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TEACHING BIOLOGY USING AGRICULTURE AS THE CONTEXT: PERCEPTIONS OF HIGH SCHOOL STUDENTS

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Abstract

The purpose of this study was to determine how high school students perceived science and agriculture after completing a yearlong biology class that used animal agriculture as the context. This study utilized a case-study approach. The population for the study included all students who participated in a biology course utilizing animal agriculture as the context for teaching biology (N=531). More than 90% of the subjects reported they agreed or strongly agreed that participating in a biology class that used agriculture as the context helped them understand the relationship between science and agriculture. Over 85% of those responding agreed or strongly agreed that they appreciated the complex nature of animal agriculture as a result of taking the class, and the class helped them understand the practices used in animal agriculture. Nine of 10 respondents agreed or strongly agreed that they appreciated the importance of agriculture and those who work in agriculture after participating in the class. Almost 90% disagreed or strongly disagreed with statements that animals should not be used for meat and that farmers raising animals are not concerned with the environment. Over 80% strongly agreed or agreed that raising animals for food and/or being a farmer is a noble profession.

Introduction/Theoretical Framework

Agricultural Education teachers have been encouraged to work at establishing methods for integrating more scientific principles into their agriculture curriculum. The concept of integrating science into agricultural education programs has been supported from various sources for almost two decades (National Commission on Excellence in Education, 1983; National Academy of Sciences, Committee on Agricultural Education in the Secondary Schools, 1988; Secretary's Commission on Achieving Necessary Skills, 1991).

Research findings have supported the claim that integration of science into agriculture curricula is a more effective way to teach science. Studies conducted and replicated support the findings that students taught by integrating agricultural and scientific principles demonstrated higher achievement than did students taught by traditional approaches (Enderlin & Osborne, 1992; Enderlin, Petrea, & Osborne, 1993; Roegge & Russell, 1990; Whent & Leising, 1988). Osborne and Dyer (1998) discovered that "as a result curriculum redesign efforts in the 1990's in agricultural education have converged on identifying promising strategies that incorporate more science into high school agricultural curricula" (p. 8).

According to *Science for All Americans* (American Association for the Advancement of Science, 1989), a science literate person is one who: 1) is familiar with the natural world, 2) understands the key concepts and principles of science, mathematics, and technology, 3) has a capacity for scientific ways of thinking, 4) is aware of some of the important ways in which mathematics, technology, and science depend upon one another, 5) knows that science, mathematics, and technology are human enterprises, and what that implies about their strengths and limitations, and 6) is able to use scientific knowledge and ways of thinking for personal and social purposes.

A contextual approach to scientific thinking is embedded in each of the above statements. To improve science literacy and students' understanding about the nature of

science, students must be challenged to think about science as something more than just sitting in the traditional science classroom. They need exposure to multiple opportunities for thinking scientifically, and multiple opportunities for applying scientific reasoning to everyday, complex problems.

Helping students understand the nature of science rather than what they know *about* science has been a recent focus of research in science. Devlin (1998, p.B6) states, "it is neither possible nor necessary for the general population to have detailed scientific knowledge across a range of disciplines. Instead, what is important is scientific awareness." The National Commission on Mathematics and Science Teaching for the 21st Century, referred to as the Glenn Commission, calls student performance in mathematics and science unacceptable (National Commission on Mathematics and Science, 2000). By approaching students with diverse interests in various disciplines with curriculum that supports formal science education, science could be relevant to those who are disengaged with traditional approaches to teaching science.

Although recent science publications have espoused the attributes of integrating the science curricula, the level of integration referred to is almost always with *other* science courses (Scotter, Bybee & Dougherty, 2000; Steckelberg, Hoadley, Thompson, Martin, & Borman, 2000; Henriques, 2000). Limited evidence exists to support the concept that science teachers should look for ways to integrate more hands-on applied science concepts into the science curricula. To date, the researcher could find no empirical evidence to suggest that science teachers have been advised to integrate agricultural science and/or food system concepts into their curricula in an attempt to make science relevant to their students. Likewise, no information could be found advising science teachers to initiate contact with other teachers in an effort to collaborate with teachers of similar content.

The experiential learning model provides the theoretical basis for this project. According to Dewey (1938), education is not a single step in a moment of time but rather a series of overlapping events that serve to help the learner construct meaning in much more than just the subject matter being presented. Dewey (1938, p. 49-50) states:

> Perhaps the greatest of all pedagogical fallacies is the notion that a person learns only the particular thing he is studying at the time. Collateral learning in the way of formation of enduring attitudes, of likes and dislikes, may be and often is much more important...For these attitudes are fundamentally what count in the future. The most important attitude that can be formed is that of desire to go on learning. If impetus in this direction is weakened instead of being intensified, something much more than mere lack of preparation takes place.

Further evidence for providing students with multiple contexts is found in brain-based research and learning by Caine and Caine (1994) who call for education to recognize the big picture. They add, "the part is always embedded in a whole, the fact is always embedded in multiple contexts, and a subject is always related to many other issues and subjects" (p. 7). Therefore, brain-based theory and the experiential learning theory suggest that the interface between context and content provides students with multiple opportunities for transfer and overlap of complementary concepts.

In 1993, a biology teacher in a large high school in the Midwest began teaching a traditional biology course using agricultural science as the context for scientific principles. The biology teacher's training includes a Bachelor's of Science in Agricultural Education. However, the teacher did not enter the Agricultural Science and Business-teaching field, but instead chose to teach traditional science for the past 31 years. The motivation for teaching biology using a yearlong thematic approach centered around the teacher's desire to expose students to concepts of where food originates. No classes in Agricultural Science and Business are taught in this high school or the entire school district.

The teacher created a series of instructional units, field trips, laboratory activities, and guest speakers focused on a specific farm animal for each year. Alternating between poultry, swine, and dairy cows, the teacher taught traditional biology concepts using the animal agriculture context for six years. Many of the students who live in the 60,000+ communities had never experienced, first-hand, animal agriculture and never considered the scientific understanding necessary to be involved in animal agriculture.

Purpose and Objectives

The purpose of this study was to determine how high school students perceived science and agriculture after completing a traditional yearlong biology class that used animal agriculture as the context. Agricultural Science and Business teachers should benefit from this knowledge through a greater understanding of the importance of linking agriculture and science instruction. This knowledge should also be helpful to science teachers interested in developing approaches that increase interest in science and improve the relevance of science in their classrooms. To fulfill the purposes of the study, the following research questions were addressed:

1. What are selected demographic variables of students completing a traditional biology class that was taught using animal agriculture as the context?
2. What are the perceptions of students concerning the relationship between science and agriculture after completing a traditional biology class that was taught using animal agriculture as the context?
3. What are student perceptions of agriculture after completing a traditional biology class that was taught using animal agriculture as the context?
4. What level of knowledge about agriculture did students of a traditional biology class retain after completing the course?

Procedures

This study utilizes a case-study approach. Gall, Borg, and Gall (1996, p. 545) state, "[a] case study is done to shed light on a phenomenon, which is the processes, events, persons, or things of interest. Examples of phenomena are programs, curricula, roles, and events." The school involved in the study changed to a trimester schedule during the early phase of the investigation. The new schedule did not allow for the continuation of the biology course under investigation and therefore the target population for this study was limited to the completers of a traditional high school biology class that used animal agriculture as the context for teaching science. The high school involved in this study has a population of over 2,000 students and does not offer Agricultural Science and Business courses. The target population for the study included all students who participated in the biology course from the time agricultural science was used as the context for teaching biology concepts, from 1993 until 1999 (N=531). The biology teacher provided the researcher with a database containing the names and home addresses of all students. Although this study provides findings that address the specific research questions involved, the population and scope of the study are too limited to generalize beyond the original school involved.

A survey instrument developed by the researcher was used to identify the perceptions of the completers of the biology course. Input on face and content validity was gathered from agricultural education professors. Input on construct validity was furnished by the high school teacher involved in teaching the biology course. One part of the survey instrument consisted of six items ($\alpha = 0.90$) utilizing a Likert-type scale asking students for their perceptions regarding the relationship between science and agriculture after taking the biology course using animal agriculture

as the context. A second part of the instrument asked for students to identify their perceptions on 10 statements (α= 0.70) regarding their perceptions of agriculture in general after taking the biology course using animal agriculture as the context. The participants were asked to rate their perceptions using a Likert-type scale (1=strongly disagree, 2=disagree, 3=unsure, 4=agree, 5=strongly agree). Cronbach's alpha coefficient reliability estimate for the overall instrument was .73. In cases where statements were worded negatively, respondent scores were reverse coded for data computation and analysis when aggregate scores were needed.

The survey instrument was developed in conjunction with guidelines provided by the Institutional Review Board for governing research conducted using human subjects by the institution employing the researcher. In addition, permission to gather data from students and past high school graduates was granted by the administration of the high school.

Elements of Dillman's Total Design Method (1978) were utilized to achieve an optimal return rate. The survey instrument, cover letter, and parent release form were mailed to the home of the subjects in June 2000. Subjects were instructed to return the survey instrument by mail to the high school office, or to hand carry the instrument and deliver it to the main office of the high school. Two weeks after the initial mailing, a follow-up letter was sent to all non-respondents. Four weeks after the initial mailing, a second survey instrument and cover letter were sent to all subjects who had not responded, with a follow-up reminder letter coming two weeks after that. The population included students who had taken the biology course up to six years prior to the study. As a result, some addresses for students were not current and survey packets were returned to the researcher undeliverable as indicated by the Post Office. After subtracting 75 subjects who were unable to be contacted, the researcher received 311 useable responses for a response rate of 68%. Data were analyzed and summarized using frequencies, means, and standard deviations. No additional follow-up of non-respondents was conducted.

For reporting purposes, the author determined *a priori* that aggregate mean responses for Likert-type statements would be grouped into categories to aid in interpretation. Responses equivalent to 4.50 or higher were categorized as "strongly agree." Responses ranging from 3.50 to 4.49 were categorized as "agree", and those with mean scores ranging from 2.50-3.49 were categorized as "unsure." Responses ranging from 1.50 to 2.49 were categorized as "disagree", while those responses receiving mean scores lower than 1.50 were categorized as "strongly disagree."

Results

Students who participated in the biology course that was taught using agriculture as the context were exposed to one of three different yearlong themes. During the school years of 1993-94 and 1996-97 biology students were taught with the theme "Swine Time", an emphasis on the nature of swine. During the school years of 1994-95 and 1997-98 students were taught with an emphasis on dairy animals called "Dairy Daze". And, in 1995-96 and 1998-99 students received instruction centered on poultry in a thematic approach called "Poultry Power". In each theme throughout each school year, students were exposed to traditional biology concepts through an animal agriculture context.

Research question one sought to determine selected demographic characteristics of the students who participated in the traditional biology class that was taught using animal agriculture as the context. Table 1 highlights the demographic information of the respondents.

Student responding to the study reported 30.2% had experienced Dairy Daze, 28.2% had experienced Swine Time, and the remaining 41.6% had been exposed to the Poultry Power theme. Of the students reporting, 97.7% were high school freshmen participating in their first high school science class. When asked about the grade they received in the class, 40% reported receiving an "A", while 41% reported

receiving a grade of "B". The mean overall high school GPA of the respondents was 3.46 (out of a possible 4.00 Grade Index). Approximately 60% were females, and more than nine out of 10 reported they were Caucasian. When asked for background information that might connect them to agriculture, less than 3% indicated they lived on a farm, and less than one in five (18%) reported they had been in 4-H.

Table 1
Descriptive Statistics for Selected Demographic Characteristics of Students Enrolled in a Traditional Biology Class Taught Using Agriculture as the Context (*n*=311)

Characteristic		Percentage
Grade received for Biology class using agriculture as the context:	A	40
	B	41
	C	3.5
	D	2.3
	Unsure	13.2
Gender:	Female	58.9
	Male	41.1
Ethnicity:	African American	2.6
	American Indian	0.6
	Asian American	2.3
	Caucasian	92.9
	Hispanic	0.6
	Multiracial	1.0
Location of residence:	Farm	2.6
	Rural Area	27.2
	Urban/City	70.1
Member of 4-H:	Yes	17.5
	No	82.5
Relatives that live/work on a farm:	Yes	37.4
	No	62.6
Grades received in all science classes:	All A's	25.6
	A's and B's	64.7
	B's and C's	9.1
	C's and D's	0.6
As a result of taking a biology class using agriculture as the context my *interest* in food systems and agriculture is:	High	5.2
	Moderately High	23.3
	Moderate	51.1
	Moderately Low	12.0
	Low	8.4

In addition to questions used to gather demographic information from the respondents, the subjects were asked to respond to 22 statements regarding their perceptions of science, and agriculture, and their knowledge of agriculture as a result of taking the modified biology class. Their responses were measured using a five point Likert-type scale where 1=strongly disagree, 2=disagree, 3=unsure, 4=agree, and 5=strongly agree.

The raw mean scores for the 22 statements regarding the respondents' perceptions of science and/or agriculture ranged from a low of 1.67, indicating their disagreement, for the statement "animals should not be used for meat" to a high score of 4.36 for the statement "I understand the need for people involved in animal agriculture to have a strong science background". Overall, none of the statements received an aggregate mean score of 4.50 or higher.

To address research question two, the subjects were asked to respond to statements concerning the relationship between science and agriculture. Table 2 shows the results from 6 questions used to determine respondent attitudes towards this concept. Using the same Likert-type scale, scores in this section ranged from 4.20 to 4.36, indicating the respondents "agreed" with each question concerning the relationship between science and agriculture. The composite mean score for this section concerning student perceptions of the relationship between science and agriculture was 4.29 (Table 2).

Table 2
Perceptions of High School Students Regarding the Relationship Between Science and Agriculture After Taking a Biology Course Using Animal Agriculture As the Context (*n* = 311)

Item	*Mean*	*SD*
As a result of taking a biology course that emphasized animal agriculture I:		
Understand the need for people involved in animal agriculture to have a strong science background.	4.36	0.78
Item	*Mean*	*SD*
As a result of taking a biology course that emphasized animal agriculture I:		
Understand the relationship of science with agriculture more than I did before.	4.35	0.77
Appreciate those who work in agriculture more than I did before.	4.34	0.82
Understand the practices of animal agriculture more than I did before.	4.30	0.87
Appreciate the importance of agriculture more than I did before.	4.20	0.85
Appreciate the complex nature of animal agriculture more than I did before.	4.20	0.78
Composite Mean	4.29	

Scale: 1=Strongly Disagree to 5=Strongly Agree

Research question three asked former students about their perceptions of agriculture in general. Ten questions were used to gain student perceptions in this section. Table 3 shows the results from the questions used to determine respondent attitudes towards this concept. Scores in this section ranged from 1.67 to 4.31. Respondents indicated they agreed with the statement "people who raise animals for food need to know a great deal about science in order to do their job effectively" (4.31). In addition students disagreed with the statements "farmers raising animals are not concerned with the environment" (1.75) and "animals should not be used for meat" (1.67). Statements in this section that were negatively worded were reverse coded for computation of internal consistency. Table 3 highlights the results from the 10 questions used to determine respondent attitudes towards agriculture in general.

Research question four asked students who were taught biology using agriculture as a thematic approach about their knowledge of specific agriculture as a result of participating in the biology course. Six statements were included in this section which referenced material covered during the yearlong biology class. Students were asked general agriculture and general animal science questions that were part of the instruction offered to each biology class regardless of the animal species used for the

particular year. Questions utilized a multiple-choice format, and answers were coded as either correct or incorrect for tabulation purposes. No attempt was made to categorize incorrect answers or to draw conclusions from the results of incorrect responses. Table 4 provides detailed information concerning the responses of students to the questions in this category. The correct answers given to the six questions ranged from 92% of the respondents correctly identifying the role of vaccines in animal health to a low response of 7% for correctly identifying the approximate percentage of disposable income Americans spend on food each year.

Table 3
Perceptions of High School Students Toward Agriculture in General After Taking a Biology Course Using Agriculture as the Context (*n* = 311)

Item	*Mean*	*SD*
People who raise animals for food need to know a great deal about science in order to do their job effectively.	4.31	0.83
Farmers care about their animals.	4.07	0.79
Raising animals for food and/or being a farmer is a noble profession.	4.07	0.83
All students should have knowledge about food systems and animal agriculture.	3.88	0.84
Animal agriculture and food production is all about science.	3.75	0.87
Exciting careers exist in agriculture.	3.67	0.89
Generally speaking, farming is a lucrative occupation.	2.93	0.97
Farmers do not treat their animals humanely.	2.05	0.90
Farmers raising animals are not concerned with the environment.	1.75	0.91
Animals should not be used for meat.	1.67	0.91
Composite Mean	3.22	

Table 4
High School Students' Knowledge of Agriculture After Taking a Biology Course Using Animal Agriculture as the Context (n = 311)

Item		Percentage
Animals can be made artificially immune to certain diseases with the use of which of the following?	Correct	91.8
	Incorrect	8.2
_____ is sometimes placed in animal feeds to fight bacteria?	Correct	77.6
	Incorrect	22.4
_____ is the number one livestock industry in the United States?	Correct	54.4
	Incorrect	45.6
What is an advantage to crossing two purebred animals in order to obtain a crossbred?	Correct	47.8
	Incorrect	52.2
Approximately what percentage of all jobs in the United States is related to the food and fiber system?	Correct	24.4
	Incorrect	74.6
Approximately what percentage of disposable income is spent on food in the United States?	Correct	6.7
	Incorrect	93.3

Conclusions

The conclusions of this study were based on the responses of students enrolled in a traditional biology course that was taught using agriculture as the context for teaching science. Students who were enrolled in the course were taught one of three yearlong units specializing in animal agriculture. Although other studies focus on the impact of using agriculture to teach science, caution must be exercised when generalizing the results beyond the respondents of this study.

From the findings it was concluded that the majority of the respondents did well in the biology class, receiving either an "A" or "B" for the course. In general, over 90% of the students reported receiving "A's and B's" in all of their science courses. By evidence of their relatively high Grade Index (3.46 out of a possible 4.00) it can be concluded that the respondents performed relatively well in science classes and school in general. Based on the responses of the subjects to questions regarding previous involvement with agriculture and/or involvement in agricultural youth organizations such as 4-H, no evidence appeared to indicate they had previous experience in agriculture. Over 70% reported living in an urban or city setting, more 65% did not have a relative who lived or worked on a farm, and four of five were never involved in 4-H. Furthermore, no classes in Agricultural Science and Business were offered anywhere in the city's consolidated school corporation indicating there was no chance for students to receive systematic school instruction in agricultural education. However, as a result of receiving instruction in biology using agriculture as the context, 80% of respondents indicated they now have a moderate to high level of interest in food systems and animal agriculture as a result of taking this class.

Research question two sought to determine the perceptions of respondents toward the relationship between science and agriculture. Based upon a Likert-type scale, over 90% of the subjects reported that they either agreed or strongly agreed that participating in a biology class that used

agriculture as the context helped them understand the relationship between science and agriculture. This concurs with the findings of Caine and Caine (1994) and supports the work being done in brain-based theory. Over 85% of those responding agreed or strongly agreed that they not only appreciated the complex nature of animal agriculture as a result of taking the agricultural based biology class, but the biology class also helped them understand the practices used in animal agriculture. It can be concluded that students gained a better understanding of the role that science plays in the world of animal agriculture as a result of taking a biology course that taught science concepts using animal agriculture as the context.

Almost nine of 10 respondents (88.6%) agreed or strongly agreed that they appreciated the importance of agriculture and appreciated those who work in agriculture as a result of participating in an agricultural based biology class. This response indicates that the teacher was successful in communicating the link between science and the world of agriculture. As a result of taking the biology class using agriculture as the context, respondents indicated that they understood the need for farmers to have a strong science background.

Research question three sought to determine the perceptions of the respondents toward animal agriculture in general. Almost 90% (86% and 87% respectively) disagreed or strongly disagreed with statements that animals should not be used for meat and that farmers raising animals are not concerned with the environment. Conversely, respondents felt very strongly about the people raising animals for human consumption. Four of five (78%) strongly agreed or agreed that farmers care about their animals. Over 80% strongly agreed or agreed that raising animals for food and/or being a farmer is a noble profession. This indicates a positive perception and attitude toward the people involved in animal agriculture. It can be concluded that students of the modified biology class realize the need for animal agriculture and believe that farmers treat their animals humanely.

Furthermore, since a large majority of the respondents reported living in a city or urban setting with limited exposure to animal agricultural production, many have positive perceptions about farmers and farming, with some maintaining these attitudes for up to five years. It can be concluded that subject matter taught in the context of animal agriculture, from a teacher experienced in modern animal agricultural practices, can have a positive effect upon student attitudes towards agriculture and those who work in the agriculture industry, even when taught within a school corporation located in a larger metropolitan city.

Assessing respondents' knowledge of agriculture and retention of that knowledge was the purpose of research question four. Students were asked questions concerning elements of animal agriculture, and agriculture in general, that were included in the instruction of all three themes, poultry, swine, and dairy. Of the questions asked, respondents were able to correctly determine (92% correctly responded) that vaccines were helpful to an animal's immune system for fighting disease. Subjects were also successful in determining the number one livestock industry in the United States and the purpose that antibiotics serve in animal production and animal health. However, slightly less than half (48%) of the respondents knew the advantage of crossbreeding two purebred animals.

In addition, subjects did poorest in questions regarding the percentage of disposable income that American's spend for food, and the percentage of jobs in the United States that are related to the food and fiber system. It can be concluded that the former students of the biology class using animal agriculture as the context could transfer general information regarding health to related subject matter in animal health as taught during the class. Some could transfer this information very well. However, broad ideas concerning the scope and importance of the food and fiber system within the United States were much more difficult for students to recall. This implies that although animal agriculture was the theme for each of the six years of this biology course, it was still a biology course. Scientific principles

were the main focus regardless of the context, and broad themes regarding the agricultural industry may not have received adequate attention.

Recommendations

The teacher responsible for teaching the biology course in this study was a graduate of a four-year teacher education program in agricultural education. In addition, he actively farmed with his family during the first 20 years of his teaching career. He did not teach Agricultural Science and Business but went directly into the science classroom. As a result he had a significant background and interest in agriculture and communicating that knowledge to his students. It is recommended that further research examine the relationship between the teachers' education and background and their ability to successfully utilize a thematic approach focusing on agriculture. Specifically, how much pre-service and in-service training is necessary for non-agriculture teachers to effectively utilize agricultural education in their classroom?

Agricultural education is facing a shortage of qualified teachers today. As a result, it is recommended that agricultural education teacher preparation programs explore the feasibility of offering courses of study for those pre-service teaching majors in programs that align closely with agriculture, specifically the sciences. Although this will not directly help the shortage of traditional Agricultural Science and Business teachers, it may begin to influence the agricultural literacy of students who would not traditionally have the opportunity to participate in an Agricultural Science and Business program such as the one used in this study.

Many Agricultural Science and Business programs have recently begun to implement scientific principles into their existing curriculum (Osborne & Dyer, 1998). However, no evidence exists for the number of traditional science programs that utilize some form of instruction in food, agriculture, and/or natural resource systems. It is recommended that data be collected from school corporation science departments to determine the extent, if any, that these topics are being taught. Although agriculture and/or natural resource systems education may already occur in local science departments, based upon the findings of this study and evidenced by the body of literature available, it is recommended that secondary science education become more contextual in its delivery.

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