaculture training and curriculum development. Discussion of meaning and significance of the study results are presented in chapter five.

CHAPTER 5 –
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to improve teachers' ability to effectively use aquaculture as a tool to teach math and science. It involved an exploration of how Alabama science and career tech teachers perceive the importance of aquaculture related topics, their knowledge of those topics and how they perceive the quality and quantity of available teaching materials. This information made it possible to identify the greatest areas of need with regard to aquaculture training and curriculum development (or identification). This knowledge should prove valuable to schools in scheduling in-service training, pre-service teacher training and in the long run, create more aquaculturally literate citizens with an improved ability to prosper in a technology advanced society and help feed our ever-growing population. This chapter provides an overall summary of the study, its' limitations, conclusions drawn and recommendations for future research.

Summary

Aquaculture or fish farming is the aquatic version of agriculture. Aquaculture is the reproduction and growth of aquatic organisms in a controlled or semi-controlled environment (Stickney, 1979; Lovshin, 1989). It is an important facet of agriculture and is destined to play a major role in the production of food for the earth's growing population. Aquaculture, like agriculture, is a complex subject with numerous facets for study in educational programs. Aquaculture is an excellent teaching tool, because it easily integrates many disciplines including biology, chemistry, economics, math, and physics. Growing fish, aquatic plants, and other living things in the classroom creates a living laboratory and promotes daily hands-on experiences that enrich the learning environment. A review of the literature indicated that it is generally accepted that aquaculture education programs motivate students and assist in teaching math and science principles.

However, effective use of aquaculture as a teaching tool is limited by teacher knowledge and the training materials that are currently being used. This study was conducted to validate this hypothesis by answering three research questions:

1. <u>Importance of Content Standards</u>. How do teachers certified to teach the aquaculture curricula perceive the importance of various content standards of the Alabama aquaculture science course of study?
2. <u>Abilities</u>. What are teachers', certified to teach the aquaculture curricula, perceived abilities, indicated by their current knowledge, to teach the content standards of the Alabama aquaculture science course of study?
3. <u>Teaching Materials</u>. How do Alabama teachers, certified to teach the aquaculture curricula, perceive of the quality of aquaculture teaching materials?

Conclusions

Based on the limited demographic data related to our study sample it is difficult to draw many conclusions. Assuming that the study sample is representative of the population in question it appeared that there were more female, 75%, than male science teachers, 25%. That trend was reversed in the CTE category where only 20% were female and 80% were male. This indicates that there is a need to recruit more females to teach CTE and more males to teach science. The mean age of the teachers was 42.5 years but the age distribution of the teachers in the sample indicated that 29% of the teachers were more than fifty years old. This indicates that there will be excellent opportunities for science and career and technical teachers in the next 10-20 years. Few of the teachers in the study had PhDs (1.6%) but the majority had masters (64.9%). This seems to indicate that there is little incentive (or time available) for teachers to pursue a PhD.

Data related to the importance (IMP), knowledge of (KNOW), and materials (MAT) used to teach the content standards (CS) indicate that in general the CTE teachers rated the topics more important, had greater knowledge of, and rated the materials of higher in quality. Based on the analysis, the CTE teachers thought that the contents standards were more important (M = 3.82, SD = 1.06) than the BOTH group (3.80, SD = 1.07) or the SCI teachers (M = 3.60, SD = 1.14). Teachers often regard topics that they know more about as more important so the finding is not surprising. Among the 65 CTE teachers responding to the survey 52 indicated teaching one or more of the classes related to aquaculture (aqua experience, aquaculture science, aquatic biology, and fish and wildlife management). There were 130 respondents that indicated they taught one or more science courses, but only 23 indicated that they taught either aquaculture science or the aquascience elective. It makes sense then that science teachers would have less knowledge of aquaculture in general.

The CTE group also indicated that they had greater knowledge of the content standards (CTE KNOW M = 3.36 SD = .084; BOTH KNOW M = 3.35, SD = 1.08; SCI KNOW M = 3.07, SD = 1.10). Interestingly 7 of the 10 shared (CS 1-10) were ranked higher by the BOTH group than the CTE teachers but 5 of the 6 CS shared only between the CTE and BOTH groups (CS11-16) were ranked higher by the CTE teachers. This seems to imply that those teachers that specialize in the CTE area have greater knowledge of the content standards specific to their courses. This is most likely a result of their CTE training.

In the materials section the CTE teachers gave the highest overall ratings 2.84, SD = 0.94 followed by the BOTH teachers 2.75, SD = 1.30 and the science teachers 2.20, SD = 1.04 thought the least of the materials. According to the MANOVA, the difference between the SCI teachers and the CTE teachers was highly significant ($p < 0.001$) and significantly different than the BOTH category ($p = 0.045$). The SCI group rated the materials as a whole below average (M = 2.20) while the CTE and BOTH groups rated the materials as average (M = 2.84 and 2.75), respectively. This indicates a need for improving the quality of aquaculture teaching materials available to SCI teachers. It should be noted, however, many of the SCI teachers who are qualified to teach aquaculture courses do not teach it and it is unknown how much aquaculture content they are using in the other courses. It could be that because many of the SCI do not teach aquaculture they do not pursue the material to do so and are therefore less aware of what resources are available. It would benefit the aquaculture community and educators to improve the general awareness of aquaculture.

Discrepancies

One of the key elements of this study was to identify discrepancies between importance and knowledge, importance and materials, and knowledge and materials. The researcher found the most illustrative portion of the analysis was shown in figures 4-6. These figures show not only discrepancies but indicate the magnitude of those discrepancies. In all cases the data showed positive discrepancies. All of the mean importance ratings were higher than the mean knowledge ratings. The mean importance ratings were also greater than the mean materials ratings and all the knowledge ratings were greater than the materials ratings. These discrepancies indicate a strong need for additional aquaculture training and materials development.

When the importance rating of each CS was used to weight the discrepancies to create the (WDS) the discrepancies between both IMP-KNOW and IMP-MAT appeared even larger. In fact the MANOVA indicated that all of the discrepancies were in fact highly significant in all pairwise comparisons (IMP-KNOW, $p < 0.001$; IMP-MAT, $p < 0.001$, and KNOW-MAT, $p < 0.001$). The two CS with the greatest mean weighted discrepancy scores (MWDS) were both related to diseases and health management of aquatic species (CS10 and CS16). This discrepancy indicates that while the teachers consider the theme of health management and disease important they have relatively little knowledge of the topics. This represents an outstanding opportunity for in-service training. As aquaculture continues to grow and the intensity of the aquaculture production systems increase there will be a greater emphasis on maintaining an appropriate environment and understanding and controlling disease and disease vectors.

The larger magnitude of the DS and the MWDS between the IMP and the MAT indicates a need even greater than that for improved training. The need for the development of quality teaching materials that can be used to educate students about aquaculture principles is plainly evident. This need is especially great with respect to science teachers. As noted earlier the MANOVA indicated that the science teachers thought significantly less of the materials than either the CTE or the BOTH groups. However, it is possible that quality materials available in these subject areas exist but teachers' awareness of these materials is low. The greatest MWDS between IMP and MAT was CS-8 Determine the effects of the fishing industry on the environment. Aquaculturists often point to the declining catches from the ocean as a primary need to expand aquaculture. Educational materials, however, to convey this message to educators and children are considered below average. If the aquaculture industry hopes to gain support for its' activities then providing this kind of information is critical.

Teacher Experience

The data shows that there was no significant difference between teachers experience level (< 14yrs, >14yrs) and the way they rated the importance, knowledge or quality of materials. In historical terms using aquaculture as a teaching tool is a relatively new phenomena started approximately 20 years ago. The realization that there is no significant difference between the experience groups indicates that while aquaculture education is growing, pre-service teacher training is lacking. This appears to be the case with both science teachers and CTE teachers.

Content standard observations

CS 2 – Relate geological and hydrological phenomena and fluid dynamics to aquatic systems was rated the lowest in all three of the categories examined, IMP, KNOW, and MAT. It's placement at the bottom of all three categories means that not only is it not important but teachers have a low knowledge how to teach it. It is not surprising then that they rate the materials available below average as well. Just as teachers often tend to think that the subject they know most about are more important, conversely, it may be that the less they know about a topic the less important it will be. In personal conversation with both CTE and SCI teachers it has been my experience that there is some confusion as to what this CS is really about. The wording of CS-2 is very broad, somewhat ambiguous and seems to share a lot of content with CS-3 Explain the importance of biogeochemical cycles in an aquatic. It might be possible to eliminate CS-2 altogether and not significantly reduce the information provided to the students. At a minimum CS-2 should be reworded.

Recommendations

The study of aquaculture education is in its infancy so there are a myriad of potential areas of continued study. Based on the nature of this study and its results recommendations for future studies might include

1. Expand this type of study to other states, regions or nationally.
2. Identify the reasons that more aquaculture training is not included in the pre-service training of science and career tech teachers.

3. Investigate if and how science teachers are infusing aquaculture into other science courses.
4. Develop aquaculture in-service training opportunities and evaluate the post-training use of aquaculture in the classroom.
5. Examine successful secondary school aquaculture programs to investigate whether these programs affect student grades.

There is a growing body of evidence to suggest the significant capacity of aquaculture as an area of study to improve agriscience programs and serve as a cross-curricular mechanism to improve students' competency in math and science. Educators have found that using aquaculture to teach the principles of math and science improves student interest and motivation (Conroy, 1999; Conroy & Walker, 2000; El-Ghamrini, 1996; Leighfield, 2005; Lovitt, 1999; Mengel, 1999; Reese, 2001; Wingenbach, Gartin & Lawrence, 2000). Scientists and economists forecast that aquaculture will play an increasingly important role in providing protein to the world's expanding population. These highlights from chapter two indicate why this study was conducted. The results indicate that there is still a significant gap between the importance and knowledge of aquaculture related topics and an even greater gap between the importance of these topics and the materials available to teach them. This should provide motivation for pre-service teacher education providers to improve the amount of aquaculture content in their teacher preparation. It should also provide stimuli for the aquaculture community to do a better job of telling their story. The motivation to use aquaculture as a teaching tool is clear, now we must improve the ability of the teachers to use it.

REFERENCES

Abunejmeh, M. (1985). Selected attitudes, perceptions, and preferences of highschool chemistry students who experience three quantitatively-defined science learning environments (Doctoral dissertation, Florida State University, 1985). Dissertation Abstracts International, 46, 3309.

Adams, C., Biddle, B. & Thomas, J. (1988) Present status of environmental science in Texas public schools. The Journal of Environmental Education, 19(3), 19-24.

Agne, R.M. & Nash, R.J. (1974). Environmental education: A fraudulent revolution? Teachers College Record, 76 (1974, No.2), 304-315.

Alexander, P.A. (1988). The interaction of domain-specific and strategic knowledge in academic performance. Review of the Journal of Education, 58(4) 375-411.

Archer, T.M. (2003). Web-based surveys. The Journal of Extension, 41(4). Retrieved September 13, 2010 from http://www.joe.org/joe/2003august/tt6.php

Archer, T.M. (2008). Response rates to expect from web-based surveys and what to do about it. Journal of Extension, 46(3). Retrieved September 13, 2010 from http://www.joe.org/joe/2008june/rb3.php

Ajzen, I. & Fishbein (1969). The prediction of behavioral intentions in a choice situation. Journal of Experimental and Social Psychology, 5(4), 400-416.

Ajzen, I. & Fishbein (1972). Attitudes and normative beliefs as factors influencing behavioral intentions. Journal of Personal and Social Psychology, 21(1), 1-9.

Angelis, Z. (2003). The structure of attitudes towards science. Masters Abstracts International, 42(03), 728. (UMI No. ATT MQ84206).

Bardach, J.E., Ryther, J.H. & McLarny, W.O. (1972). Aquaculture: the farming and husbandry of freshwater and marine organisms. John Wiley & Sons, New York.

Barrich, R. K., Ladewign, H.W., & Hedges, L.E. (1983). Development of a systematic approach to identify technical inservice needs of teachers. Journal of the American Association of Teacher Educators in Agriculture, 24(1), 13-19.

Bartlett, H.P., Simonite, V., Westcott, E. & Taylor, H.R. (2000) A comparison of the nursing competence of graduates and diplomates from UK nursing programmes. Journal of Clinical Nursing, 2000(9), 369-381.

Billeh, V.Y. & Zakhariades, G.A. (1975). The development and applications of a scale for measuring scientific attitudes. Science Education, 59(2), 155-165.

Beiswenger, R. Sturgese, E.L. & Jones R. (1991) Water education in Wyoming: assessing educators' knowledge of water topics and their use in the elementary curriculum. Journal of Environmental Education, 23(1), 24-29.

Borgotti, R. & Buck, E. H. (2004). Open ocean aquaculture: CRS report for Congress Order Code RS21914. Congressional Research Service. Retrieved September 30, 2009 from http://dnr.louisiana.gov/mariculture/appendix/appendix_d.pdf

Borich, G. D. (1974). Evaluating educational programs and products. Englewood Cliffs, NJ: Educational Technology Publications, Inc.

Borich, G.D. (1979). Implications for developing teacher competencies from process-product research. Journal of Teacher Education, 30(1), 77-86.

Borich, G.D. (1980). A needs assessment model for conducting follow-up studies. Journal of Teacher Education, 31(3), 39-42.

Brody, M. & Patterson, B. (1992). All about aquaculture: A systematic approach. The Science Teacher, 59(2), 36-40.

Brown, J.H. & Shavelson, R.J. (1996). Assessing hands-on science: a teacher's guide to performance assessment. Thousand Oaks, CA: Corwin Press,

Bruder, I. (1993). Redefining science: Technology and the new literacy. Electronic Learning, 12(6), 20-24.

Burgess, T.F. (2001). A general introduction to the design of questionnaires for survey research. University of Leeds. Retrieved November 5, 2009 from http://iss.leeds.ac.uk/info/312/surveys/217/guide_to_the_design_of_questionnaires

Byo, S.J. (1999). Classroom teachers' and music specialists' ability to implement the national standards for music education. Journal of Research in Music Education, 47(2), 111-23.

Campbell-Bradley, J., Wakiczek, T. & Zajicek, J. (1999). The relationship between environmental knowledge and environmental attitude of high school students. The Journal of Environmental Education, 30(3), 17.

Cannon, R. K. Jr. & Simpson, R. D. (1985). Relationships among attitude, motivation, and achievement of ability grouped, seventh-grade, life science students. Science Education, 69(2), 121-138.

Carlberg, J.M. (2001). U.S. Aquaculture: Current status and future directions. Aquaculture Magazine, 27(4), 36-43.

Carlson, R.E., Donaldson, G.W., Masters, H.B. & Smith, J.W. (1963). Outdoor Education. Englewood, NJ: Prentice-Hall, Inc.

Chankook, K. & Fortner, R. (2006). Issue-specific barriers to addressing environmental issues in the classroom: An exploratory study. The Journal of Environmental Education, 37(3), 15-22.

Cline, D. (2000). Something fishy in Alabama high schools, Aquaculture Magazine, 26(6), 11-15.

Cline, D. J, (2004). Recirculating aquaculture systems in Alabama high schools, Paper presented at the Fifth International Recirculating Aquaculture Conference, Roanoke, VA.

Cline, D. (2005). Aquatic science programs in Alabama, United States Aquaculture Association Newsletter, (11), 2. Retrieved May 12, 2010 from https://www.was.org/Usas/USChapter_files/Newsletter/April05.pdf

Conn, C. Using the internet for surveying: Techniques for designing, developing and delivering. Office of Academic Assessment, Northern Arizona University, Retrieved September, 15, 2010 from https://www4.nau.edu/assessment/main/research/responserates.htm

Conry, C. & Peasley, D. (1997). National aquaculture curriculum phase I evaluation report. Submitted to the National Council for Agriculture Education/USDA.

Conroy, C. & Peasley, D. (1998). National aquaculture curriculum phase II evaluation report. Submitted to the National Council for Agriculture Education/USDA.

Conroy, C. & Walker, N.J. (2000). An examination of academic and vocational subject matter in the aquaculture classroom. Journal of Agricultural Education, 41(2), 54-64.

Couper, M.P. (2008). Designing effective web surveys. Cambridge University Press, New York: NY.

Coyle, K. (2005). Environmental literacy in America. Washington, DC: The National Environmental Education and Training Foundation. Retrieved August 24, 2009 from http://www.neefusa.org/pdf/ELR2005.pdf

Crews, J.R. & Chappell, J.A. (2007, Feb). 2006 Alabama aquaculture factsheet. Auburn: AL. Alabama Cooperative Extension System. Retrieved September 25, 2009 from http://www.aces.edu/timelyinfo/Ag&NatResEcon/2007/February/daers_07_4.pdf

Davis-Hodgkins, M. (1999). Aquaculture training and education: an applied approach for industry. World Aquaculture, 30(2), 31-34.

Dewey, J. (1938). Experience and education. The Macmillan Company. New Jersey.

Dillman, D.A. (2000). Mail and internet surveys: The tailored design method. New York: John Wiley & Sons, Inc.

Dillman, D.A., & Bowker, D.K. (2008). The web questionnaire challenge to survey methodologists. Retrieved November 5, 2009 from http://www.sesrc.wsu.edu/dillman/zuma_paper_dillman_bowker.pdf

Disinger, J. F. (1985). What research says: Environmental education's definitional problem. School Science and Mathematics, 85(1) 59-68.

Disinger, J. F. (1989). The current status of environmental education in U.S. school curricula. Contemporary Education, 60(3), 126-136.

Disinger, J.F., & Howe, R.W. (1992) Environmental Education Research News. Environmentalist, 12(1), 3-7.

Duffy, R.M., & Cunningham, D.J. (2007). Constructivism: Implications for the design and delivery of construction. In David H. Jonassen (Ed) Handbook of Research for
Educational Communications and Technology. Bloomington; IN, AECT. Retrieved September 9, 2009 from http://iris.nyit.edu/~kkhoo/Spring2008/Topics/Cons/ConstructivismImplications.pdf

Dumouchel, D. (2003). Experiential practice: Outdoor, environmental and adventure education. New Horizons for Learning. Retrieved August 10, 2009 from http://www.newhorizons.org/strategies/environmental/dumouchel.htm

Duncan, D.W., Ricketts, J.C., Peake, J.B. & Uesseler, J. (2006). Teacher preparation and in-service needs of Georgia agriculture teachers. Journal of Agricultural Education, 47(2), 24-35.

Edwards, M.C., & Briers, G.E. (1999). Assessing the in-service needs of entry-phases agriculture teachers in Texas: A discrepancy model versus direct assessment. Journal of Agricultural Education 40(3), 40-49.

El Ghamrini, S.A. (1996). Adoption of aquaculture by high school agriculture teachers in the central region of the United States (Doctoral dissertation, Iowa State University, 1996). Dissertations Abstracts International 57/04 p. 1446

Ericson, H.L. (1995). Stirring the head, heart, and soul: redefining curriculum and instruction. Thousand Oaks: Corwin Press.

Engle, C.R. (1991). Teaching aquaculture economics and marketing. World Aquaculture, 30(2), 17-19.

FAO – See United Nations Food and Agriculture Organization

Fitzpatrick, C.N. (1968). Philosophy and goals for outdoor education. (Doctoral Dissertation, Colorado State College, 1968) University Mircofilms, Inc., Ann Arbor, Michigan.

Flick, L.B. (1993, winter). The meanings of hands-on science. Journal of Science Teacher Education, 4(1), 1-8.

Fortner, R. (1983). Knowledge, attitudes, experiences: The aquatic connection. Current; The Journal of Marine Education, 5(1), 7-11.

Fortner, R.W. (2001). The right tools for the job: How can aquatic resources education succeed in the classroom. Retrieved November 18, 2009 from
http://www.rbff.org/uploads/Resources_bestpractices/rosannefortner_paper.pdf

Fortner, R.W. & Corney, J.R. (2002). Great lakes educational needs assessment: Teachers' priorities for topics, materials and training. Journal of Great Lakes Research, 28(1), 3-14.

Fortner, R. & Meyer, R.L. (2000). Discrepancies among teachers' priorities for and knowledge of freshwater topics. Journal of Environmental Education, 31(4), 51-53.

Fortner, R. & Wildman, T.M. (1980). Marine Education: Progress and Promise. Science Education, 64(5), 717-723.

Francis, L.J. and Greer, J.E. (1999). Measuring attitude towards science among secondary school students: the affective domain. Research in Science and Technological Education, 17(2), 219-226.

Frederick, J. A. (2005) Science in action: tools for teaching urban aquaculture concepts. In B.Costa-Pierce, A. Desbonnet, P. Edwards and D. Baker (Eds.) Urban Aquaculture (pp. 233-245). Cambridge, MA: CABI Publishing.

Friesen, E. & Kristjanson, C. (Eds.). (2007). Teaching at the University of Manitoba: A handbook (pp. 2.4-2.11). Winnipeg, Manitoba: University Teaching Services. Retrieved August 31, 2009 from http://www.umanitoba.ca/academic_support/uts/media/5_lr_UTShandbook.pdf#page=43

Frykholm, J. A. (1996). Pre-service teachers in mathematics: struggling with the standards. Teaching & Teacher Education, 12(6), 665-681.

Garton, B.L. & Chung, N. (1996). The inservice needs of beginning teachers of agriculture as perceived by beginning teachers, teacher educators, and state supervisors. Journal of Agricultural Education, 37(3), 52-58.

Gayford, C. (1998). The perspective of science teachers in relation to current thinking about environmental education. Research in Science &Technological Education, *16*(2), 101-113.

Gilberson, K., Bates, T., McLaughlin, T. & Ewert, A. (2006) Outdoor education: Methods and strategies. Champaign, IL: Human Kinetics.

Goodwin, J. & Schaadt, J. (1978). The need for marine and aquatic education, Delaware Sea Grant College Program, University of Delaware, Newark, DE. Retrieved Nov. 10, 2008 from National Sea Grant Library http://nsgl.gso.uri.edu/delu/delue78001.pdf

Hair, J.J., Bush, R.P. & Ortinau, D.J. (2006). Marketing research within a changing information environment 3rd edition. New York, NY: McGraw Hill Companies Inc..

Haladyna, T. & Shaughnessy, J. (1982). Attitudes toward science: a quantitative synthesis. Science Education, 66(4), 547-563.

Haladyna, T., Olsen, R. & Shaughnessy, J. (1983). Correlates of class attitude toward science. Journal of Research in Science Teaching, 20(4), 311-324.

Ham, S. H. & Sewing, D.R. (1987). Barriers to environmental education. Journal of Environmental Education, 19(2), 17-24.

Ham, S. H., Rellegert-Taylor, & Krumpe, E.E. (1987). Reducing barriers to environmental education. Journal of Environmental Education, 19(2), 25-33.

Hammerman, D.R., & Hammerman, W.M. (1964). Teaching in the outdoors. Minneapolis, MN: Burgess Publishing Company.

Hammerman, W. M. (1980). Fifty years of resident outdoor education: 1930-1980: Its impact on American education. Martinsville, IN: American Camping Association.

Hart, P. (2002). Environmental in the science curriculum: The politics of change in the Pan- Canadian science curriculum development process. International Journal of Science Education, 24(11), 1239-1254.

Hasan, O. E. (1985). Investigation into factors affecting attitudes toward science of secondary school students in Jordan. Science Education, 69(1), 3-18.

Haury, D. L. & Rillero, P. (1994). Perspectives of hands-on science teaching. The ERIC clearinghouse for science, mathematics and environmental education. Columbus, OH. Retrieved May 9, 2011 from http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-toc.htm#aut

Hirsch, E. D. (1996). The schools we need and why we don't have them. New York, NY: Doubleday.

Jensen, E. (2000). Brain-based learning. San Diego, CA: The Brain Store.

Joerger, R. M. (2002). A comparison of the inservice education needs of two cohorts of beginning Minnesota agricultural education teachers. Journal of Agricultural Education, 43(3), 11-24.

Johnson, D., Schumacher, L.G., & Stewart, B.R. (1990, February). Determination of the agricultural mechanics laboratory management inservice needs of Missouri agriculture teachers, Proceedings of the Forty-Fourth Annual Central Region Research Conference. Chicago, IL. (ERIC Document Reproduction Service No. ED319903)

Kirkley, J.E., Ward, J.M., Moore, C.M., Hayes, C., Hooker, B., & Walden. (2009). International trade in seafood and related products: An assessment of U.S. trade patterns. Retrieved October 15, 2009 from http://www.nmfs.noaa.gov/sfa/PartnershipsCommunications/tradecommercial/documents/usinternationaltradereport_draft_August_4.pdf

Ko, Chi-Chung, A. & Lee, Chi-kin, J. (2003). Teachers` perceptions of teaching environmental issues within the science curriculum: A Hong Kong Perspective. Journal of Science Education and Technology, 12(3), 187-204.

Kolb, D.A. (1984). The process of experiential learning. In Kolb, Experiential learning: Experience as the source of learning and development (pp.20-38). Englewood Cliffs, NJ: Prentice Hall. Retrieved September 9, 2009 from http://www.taekwondo.co.at/oetdv/alex/kolb84_Kolb_Experiential_learning.pdf

Lambert, J. (2006). High school marine science and scientific literacy: the promise of an integrated science course, The International Journal of Science Education, 28(6) 633-654 Retrieved May 12, 2010 from http://people.uncw.edu/lambertjl/documents/MarineScienceIJSE.pdf

Landau, M., Landau, B.J. & Youakim, A. (2003). A survey of attitudes on college aquaculture education. Aquaculture Magazine, 29(6) 32-36.

Lane, J., Wilke, R. Champeau, R. & D. Sivek, (1994). Environmental education in Wisconsin: A teacher survey. Journal of Environmental Education, 25(4), 9-17.

Lange, K. (2005). Environmental education – Learning in a non-traditional environment. Retrieved August 24, 2009 from http://interact.uoregon.edu/pdf/edld/programs/masters/specialtyprojects.pdf

Layfield, K. D. & Dobbins, T. R. (2002). Inservice needs and perceived competencies of South Carolina agricultural educators. Journal of Agricultural Education, 43(4), 46-55.

Lee, J.S., Burtle, G.J. & Newman, M.E. (2005). Aquaculture (3rd ed.). Upper Saddle River, NJ: Pearson Prentice Hall Interstate.

Lieghfield, C.E., Tiu, L.G, Connors, J.J., Swan, B. Semmens, K.J., Mengel, G., Escovitz, T.P. & Dasgupta, S. (2005, February). ADEC Tri-state aquaculture outreach to teachers using technology. Poster session presented at the annual Aquaculture America meeting, New Orleans, LA.

Lisowski, M., & Disinger, J.F. (1987). Cognitive learning in the environment: Secondary students. ERIC/SMEAC Environmental Education Digest No. 1 ERIC #

ED286756, Retrieved August 21, 2009 from http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/1b/f2/89.pdf

Lott, K.H. (2002). Evaluation of a statewide science inservice and outreach program: Teacher and student outcomes (Alabama) (Doctoral dissertation, Auburn University, 2002) Dissertation Abstracts International 63/06, 2186.

Lovett, P. A. (1999). Experiences of selected West Virginia agriculture teachers who have established aquaculture units in their schools and have taught aquaculture classes for two years or more (Master's thesis, West Virginia University 1999) Masters Abstracts International, 39/04, 968.

Lubchenco, J. (2003). The blue revolution: A global economic perspective. World Aquaculture, 34(4), 8-10.

Lucas, A. M. (1980-81). The role of science education for the environment. Journal of Environmental Education, 12(2), 32-37.

Lundie, S. (1989, March). A research-based design for inservice training in marine science for primary, middle school and high school. Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Francisco, CA. (ERIC Document Reproduction Service No. ED305253)

Malhorta, N.K. (2007). Marketing research: An applied orientation. Upper Saddle River, NJ: Pearson Education.

Maultsby, C. (1997). Inservice needs of agricultural science teachers. (Master's thesis, Texas Tech University). Retrieved Feb 28, 2011 from http://etd.lib.ttu.edu/theses/available/etd-01292009-31295011710216/unrestricted/31295011710216.pdf

McDonald, B, Y & Lawver, D.E. (1997, December) Laboratory safety inservice needs of Texas agricultural science teachers. Proceedings of the Twenty-Fourth Annual National Agricultlural Education Research Meeting. Las Vegas, NV. (ERIC Document Reproduction Service No. ED414479)

Montessori, Maria. (2009). In Encyclopedia Britannica. Retrieved October 06, 2009, from Encyclopedia Britannica Online: http://www.britannica.com/EBchecked/topic/390804/Maria-Montessori

Mengel, G.J. (1999). Aquaculture education: providing innovative opportunities for students. World Aquaculture, 30(2), 27-30.

Milkent, M., Irby, B. & Story, L. (1979). Teachers and marine education: A survey. National Sea Grant Library # MASGC-E-79-002, Retrieved November, 19, 2008 from http://nsgl.gso.uri.edu/masgc/masgce79002.pdf

Miller, A.S. (1990). Effects of hands-on, activity-based science and a supportive environment on at-risk sixth-grade students' attitude toward science, achievement in science, goal orientation, and cognitive engagement in science. Dissertation Abstracts International, 52 (05), 1703.

Moore, J.A. (1987). New wine in old bottles? The Agriculture Education Magazine, 60(4), 5-6.

Mooring, D. & Hoyle, J. (1994). Aquaculture is agriculture: The high school experience. The Agriculture Education Magazine. 67(1), 20-23.

Morris, W. (Ed.) (1982. The American heritage dictionary of the English language (High School Edition). Boston, MA: Houghton Mifflin Co.

Mullins, J.E. (1993). The relationship between teacher qualification and student learning: A study of standard one classroom in Belize, Central America. (Doctoral dissertation, Harvard University, 1993) Dissertation Abstract International, 54(05), 1766.

Munby, H. (1983). Thirty studies involving the "Scientific Attitude Survey": What confidence can we have in this instrument? Journal of Research in Science Teaching, 20(2), 141-162.

National Academy of Sciences, (2007). Rising above the gathering storm: Energizing and employing America for a brighter economic future. Retrieved May 17, 2010 from http://www.nap.edu/openbook.php?record_id=11463&page=94

National Agricultural Research, Teaching, and Extension Policy Act of 1977 ø7 U.S.C. 3321, Retrieved January 28, 2008 from http://www.csrees.usda.gov/about/offices/legis/pdfs/nar77.pdf

National Aquaculture Act of 1980, 16 U.S.C. 2801, et seq. Retrieved January 28, 2008, from http://www.nmfs.noaa.gov/sfa/sfweb/aqua_act.htm

National Education and Environment Partnership, (2002). Environmental education and educational achievement: Promising programs and resources. Washington, DC: Retrieved August 24, 2009 from http://www.neefusa.org/pdf/prom-programs.pdf

National Marine Educators Association, (1976). Retrieved May 24, 2010 from http://history.nmeaweb.org/original/History1976.html

National Oceanic and Atmospheric Administration [NOAA], (2008). Seafood consumption declines slightly in 2007. Retrieved September 30, 2009 from http://www.noaanews.noaa.gov/stories2008/20080717_seafood.html

National Research Council (1988). Understanding agriculture: New directions for education. Washington, DC: National Academy Press. (ERIC Document Reproduction Service No. ED338795)

National Science Foundation (NSF) and U.S. Department of Education (USDE))1980). Science and engineering education for the 1980s and beyond. Washington, D.C. NSF.

New, M.B. (1999). Global aquaculture: Current trends and challenges for the 21st century. World Aquaculture, 30(1), 8-13, 63-79.

Newman, M.E., & Johnson, C.M. (1994). Inservice education needs of teachers of pilot agriscience courses in Mississippi. Journal of Agricultural Education, 35(1), 54-60.

Oguz, A., Fortner, R., Adadan, E., Gay, K., Kim, C.K., Yalcinoglu, P., Betasli, B., Cook-Hoggarth, K., McDonald, C., Mishler, K., & Manzo, L. (2004). A look at environmental education through science teachers' perspectives and textbooks' coverage. Paper presented at the annual meeting of the School Science and Mathematics Association, Atlanta, GA. Retrieved August 18, 2009 from http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/27/f4/06.pdf

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. International Journal of Science Education, 25(9), 1049-1079.

Papanastasiou, E.C. and Zembylas, M. (2002). The effect of attitudes on science achievement: a study conducted among high school students in Cyprus. International Review of Education, 48(6), 469-484.

Parker, H.S. (2001). Aquaculture research is key to the future of U.S. fish farming. Agricultural Research, 49(12). Retrieved September 29, 2007, from http://search.ebscohost.com/login.aspx?direct=true&db=voh&AN=5761109&site=ehost-live

Parker, R. (2002). Aquaculture Science, 2nd ed. Albany, NY: Delmar.

Pauly, D. & Watson, R. (2003). Counting the last fish. Scientific American, 289(1), 42-47.

Perez, K.R., (2006). Fishing for gold: the story of Alabama's catfish industry. Tuscaloosa, AL: The University of Alabama Press.

Pew Oceans Commission (2003). Americas living oceans: Charting a course for sea change [Executive summary]. Retrieved October 1, 2009 from http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Protecting_ocean_life/env_pew_oceans_final_report_summary.pdf

Picker, L. (1985). Development and use of a conceptual scheme for aquatic studies: Implications for science curriculum development. Science Education, 69(5), 665-671.

Plevyak, L. H., Bendixen-Noe, M., Henderson, J., Roth, R. E., & Wilke, R. (2001). Level of teacher preparation and implementation of EE: Mandated and non-mandated EE teacher preparation states. The Journal of Environmental Education, 32(2), 28-36.

Presser, S., Rothgeb, J.M., Couper M.P., Lessler, J.T., Martin, E, Martin, J. & Singer, E. (editors) (2004). Methods for testing and evaluating survey questionnaires. Hobokin, NJ: John Wiley & Sons.

Priest, S. (1986). Redefining outdoor education: A matter of many relationships. Journal of Environmental Education 17(3), 13-15.

Rakow, S.J. (1993). Development of a conceptual structure for aquatic education and its application to existing aquatic curricula and needed curriculum development. Journal of Environmental Education, 25(2), 12-16

Ramsey, J. (1993). The effects of issue investigation and action training on environmental behavior. Journal of Environmental Education, 24(3), 31-36.

Reese, S. (2001). Keeping agriculture alive in the suburbs. Techniques: Connecting Education & Careers, 26(2). Retrieved September 23, 2007, from http://search.ebscohost.com/login.aspx?direct=true&db=voh&AN=4121809&site=ehost-live

Richardson, J.G. (1994). Learning best through experience. Journal of Extension, 32(2), Retrieved August 31, 2009 from http://www.joe.org/joe/1994august/a6.php

Ritz, W. (1977). Involving teachers in environmental education. Journal of Environmental Education, 8(3), 40-47

Riveken, M. (2000, December). Outdoor experiences for young children. Retrieved August 18, 2008 from ERIC Digest Database (ED448013).

Roberts, J.W. (2007). Beyond learning by doing: The brain compatible approach. In E. Friesen & C. Kristjanson (Eds.) Teaching at the University of Manitoba: A handbook (pp. 2.4-2.11). Winnipeg, Manitoba. Retrieved August 31, 2009 from http://www.umanitoba.ca/academic_support/uts/media/5_lr_UTShandbook.pdf#page=43

Roberts, P. H. (1999). Effects of multisensory resources on the achievement and science attitudes of seventh-grade suburban students taught science concepts on and above grade level (Doctoral dissertation, St. John's University, 1999) Dissertation Abstracts International, 60/08, p.2786.

Rouse, D. B. (1999). Graduate education in aquaculture. World Aquaculture, 30(2), 15-16.

Roy, J. (2005). Growing a future crop of aquaculturists: Creating an urban aquaculture education program in New Haven, Connecticut, USA. In B. Costa-Pierce, A. Desbonnet, P. Edwards, and D. Baker (Eds.), Urban Aquaculture (pp. 223-231). Cambridge, MA: CAB International.

Rutherford, F.J. (1993, March). Hands-on: A means to an end. 2061 Today, 3(1), 5.

Ryan, C. (1991). The effect of a conservation program on schoolchildren's attitudes toward the environment. The Journal of Environmental Education, 22(4), 30-35.

Sachs, J.D. (2007). The promise of the blue revolution. Scientific American, 297(1), 37-38. Retrieved September 24, 2007, from http://web.ebscohost.com.spot.lib.auburn.edu/ehost/detail?vid=7&hid=7&sid=fcb56a5e-905e-4677-bd88-8248514b17dd%40SCRSM2

Scarpa, J. (1999). Aquaculture education: what shall we do? World Aquaculture, 30(2), 14.

Schreibman, M.P. & Zarnoch, C.B. (2005). Urban aquaculture in Brooklyn, New York, USA. In B.Costa-Pierce, A. Desbonnet, P. Edwards and D. Baker (Eds.) Urban Aquaculture (pp. 207-221). Cambridge, MA: CABI Publishing.

Schonlau, M., Fricker, R.D., & Elliot, M.N. (2002). Conducting research surveys via e-mail and the web. MR-1480-RC, RAND.

Sea Grant – Retrieved May 24, 2010 from http://www.seagrant.noaa.gov/aboutsg/historyofsg.html

Simmons, B., Archie, M., Mann, L., Vymetal-Talyor, M., Berkowitz, A., Bedell, T., et al. (2004). Excellence in environmental education: Guidelines for learning (PreK-12). Washington, DC: North American Association for Environmental Education.

Simpson, R. D. & Oliver, S. J. (1985). Attitude toward science and achievement motivation profiles of male and female science students in grades six through ten. Science Education, 69(4), 511-526.

Snowden, J. (1984). A brief history of boy scouts in America 1910 to today. Retrieved May 22, 2010 from http://www.troop97.net/bsahist1.htm

Solomon, D.J. (2001). Conducting web-based surveys. Office of Medical Education Research and Development, Michigan State University. Retrieved September 15, 2010 from http://cogprints.org/2357/1/Web_Survey_Article.pdf

Strauss, R.P. & Sawyer, E.A. (1986). Some new evidence on teacher and student competencies. Economics of Education Review, 5(1), 41-48.

Stickney, R. R. (1979). Principles of warmwater aquaculture. New York: John Wiley and Sons.

Swann, D, L., Branson, F. Jr., & Talbert, B.A. (2003) Educator beliefs regarding computer-based instruction. Journal of Extension, 41(1). Retrieved September 10, 2009 from http://www.joe.org/joe/2003february/rb4.php

Talton, L.E. & Simpson, R.D. (1987). Relationships of attitude toward classroom environment with attitude toward and achievement in science among tenth grade biology students. Journal of Research in Science Teaching, 24(6), 507-525.

Talton, L.E. & Simpson, R.D. (1988). Relationships between peer and individual attitudes towards science among adolescents. Science Education, 69(1), 19-24.

Talton, L.E. & Simpson R.D. (1989). Relationships of attitudes towards self, family and school with attitude towards science among adolescents. Science Education, 70(4), 365-374.

Team Ag Ed, (2009). Aquaculture education: Making a splash. Retrieved September 29, 2009 from http://www.agedhq.org/aquaculture/aquaculture1.htm

The WorldFish Center, (2008) Using fisheries and aquaculture to reduce poverty and Hunger. Corporate Brochure No. 1893. Retrieved December 2, 2009 from http://www.worldfishcenter.org/resource_centre/WF_1105.pdf

Tidwell, J. H. & Allan, G. (2002). Fish as food: aquacultures contribution. World Aquaculture, 33(3), 44-48.

Timmons, M.B. (2005). Competitive potential for USA urban Aquaculture. In B. Costa-Pierce, A. Desbonnet, P. Edwards & D. Baker (Eds.) Urban Aquaculture (pp. 137-158). Cambridge, MA: CABI Publishing.

Trent, J.H. (1983). Environmental education in our schools during the 1970s. The Journal of Environmental Education, 15(1), 11-15.

United Nations Educational, Scientific and Cultural Organization (UNESCO), (1976). The Belgrade charter. Retrieved August 24, 2009 from http://portal.unesco.org/education/en/files/33037/10935069533The_Belgrade_Charter.pdf/The%2BBelgrade%2BCharter.pdf

United Nations Educational, Scientific and Cultural Organization (UNESCO), (1977). Intergovernmental conference on environmental education: Final Report. The Tbilisi declaration. Retrieved August 24, 2009 from http://www.gdrc.org/uem/ee/EE-Tbilisi_1977.pdf

United Nations Food and Agriculture Organization (FAO). (2002). The state of world fisheries and aquaculture report. United Nations Food and Agriculture Organization, Rome, Italy. Retrieved February 23, 2007 from www.fao.org/documents/show_cdr.asp?url_file=/docrep/005/y7300e/y7300e00.htm

United Nations Food and Agriculture Organization (FAO). (2007). The state of world fisheries and aquaculture report 2006. United Nations Food and Agriculture Organization, Rome, Italy. Retrieved September 10, 2009 from ftp://ftp.fao.org/docrep/fao/009/a0699e/a0699e.pdf

United Nations Food and Agriculture Organization (FAO). (2009). The state of world fisheries and aquaculture report 2008. United Nations Food and Agriculture Organization, Rome, Italy. Retrieved September 10, 2009 from ftp://ftp.fao.org/docrep/fao/011/i0250e/i0250e.pdf

United States Department of Agriculture, National Agricultural Statistics Service, (2006) 2005 Census of Aquaculture, Retrieved September 30, 2009 from http://www.agcensus.usda.gov/Publications/2002/Aquaculture/AQUACEN.pdf

Visconti-Phillips, N. (1998). Mastering the waters. Science Scope, 21(6), 22-23.

Wade, K.S. (1996). Environmental education teacher inservice education; The need for new perspectives. Journal of Environmental Education, 27(2), Retrieved September 9, 2008 from http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=9604111674&site=ehost-live

Walsh, M. (1992). Homemade aquaculture. The Agriculture Education Magazine, 64(8), 18-23.

Walsh, M. (1992a). Let's not reinvent the wheel. The Agriculture Education Magazine, 64(11), 20-22.

Waters, R. G., & Haskell, L. J. (1989). Identifying staff development needs of Cooperative Extension faculty using a modified Borich needs assessment model. Journal of Agricultural Education, 30(2), 26-32.

Weisberg, H.F. (2005). The total survey error approach: A guide to the new science of survey research. Chicago, IL: University of Chicago Press.

Wilson, F.R. (1999). The real meaning of hands-on education, Presented at the Institute for Development of Educational Activities (IDEA) Los Angeles, Atlanta, Appleton, Denver – July 1999 (Revised for publication in the Waldorf Research Bulletin, October, 1999). Retrieved Dec. 9 2007 from http://www.waldorflibrary.org/Journal_Articles/RB5101.pdf

Wingenbach, G., Gartin, S. & Lawrence, L. (1998). Information sources, technologies, teachers' attitudes, and community impact from teaching aquaculture in the northeastern region. Journal of Agricultural Education, 39(3), 11-20. Retrieved November 28, 2007 from http://pubs.aged.tamu.edu/jae/pdf/vol39/39-01-11.pdf

Wingenbach, G., Gartin, S. & Lawrence, L. (1999). Students' perceptions of aquaculture education in the northeastern region. Journal of Agricultural Education, 40(1), 14-22.

Wingenbach, G., Gartin, S. & Lawrence, L. (2000). Assessing the aquaculture curricula in the northeaster region. Journal of Agricultural Education, 41(2), 2-10.

Wright, K.B. (2005). Researching internet-based populations: Advantages and disadvantages of online survey research, online questionnaire authoring software packages, and web survey services. Journal of Computer-Mediated Communication, 10(3) article 11. Retrieved September 15, 2010 from http://jcmc.indiana.edu/vol10/issue3/wright.html

Yaakub, M. & Finch, C. (2001). Effectiveness of computer-assisted instruction in technical education: A Meta- Analysis. In J. Kapes, (ed), Occupational Education Forum/Workforce Education Forum (OEF/WEF), *28(2), 5-19.*

APPENDIX A

IRB Approval Letter from Auburn University

From: Human Subjects 4/22/2011 10:11 AM
To: David Cline
CC: David Rouse; James Witte
Subject: Protocol #10-292 EX 1010, (delayed approval notice)

Dear Mr. Cline.

Your protocol, "Aquaculture Education Needs Assessment: An Exploratory Study to Identify Teachers' Priorities for Aquaculture Topics, Training, and Materials", was approved in October 2010. This is a follow-up notice.

This e-mail serves as official notice that your protocol has been approved. A formal approval letter will not be sent unless you notify us that you need one. *By accepting this approval, you also accept your responsibilities associated with this approval. Details of your responsibilities are attached. Please print and retain.*

Please forward the actual online information letter, which includes the IRB approval information and the link to the survey, so that we may print a final copy for our files.

Your protocol will **expire on October 26, 2011.** Put that date on your calendar now. About three weeks before that time you will need to submit a final report or renewal request. (You may want to consider sending yourself a delayed e-mail reminder to be received late this coming September.)

If you have any questions, please let us know.
Best wishes for success with your research!

Office of Research Compliance
115 Ramsay Hall, basement ***NOTE NEW ADDRESS - SEE ATTACHED MAP***
Auburn University, AL 36849
(334) 844-5966
hsubjec@auburn.edu

AUBURN UNIVERSITY INSTITUTIONAL REVIEW BOARD for RESEARCH INVOLVING HUMANSUBJECTS

RESEARCH PROTOCOL REVIEW FORM

For Information or help contact **THE OFFICE OF HUMAN SUBJECTS RESEARCH**, 307 Samford Hall, Auburn University
Phone: 334-844-5966 **e-mail:** hsubjec@auburn.edu **Web Address:** http://www.auburn.edu/research/vpr/ohs/

Complete this form using Adobe Acrobat (versions 5.0 and greater). *Hand written copies not accepted.*

1. PROPOSED START DATE of STUDY: Oct 15, 2010

PROPOSED REVIEW CATEGORY (Check one): ☐ FULL BOARD ☒ EXPEDITED ☐ EXEMPT

2. PROJECT TITLE: Aquaculture Education Needs Assessment: An Exploratory Study to Identify Teachers' Priorities for Aquaculture Topics, Training, and Materials

3. David J. Cline · Aquaculture Specialis · ACES/FAA · 334-844-2874 · clinedj@auburn.edu
PRINCIPAL INVESTIGATOR · TITLE · DEPT · PHONE · AU E-MAIL
203 Swingle Hall, Auburn University, AL 36849 · 334-844-0830
MAILING ADDRESS · FAX · ALTERNATE E-MAIL

4. SOURCE OF FUNDING SUPPORT: ☑ Not Applicable ☐ Internal ☐ External Agency ______ ☐ Pending ☐ Received

5. LIST ANY CONTRACTORS, SUB-CONTRACTORS, OTHER ENTITIES OR IRBs ASSOCIATED WITH THIS PROJECT:

6. GENERAL RESEARCH PROJECT CHARACTERISTICS

6A. Mandatory CITI Training

Names of key personnel who have completed CITI:
David J. Cline / SOE · Dr. James Witte / SOE

CITI group completed for this study: ☑ Social/Behavioral ☐ Biomedical

Protocol-Specific modules completed
☐ Genetic ☐ Vet's Administration
☐ International ☐ Prisoner Research
☐ Public School Students ☐ Pregnant Women/Fetuses
Other

6B. Research Methodology

Please check all descriptors that best apply to the research methodology.

Data Source(s): ☑ New Data ☐ Existing Data

Will data be recorded so that participants can be directly or indirectly identified? ☐ Yes ☑ No

Data collection will involve the use of:
☐ Educational Tests (cognitive diagnostic, aptitude, etc.)
☑ Surveys / Questionnaires
☑ Internet / electronic
☐ Audio / Video / Photos
☐ Interview / Observation
☐ Physical / Physiological Measures or Specimens (see Section 6E.)
☐ Private records or files

10/27/10 01/26/11 10-292 EX 1010

6C. Participant Information

Please check all descriptors that apply to the participant population.
☑ Males ☑ Females ☐ AU students

Vulnerable Populations
☐ Pregnant Women/Fetuses ☐ Children and/or Adolescents (under age 19 in AL)
☐ Prisoners
Persons with:
☐ Economic Disadvantages ☐ Physical Disabilities
☐ Educational Disadvantages ☐ Intellectual Disabilities

Do you plan to compensate your participants? ☐ Yes ☑ No

6D. Risks to Participants

Please identify all risks that participants might encounter in this research.
☑ Breach of Confidentiality* ☐ Coercion
☐ Deception ☐ Physical
☐ Psychological ☐ Social
☐ None ☐ Other

*Note that if the investigator is using or accessing confidential or identifiable data, breach of confidentiality is always a risk.

6E. Institutional Biosafety Approval

Do you need IBC Approval for this study? ☑ No ☐ Yes - BUA # ______ Expiration date ______

FOR OHSR OFFICE USE ONLY

DATE RECEIVED IN OHSR: 9-29-10 by BK PROTOCOL # 10-292
DATE OF IRB REVIEW: ______ by ______ APPROVAL CATEGORY: ______
DATE OF IRB APPROVAL: ______ by ______ INTERVAL FOR CONTINUING REVIEW: ______
COMMENTS:

APPENDIX B

Letters of Approval from ALSDE Administrators

ALABAMA FFA ASSOCIATION
STATE OF ALABAMA
DEPARTMENT OF EDUCATION

September 13, 2010

Institutional Review Board
c/o Office of Human Subjects Research
307 Samford Hall
Auburn University, AL 36849

Dear IRB Members,

After reviewing the proposed study, "Aquaculture Education Needs Assessment: An Exploratory Study to Identify Teachers' Priorities for Aquaculture Topics, Training and Materials", presented by Mr. David Cline, a graduate student at Auburn University, I have granted him permission to contact Alabama career and technical education teachers that are certified to teach the aquaculture science, aquatic biology, and aqua experience classes within the Alabama course of study.

The purpose of the study is to improve teachers' ability to effectively use aquaculture as a tool to teach math and science. The primary activity will be a short 10 to 15 minute online survey to collect data and demographic information that will allow the prioritization of aquaculture topics, training and materials. I understand that the data will be anonymous, secure (on password protected computers in locked offices), and individual respondents and schools will not be identifiable in the results or reports.

I will help Mr. Cline recruit the necessary participants by passing his invitation and materials along to teachers through my office and email list. It is my understanding that the data collection will involve a pre-letter of invitation, the survey, and two follow up notices and will be completed prior to December 31, 2010. Mr. Cline has offered to provide to my office a copy of all Auburn University IRB-approved protocol documents and has agreed to provide to us a copy of the aggregate results from his study.

If the IRB has any concerns about the permission being granted by this letter, please contact me at the phone number listed below.

Sincerely,

Jacob Davis

Jacob Davis
FFA Executive Secretary
Alabama Department of Education

Mailing: P.O. BOX 302101 – MONTGOMERY, AL 36130-2101
Shipping: GORDON PERSONS BUILDING – 50 NORTH RIPLEY STREET – MONTGOMERY, AL 36104-3744
OFFICE (334) 242-9114 FAX (334) 353-8406

Name
Page 2
Date

STATE OF ALABAMA
DEPARTMENT OF EDUCATION

Joseph B. Morton
State Superintendent
of Education

October 20, 2010

Institutional Review Board
c/o Office of Human Subjects Research
307 Samford Hall
Auburn University, AL 36849

Dear IRB Members:

After reviewing the proposed study, "Aquaculture Education Needs Assessment: An Exploratory Study to Identify Teachers' Priorities for Aquaculture Topics, Training, and Materials," presented by Mr. David Cline, a graduate student at Auburn University, I have agreed to notify science teachers that are certified to teach the AquaScience course, within the *Alabama Course of Study*: *Science* regarding this study.

I understand that the purpose of this study is to improve teachers' ability to effectively use aquaculture as a tool to teach math and science. The teachers will be asked to complete a short 10-15 minute online survey. Data and demographic information will be collected that will allow the prioritization of aquaculture topics, training, and materials. I understand that the data will be anonymous, secure, (on password-protected computers in locked offices) and individual respondents and schools will not be identifiable in the results or reports.

I will e-mail the invitation and materials to teachers through my office e-mail list. It is my understanding that the data collection will involve a pre-letter of invitation, the survey, two follow-up notices, and will be completed prior to December 31, 2010. Mr. Cline has offered to provide the Alabama State Department of Education (SDE) with a copy of all Auburn University Institutional Review Board (IRB)-approved protocol documents and has agreed to provide the SDE with a copy of the aggregate results from his study.

If the IRB has any concerns about the permission being granted by this letter, please contact me by telephone at 334-242-8059 or by e-mail at gmontgomery@alsde.edu.

Sincerely,

Ginger P. Montgomery, pag

Ginger P. Montgomery
Science Education Specialist

GPM:PAG

GORDON PERSONS BUILDING • P.O. BOX 302101 • MONTGOMERY, ALABAMA 36130-2101 • TELEPHONE (334) 242-9700 • WEB SITE: www.alsde.edu

APPENDIX C

Invitation Letter to Participants

Mail | Properties | Personalize

From: David Cline 11/15/2010 9:52 AM

To: Jacob Davis

BC: David Cline

Subject: Cline_AU_Dissertation_Survey_Aquaculture Education

Mr. Davis,

The aquaculture education survey is ready to go out. Thank you for sending out the pre-survey invitation. If you would, please write another short personal note to the teachers on your mailing list encouraging them to participate and cut and paste the information from this letter. Please make sure to get the survey link when you cut and paste.

Thank you so much for your help. Please cc me when you send it out. I look forward to getting some good information.

Sincerely,
David

Greetings,

Please help us help you. You are invited to take part in an important educational initiative that is being conducted by Auburn University Aquaculture Extension Specialist and PhD candidate David Cline. The purpose of the study is to improve teachers' ability to effectively use aquaculture as a tool to teach math and science. You have been identified as a potential participant because you are certified by ALSDE to teach one of the aquaculture classes in the Alabama course of study. Even if you are not currently teaching an aquaculture or aquascience class we would like you to participate and get your opinion as if you were teaching an aquaculture course. You will be asked prioritize aquaculture related topics, rate your ability to teach those topics and the availability of quality of resource materials available to teach those topics. This information will make it possible to determine the greatest areas of need with regard to aquaculture training and curriculum development. This knowledge should prove valuable to schools in scheduling in-service training, pre-service teacher training and in the long run, create more aquaculturally literate citizens with an improved ability to prosper in a technology advanced society and help feed our ever-growing population.

Please take a moment and fill out the short online survey. It will less than 10 minutes to complete and all data will be anonymous, secure, and individual respondents and schools will not be identifiable in the results or reports.

I appreciate your time and consideration. Your input is valuable and can help advance Alabama education.

Respectfully,

David Cline
Aquaculture Extension Specialist

LINK TO SURVEY
http://www.surveymonkey.com/s/Aquaculture_Education_VT_11_15_10

David Cline
Extension Aquaculturist
Alabama Cooperative Extension System
203 Swingle Hall
Auburn University, AL 36849
334-844-2874
334-844-0830 Fax
334-744-2688 Cell
clinedj@auburn.edu
www.alearn.info

-

APPENDIX D

Survey Instrument

Aquaculture Education Needs Assessment

WELCOME

Thank you for taking some of your valuable time to help with this important research. You have been identified as a potential participant because you are certified by the Alabama State Department of Education to teach one of the aquaculture classes in the Alabama course of study. Even if you are not currently teaching an aquaculture or aquascience class we would like you to participate and get your opinion as if you were teaching an aquaculture course.

On the following page you will find an informational letter and the consent agreement that I am required to include by our office of human subjects research. Please look at the letter and if you consent to participate click on the next button at the bottom of that page.

Aquaculture Education Needs Assessment

LETTER OF CONSENT

(NOTE: Do not agree to participate unless IRB approval information with current dates has been added to the bottom of this document.)

INFORMATION LETTER
for a Research Study entitled
"Aquaculture Education Needs Assessment: An Exploratory Study to Identify Teachers' Priorities for Aquaculture Topics, Training and Materials"

You are invited to participate in a research study to improve teachers' ability to effectively use aquaculture as a tool to teach math and science. The purpose of this study is to identify discrepancies among teachers' priorities for and knowledge of aquaculture topics. This information will make it possible to determine the greatest areas of need with regard to aquaculture training and curriculum development. The study is being conducted by David Cline, an Alabama Cooperative Extension System Aquaculture Specialist, under the direction of Dr. James Witte, Associate Professor in the Auburn University Department of Educational Foundations Leadership and Technology. You were selected as a possible participant because you are qualified to teach an aquaculture related class under the Alabama course of study and are age 19 or older.

What will be involved if you participate? Your participation is completely voluntary. If you decide to participate in this research study, you will be asked to complete a short survey. Your total time commitment will be approximately 10 minutes.

Are there any benefits to yourself or others? If you participate in this study, your information will be used to improve teaching capacity and materials related to aquaculture.

If you change your mind about participating, you can withdraw at any time by closing your browser. If you choose to withdraw, your data can be withdrawn as long as it is identifiable. Once you have submitted anonymous data, it cannot be withdrawn since it will be unidentifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University, the Department of Fisheries and Allied Aquacultures or the Alabama Cooperative Extension System.

Any data obtained in connection with this study will remain anonymous. No personal information (demographic information) will be personally identifiable. We will protect your privacy and the data you provide by keeping all information on secure servers and will limit the access to the data to only those directly involved in the project. Information collected through your participation may be used to fulfill an educational requirement, published in a professional journal, and/or presented at a professional meeting.

If you have questions about this study, please contact David Cline at clinedj@auburn.edu or Dr. James Witte at witteje@auburn.edu .

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334) 844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu.

Having read the information above, you must decide if you want to participate in this research project. If you decide to participate please click on the (Next) link below. You may print a copy of this letter to keep.

David Cline Date 10/29/2010

The Auburn University Institutional Review Board has approved this document for use from October 27,2010 to October 26, 2011. Protocol #10-292 EX1010

TAKE THE SURVEY

Aquaculture Education Needs Assessment

WHAT TEACHING CATEGORY are you in?

Please answer the following question to help us guide you through the survey as quickly and efficiently as possible.

I am certified to teach

- General science classes (Aquascience Elective)
- Career and Technical Education courses (Aquaculture Science, Aquatic Biology, and Aqua-Experience)
- Both general science and CTE classes

Aquaculture Education Needs Assessment

HOW IMPORTANT is it that your students know about this topic?

Please rate HOW IMPORTANT it is that your students know about the topics covered in each aquaculture content standard using the rating system below.

1= very unimportant

2= unimportant

3= average importance

4= important

5= very important

	1	2	3	4	5
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.					
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.					
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).					
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).					
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.					
Describe adaptations that allow organisms to exist in specific aquatic environments.					
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).					
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).					
Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).					
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).					

Aquaculture Education Needs Assessment

HOW MUCH DO YOU KNOW about this topic?

Please RATE YOUR CURRENT KNOWLEDGE of each of the following aquaculture content standards.

1= no knowledge

2= little knowledge

3= average knowledge

4= good knowledge

5= excellent knowledge

	1	2	3	4	5
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	○	○	○	○	○
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	○	○	○	○	○
Explain the importance of biogeochemical cycles in an aquatic environment e.g. nitrogen cycle).	○	○	○	○	○
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	○	○	○	○	○
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	○	○	○	○	○
Describe adaptations that allow organisms to exist in specific aquatic environments.	○	○	○	○	○
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	○	○	○	○	○
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	○	○	○	○	○
Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	○	○	○	○	○
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).	○	○	○	○	○

Aquaculture Education Needs Assessment

RATE THE QUALITY OF MATERIALS that you use to teach each content standard.

Please RATE THE QUALITY OF MATERIALS you use to teach each aquaculture content standard

1= poor

2= below average

3= average

4= above average

5= excellent

	1	2	3	4	5
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	○	○	○	○	○
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	○	○	○	○	○
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).	○	○	○	○	○
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	○	○	○	○	○
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	○	○	○	○	○
Describe adaptations that allow organisms to exist in specific aquatic environments.	○	○	○	○	○
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	○	○	○	○	○
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	○	○	○	○	○
Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	○	○	○	○	○
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).	○	○	○	○	○

Aquaculture Education Needs Assessment

HOW IMPORTANT IS IT that your students know about this topic?

Please RATE HOW IMPORTANT IT IS THAT YOUR STUDENTS KNOW about the topics covered in each aquaculture content standard using the rating system below.

1= very unimportant

2= unimportant

3= average importance

4= important

5= very important

	1	2	3	4	5
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	○	○	○	○	○
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	○	○	○	○	○
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).	○	○	○	○	○
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	○	○	○	○	○
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	○	○	○	○	○
Describe adaptations that allow organisms to exist in specific aquatic environments.	○	○	○	○	○
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	○	○	○	○	○
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	○	○	○	○	○
Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	○	○	○	○	○
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).	○	○	○	○	○
Describe various career opportunities in the aquaculture industry.	○	○	○	○	○
Describe safety precautions for the aquaculture industry.	○	○	○	○	○
Explain the historical background of aquaculture (how aquaculture relates to agriculture, science/technology of production and importance to the economy).	○	○	○	○	○
Categorize aquaculture species as cold, cool, or warm water species.	○	○	○	○	○
Describe infrastructure necessary for aquaculture production (e.g. labor, feed manufacturing, transportation).	○	○	○	○	○
Define concepts associated with health management of aquacrops.	○	○	○	○	○

Aquaculture Education Needs Assessment

HOW MUCH DO YOU KNOW about this topic?

Please rate your current knowledge of each aquaculture content standard using the rating system below

Please RATE YOUR CURRENT KNOWLEDGE of each of the following aquaculture content standards using the rating system described below

1= no knowledge

2= little knowledge

3= average knowledge

4= good knowledge

5= excellent knowledge

	1	2	3	4	5
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	○	○	○	○	○
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	○	○	○	○	○
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).	○	○	○	○	○
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	○	○	○	○	○
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	○	○	○	○	○
Describe adaptations that allow organisms to exist in specific aquatic environments.	○	○	○	○	○
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	○	○	○	○	○
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	○	○	○	○	○
Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	○	○	○	○	○
Describe the control of disease and pests in aquatic environments (ie. pathogens, parasites, predators).	○	○	○	○	○
Describe various career opportunities in the aquaculture industry.	○	○	○	○	○
Describe safety precautions for the aquaculture industry.	○	○	○	○	○
Explain the historical background of aquaculture (how aquaculture relates to agriculture, science/technology of production and importance to the economy).	○	○	○	○	○
Categorize aquaculture species as cold, cool, or warm water species.	○	○	○	○	○
Describe infrastructure necessary for aquaculture production (e.g. labor, feed manufacturing, transportation).	○	○	○	○	○
Define concepts associated with health management of aquacrops.	○	○	○	○	○

Aquaculture Education Needs Assessment

RATE THE QUALITY OF MATERIALS that you use to teach each content standard.

Please RATE THE QUALITY OF MATERIALS you use to teach each aquaculture content standard

1= poor

2= below average

3= average

4= above average

5= excellent

	1	2	3	4	5
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.					
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.					
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).					
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).					
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.					
Describe adaptations that allow organisms to exist in specific aquatic environments.					
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).					
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).					
Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).					
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).					
Describe various career opportunities in the aquaculture industry.					
Describe safety precautions for the aquaculture industry.					
Explain the historical background of aquaculture (how aquaculture relates to agriculture, science/technology of production and importance to the economy).					
Categorize aquaculture species as cold, cool, or warm water species.					
Describe infrastructure necessary for aquaculture production (e.g. labor, feed manufacturing, transportation).					
Define concepts associated with health management of aquacrops.					

Aquaculture Education Needs Assessment

DEMOGRAPHIC INFORMATION

Please provide the following DEMOGRAPHIC INFORMATION.

What is your sex?

- Male
- Female

What is your age?

Years of teaching experience?

Highest degree earned?

- Bachelors
- Masters
- Doctorate

Which science course(s) do you teach?

- None
- Anatomy and Physiology Elective
- Aquaculture Science
- Aquascience Elective
- Biology
- Botany Elective
- Chemistry
- Earth and Space Elective
- Environmental Elective
- Forensic Science Elective
- Genetics Elective
- Geology Elective
- Marine Biology Elective
- Physical Science
- Physics
- Zoology Elective

Other (please specify)

Aquaculture Education Needs Assessment

DEMOGRAPHIC INFORMATION

Please provide the following DEMOGRAPHIC INFORMATION.

What is your sex?

- Male
- Female

What is your age?

Years of teaching experience?

Highest degree earned?

- Bachelors
- Masters
- Doctorate

Which science course(s) do you teach?

- None
- Anatomy and Physiology Elective
- Aquaculture Science
- Aquascience Elective
- Biology
- Botany Elective
- Chemistry
- Earth and Space Elective
- Environmental Elective
- Forensic Science Elective
- Genetics Elective
- Geology Elective
- Marine Biology Elective
- Physical Science
- Physics
- Zoology Elective

Other (please specify)

Aquaculture Education Needs Assessment

Which career/technical education course(S) do you teach?

- [ ] None
- [ ] Agribusiness Management
- [ ] Agribusiness Marketing
- [ ] Agribusiness Technology
- [ ] Agricultural Communications
- [ ] Agriscience
- [ ] Agriscience Exploration
- [ ] Animal Biotechnology
- [ ] Animal Science
- [ ] Aqua Experience
- [ ] Aquaculture Science
- [ ] Aquatic Biology
- [ ] Construction Finishing and Interior Systems
- [ ] Construction Framing
- [ ] Construction Site Preparation and Foundation
- [ ] Creative Floral Design
- [ ] Environmental Management
- [ ] Equine Science
- [ ] Fish and Wildlife Management
- [ ] Floral Design and Interiorscaping
- [ ] Forestry Equipment
- [ ] Forestry
- [ ] Greenhouse Production and Management
- [ ] Horticultural Science
- [ ] Introduction to Agriscience
- [ ] Introduction to Drafting Design
- [ ] Introduction to Masonry
- [ ] Introduction to Metal Fabrication
- [ ] Introduction to Metal Inert Gas and Flux Cored Arc Welding
- [ ] Introduction Veterinary Science
- [ ] Landscape Design and Management
- [ ] Nursery Production and Management
- [ ] Plant Biotechnology
- [ ] Poultry Science
- [ ] Power Equipment Technology
- [ ] Residential and Commercial Power Equipment
- [ ] Residential Landscape Establishment and Maintenance
- [ ] Residential Wiring
- [ ] Safety and Health Regulations
- [ ] Specialty Floral Design and Management
- [ ] Sports Turfgrass Production and Management
- [ ] Two- and Four-Stroke Engines
- [ ] Urban Forestry
- [ ] Veterinary Science

Other (please specify)

Are you interested in learning more about aquaculture?

- ( ) Yes
- ( ) No

If your schedule allowed would you be interested in teaching an aquaculture course?

- ( ) Yes
- ( ) No

Aquaculture Education Needs Assessment

Thank You for Completing the Survey

Your information will be used to help improve the aquaculture training and materials available to Alabama teachers.

APPENDIX E

Summary of Survey Results

Aquaculture Education Needs Assessment

SurveyMonkey

1. I am certified to teach

	Response Percent	Response Count
General science classes (Aquascience Elective)	**65.6%**	**164**
Career and Technical Education courses (Aquaculture Science, Aquatic Biology, and Aqua-Experience)	25.2%	63
Both general science and CTE classes	9.2%	23
answered question		**250**
skipped question		**0**

2. Please rate HOW IMPORTANT it is that your students know about the topics covered in each aquaculture content standard using the rating system below. 1= very unimportant 2= unimportant 3= average importance 4= important 5= very important

	1	2	3	4	5	Response Count
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	9.5% (13)	5.1% (7)	27.7% (38)	**32.1% (44)**	25.5% (35)	137
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	9.5% (13)	20.4% (28)	**35.0% (48)**	20.4% (28)	14.6% (20)	137
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).	12.4% (17)	8.0% (11)	23.4% (32)	**29.2% (40)**	27.0% (37)	137
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	10.2% (14)	11.7% (16)	24.1% (33)	**29.2% (40)**	24.8% (34)	137
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	9.5% (13)	11.7% (16)	26.3% (36)	**30.7% (42)**	21.9% (30)	137
Describe adaptations that allow organisms to exist in specific aquatic environments.	8.0% (11)	6.6% (9)	19.0% (26)	32.8% (45)	**33.6% (46)**	137
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	6.6% (9)	6.6% (9)	20.4% (28)	**34.3% (47)**	32.1% (44)	137
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	8.0% (11)	2.9% (4)	**31.4% (43)**	27.7% (38)	29.9% (41)	137

Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	12.4% (17)	16.8% (23)	**29.9% (41)**	26.3% (36)	14.6% (20)	137
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).	10.9% (15)	6.6% (9)	23.4% (32)	**29.9% (41)**	29.2% (40)	137
					answered question	**137**
					skipped question	**113**

3. Please RATE YOUR CURRENT KNOWLEDGE of each of the following aquaculture content standards. 1= no knowledge 2= little knowledge 3= average knowledge 4= good knowledge 5= excellent knowledge

	1	2	3	4	5	Response Count
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	6.7% (9)	12.7% (17)	**35.8% (48)**	32.1% (43)	12.7% (17)	134
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	12.7% (17)	**34.3% (46)**	33.6% (45)	15.7% (21)	3.7% (5)	134
Explain the importance of biogeochemical cycles in an aquatic environment e.g. nitrogen cycle).	12.7% (17)	16.4% (22)	**28.4% (38)**	27.6% (37)	14.9% (20)	134
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	10.4% (14)	17.2% (23)	**32.8% (44)**	24.6% (33)	14.9% (20)	134
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	11.2% (15)	**26.1% (35)**	23.9% (32)	23.1% (31)	15.7% (21)	134
Describe adaptations that allow organisms to exist in specific aquatic environments.	6.7% (9)	6.7% (9)	30.6% (41)	**38.1% (51)**	17.9% (24)	134
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	6.0% (8)	14.9% (20)	32.8% (44)	**35.8% (48)**	10.4% (14)	134
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	7.5% (10)	17.2% (23)	**37.3% (50)**	29.1% (39)	9.0% (12)	134

Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	17.2% (23)	**37.3% (50)**	27.6% (37)	16.4% (22)	1.5% (2)	134
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).	9.0% (12)	**29.1% (39)**	28.4% (38)	26.9% (36)	6.7% (9)	134
					answered question	**134**
					skipped question	**116**

4. Please RATE THE QUALITY OF MATERIALS you use to teach each aquaculture content standard 1= poor 2= below average 3= average 4= above average 5= excellent

	1	2	3	4	5	Response Count
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	30.2% (38)	27.0% (34)	**34.1% (43)**	6.3% (8)	2.4% (3)	126
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	**41.3% (52)**	26.2% (33)	29.4% (37)	2.4% (3)	0.8% (1)	126
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).	31.0% (39)	21.4% (27)	**36.5% (46)**	11.1% (14)	0.0% (0)	126
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	**33.3% (42)**	19.0% (24)	32.5% (41)	11.1% (14)	4.0% (5)	126
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	**34.9% (44)**	20.6% (26)	34.1% (43)	7.1% (9)	3.2% (4)	126
Describe adaptations that allow organisms to exist in specific aquatic environments.	27.0% (34)	20.6% (26)	**41.3% (52)**	8.7% (11)	2.4% (3)	126
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	27.0% (34)	23.8% (30)	**39.7% (50)**	7.1% (9)	2.4% (3)	126
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	**34.1% (43)**	25.4% (32)	31.7% (40)	6.3% (8)	2.4% (3)	126
Describe various structures and						

equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	**45.2% (57)**	25.4% (32)	23.8% (30)	5.6% (7)	0.0% (0)	126
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).	**34.9% (44)**	26.2% (33)	30.2% (38)	5.6% (7)	3.2% (4)	126
					answered question	**126**
					skipped question	**124**

5. Please RATE HOW IMPORTANT IT IS THAT YOUR STUDENTS KNOW about the topics covered in each aquaculture content standard using the rating system below. 1= very unimportant 2= unimportant 3= average importance 4= important 5= very important

	1	**2**	**3**	**4**	**5**	**Response Count**
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	5.6% (4)	0.0% (0)	28.2% (20)	**38.0% (27)**	28.2% (20)	71
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	5.6% (4)	11.3% (8)	**39.4% (28)**	35.2% (25)	8.5% (6)	71
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).	4.2% (3)	7.0% (5)	25.4% (18)	**33.8% (24)**	29.6% (21)	71
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	5.6% (4)	4.2% (3)	18.3% (13)	29.6% (21)	**42.3% (30)**	71
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	5.6% (4)	11.3% (8)	**31.0% (22)**	29.6% (21)	22.5% (16)	71
Describe adaptations that allow organisms to exist in specific	4.2% (3)	2.8% (2)	25.4% (18)	**46.5% (33)**	21.1% (15)	71

aquatic environments.						
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	7.0% (5)	1.4% (1)	19.7% (14)	**36.6% (26)**	35.2% (25)	71
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	4.2% (3)	4.2% (3)	18.3% (13)	33.8% (24)	**39.4% (28)**	71
Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	4.2% (3)	5.6% (4)	21.1% (15)	**35.2% (25)**	33.8% (24)	71
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).	5.6% (4)	2.8% (2)	15.5% (11)	**38.0% (27)**	**38.0% (27)**	71
Describe various career opportunities in the aquaculture industry.	4.2% (3)	2.8% (2)	18.3% (13)	35.2% (25)	**39.4% (28)**	71
Describe safety precautions for the aquaculture industry.	5.6% (4)	4.2% (3)	18.3% (13)	28.2% (20)	**43.7% (31)**	71
Explain the historical background of aquaculture (how aquaculture relates to agriculture, science/technology of production and importance to the economy).	1.4% (1)	5.6% (4)	**36.6% (26)**	32.4% (23)	23.9% (17)	71
Categorize aquaculture species as cold, cool, or warm water species.	4.2% (3)	5.6% (4)	29.6% (21)	29.6% (21)	**31.0% (22)**	71
Describe infrastructure necessary for aquaculture production (e.g. labor, feed manufacturing, transportation).	2.8% (2)	5.6% (4)	26.8% (19)	**38.0% (27)**	26.8% (19)	71
Define concepts associated with health management of aquacrops.	5.6% (4)	5.6% (4)	22.5% (16)	**40.8% (29)**	25.4% (18)	71
					answered question	**71**
					skipped question	**179**

6. Please RATE YOUR CURRENT KNOWLEDGE of each of the following aquaculture content standards using the rating system described below 1= no knowledge 2= little knowledge 3= average knowledge 4= good knowledge 5= excellent knowledge

	1	2	3	4	5	Response Count
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	0.0% (0)	14.5% (10)	30.4% (21)	**42.0% (29)**	13.0% (9)	69
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	7.2% (5)	24.6% (17)	**44.9% (31)**	21.7% (15)	1.4% (1)	69
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).	1.4% (1)	13.0% (9)	**42.0% (29)**	33.3% (23)	10.1% (7)	69
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	2.9% (2)	7.2% (5)	29.0% (20)	**46.4% (32)**	14.5% (10)	69
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	2.9% (2)	18.8% (13)	**36.2% (25)**	**36.2% (25)**	5.8% (4)	69
Describe adaptations that allow organisms to exist in specific aquatic environments.	0.0% (0)	11.6% (8)	**44.9% (31)**	36.2% (25)	7.2% (5)	69
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	0.0% (0)	10.1% (7)	**39.1% (27)**	36.2% (25)	14.5% (10)	69
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	1.4% (1)	15.9% (11)	**36.2% (25)**	**36.2% (25)**	10.1% (7)	69

Describe various structures and equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	5.8% (4)	13.0% (9)	27.5% (19)	**39.1% (27)**	14.5% (10)	69
Describe the control of disease and pests in aquatic environments (ie. pathogens, parasites, predators).	2.9% (2)	17.4% (12)	**47.8% (33)**	27.5% (19)	4.3% (3)	69
Describe various career opportunities in the aquaculture industry.	1.4% (1)	13.0% (9)	30.4% (21)	**39.1% (27)**	15.9% (11)	69
Describe safety precautions for the aquaculture industry.	1.4% (1)	15.9% (11)	31.9% (22)	**36.2% (25)**	14.5% (10)	69
Explain the historical background of aquaculture (how aquaculture relates to agriculture, science/technology of production and importance to the economy).	4.3% (3)	11.6% (8)	36.2% (25)	**39.1% (27)**	8.7% (6)	69
Categorize aquaculture species as cold, cool, or warm water species.	0.0% (0)	13.0% (9)	**37.7% (26)**	36.2% (25)	13.0% (9)	69
Describe infrastructure necessary for aquaculture production (e.g. labor, feed manufacturing, transportation).	5.8% (4)	11.6% (8)	**40.6% (28)**	39.1% (27)	2.9% (2)	69
Define concepts associated with health management of aquacrops.	1.4% (1)	18.8% (13)	**52.2% (36)**	24.6% (17)	2.9% (2)	69
					answered question	**69**
					skipped question	**181**

7. Please RATE THE QUALITY OF MATERIALS you use to teach each aquaculture content standard 1= poor 2= below average 3= average 4= above average 5= excellent

	1	2	3	4	5	Response Count
Differentiate among freshwater, brackish water and saltwater ecosystems. (e.g. identify chemical, geological, and physical features of aquatic ecosystems.	13.8% (9)	24.6% (16)	**38.5% (25)**	20.0% (13)	3.1% (2)	65
Relate geological and hydrological phenomena and fluid dynamics to aquatic systems.	16.9% (11)	32.3% (21)	**38.5% (25)**	10.8% (7)	1.5% (1)	65
Explain the importance of biogeochemical cycles in an aquatic environment (e.g. nitrogen cycle).	12.3% (8)	23.1% (15)	**38.5% (25)**	20.0% (13)	6.2% (4)	65
Determine the important properties and content of water as related to aquaculture (e.g. dissolved oxygen, pH, turbidity, density).	10.8% (7)	20.0% (13)	**33.8% (22)**	24.6% (16)	10.8% (7)	65
Identify the genotype and phenotype for specific characteristics in aquatic animals resulting from selective breeding (e.g. for disease resistance) and explain the importance of anatomy and physiology in aquaculture.	12.3% (8)	**33.8% (22)**	**33.8% (22)**	18.5% (12)	1.5% (1)	65
Describe adaptations that allow organisms to exist in specific aquatic environments.	9.2% (6)	27.7% (18)	**40.0% (26)**	20.0% (13)	3.1% (2)	65
Describe processes and environmental characteristics that affect growth rates of aquatic animals (e.g. feeding habits, overcrowding, seasonal changes).	9.2% (6)	23.1% (15)	**44.6% (29)**	18.5% (12)	4.6% (3)	65
Determine effects of the fishing industry on the aquatic environment (e.g. aquaculture, overfishing).	13.8% (9)	20.0% (13)	**43.1% (28)**	15.4% (10)	7.7% (5)	65
Describe various structures and						

equipment used in growing aquacrops (e.g. open ponds, cages, raceways, recirculating systems).	12.3% (8)	21.5% (14)	**40.0% (26)**	20.0% (13)	6.2% (4)	65
Describe the control of disease and pests in aquatic environments (e.g. pathogens, parasites, predators).	15.4% (10)	13.8% (9)	**49.2% (32)**	18.5% (12)	3.1% (2)	65
Describe various career opportunities in the aquaculture industry.	12.3% (8)	13.8% (9)	**46.2% (30)**	20.0% (13)	7.7% (5)	65
Describe safety precautions for the aquaculture industry.	13.8% (9)	20.0% (13)	**38.5% (25)**	16.9% (11)	10.8% (7)	65
Explain the historical background of aquaculture (how aquaculture relates to agriculture, science/technology of production and importance to the economy).	12.3% (8)	23.1% (15)	**44.6% (29)**	13.8% (9)	6.2% (4)	65
Categorize aquaculture species as cold, cool, or warm water species.	12.3% (8)	16.9% (11)	**41.5% (27)**	21.5% (14)	7.7% (5)	65
Describe infrastructure necessary for aquaculture production (e.g. labor, feed manufacturing, transportation).	12.3% (8)	21.5% (14)	**43.1% (28)**	20.0% (13)	3.1% (2)	65
Define concepts associated with health management of aquacrops.	13.8% (9)	23.1% (15)	**44.6% (29)**	13.8% (9)	4.6% (3)	65
					answered question	**65**
					skipped question	**185**

8. What is your sex?

	Response Percent	Response Count
Male	42.7%	79
Female	**57.3%**	**106**
answered question		**185**
skipped question		**65**

9. What is your age?	
	Response Count
	185
answered question	185
skipped question	65

10. Years of teaching experience?	
	Response Count
	185
answered question	185
skipped question	65

11. Highest degree earned?		
	Response Percent	Response Count
Bachelors	33.5%	62
Masters	**64.9%**	**120**
Doctorate	1.6%	3
answered question		185
skipped question		65

12. Which science course(s) do you teach?

	Response Percent	Response Count
None	**30.5%**	**57**
Anatomy and Physiology Elective	7.0%	13
Aquaculture Science	7.0%	13
Aquascience Elective	4.3%	8
Biology	27.3%	51
Botany Elective	3.7%	7
Chemistry	9.1%	17
Earth and Space Elective	16.6%	31
Environmental Elective	12.8%	24
Forensic Science Elective	2.1%	4
Genetics Elective	0.5%	1
Geology Elective	1.1%	2
Marine Biology Elective	2.1%	4
Physical Science	26.7%	50
Physics	5.9%	11
Zoology Elective	7.5%	14
	Other (please specify)	41
	answered question	**187**
	skipped question	**63**

13. Which career/technical education course(S) do you teach?

	Response Percent	Response Count
None	67.9%	127
Agribusiness Management	7.0%	13
Agribusiness Marketing	4.8%	9
Agribusiness Technology	3.2%	6
Agricultural Communications	3.2%	6
Agriscience	23.5%	44
Agriscience Exploration	11.8%	22
Animal Biotechnology	1.6%	3
Animal Science	9.1%	17
Aqua Experience	3.2%	6
Aquaculture Science	9.6%	18
Aquatic Biology	1.6%	3
Construction Finishing and Interior Systems	8.6%	16
Construction Framing	12.8%	24
Construction Site Preparation and Foundation	3.2%	6
Creative Floral Design	1.1%	2
Environmental Management	4.3%	8
Equine Science	3.2%	6
Fish and Wildlife Management	13.4%	25
Floral Design and Interiorscaping	0.5%	1
Forestry Equipment	2.7%	5
Forestry	7.5%	14

Greenhouse Production and Management	8.0%	15
Horticultural Science	9.1%	17
Introduction to Agriscience	8.6%	16
Introduction to Drafting Design	0.5%	1
Introduction to Masonry	1.1%	2
Introduction to Metal Fabrication	11.2%	21
Introduction to Metal Inert Gas and Flux Cored Arc Welding	5.3%	10
Introduction Veterinary Science	2.1%	4
Landscape Design and Management	7.5%	14
Nursery Production and Management	2.7%	5
Plant Biotechnology	1.6%	3
Poultry Science	0.5%	1
Power Equipment Technology	1.6%	3
Residential and Commercial Power Equipment	0.5%	1
Residential Landscape Establishment and Maintenance	3.7%	7
Residential Wiring	3.2%	6
Safety and Health Regulations	2.1%	4
Specialty Floral Design and Management	0.5%	1
Sports Turfgrass Production and Management	3.7%	7
Two- and Four-Stroke Engines	4.8%	9
Urban Forestry	0.5%	1

		Response Percent	Response Count
Veterinary Science		1.6%	3
		Other (please specify)	9
		answered question	187
		skipped question	63

14. Are you interested in learning more about aquaculture?

		Response Percent	Response Count
Yes		79.0%	147
No		21.0%	39
		answered question	186
		skipped question	64

15. If your schedule allowed would you be interested in teaching an aquaculture course?

		Response Percent	Response Count
Yes		65.2%	122
No		34.8%	65
		answered question	187
		skipped question	63