BIOTECHNOLOGY: AN ASSESSMENT OF AGRICULTURAL SCIENCE TEACHERS' KNOWLEDGE AND ATTITUDES

Diana L. Mowen, Graduate Assistant
T. Grady Roberts, Assistant Professor
Gary J. Wingenbach, Associate Professor
Julie F. Harlin, Assistant Professor
Texas A&M University

Abstract

The purpose of this study was to explore agricultural science teachers' knowledge levels and attitudes toward biotechnology topics. The average agricultural science teacher in this study was a 37-year-old male who had taught for 12 years. He had a bachelor's degree and had lived or worked on a farm or ranch. He had not attended biotechnology-related workshops or classes since he graduated from college. Agricultural science teachers in the current study had some knowledge of biotechnology. However, great variation existed between specific topics. Teachers were most knowledgeable about animal reproduction and least knowledgeable about electrophoresis and bioremediation. Significant relationships were found between teachers' self-perceived knowledge levels of specific biotechnology topics and the likelihood that the topic was taught in the classroom. Agricultural science teachers had favorable attitudes toward biotechnology. A low positive relationship existed between agricultural science teachers' knowledge and attitudes toward biotechnology. When comparing teachers based on experience (those with less than 15 years versus those with 15 or more years) results indicated no differences in knowledge and attitudes.

Introduction

Effective agricultural science teachers are continuously looking for opportunities to continue their learning and improve the offerings of their agriculture program (Roberts & Dyer, 2004). With the increasing sophistication of science impacting agriculture now and in the future, it was necessary for agriculture students to understand the risks and benefits associated with those scientific advancements (Kirby, 2002). In order to induce more positive attitudes toward science and improve student achievement, Roegge and Russell (1990) recommended using an integrated approach to teaching. As stated by Lankard (1992), the integration of academic and vocational education was articulated in the 1990 Carl Perkins Amendments by policy makers.

Prior to the 1990 Carl Perkins Amendments, the U.S. Secretaries of Agriculture and Education requested that the National Research Council establish a Committee on Agricultural Education in Secondary Schools. The purpose of this committee was to assess the contributions of instruction in agriculture to the maintenance and improvement of agricultural productivity and economic competitiveness here and abroad. The committee was asked to generate recommendations including goals for instruction in agriculture. The committee found that much of the focus and content of many agriculture programs related to production agriculture was outdated. It was recommended that revisions be made including development of new curriculum components addressing the sciences basic to agriculture, food, and natural resources; agribusiness; marketing; management; international economics; financial accounting; and tools to improve the efficiency of agricultural productivity (National Research Council, 1988). This

strategy for educational reform was soon supported by vocational educators and people in industry as the demand increased for youth to have experience with new technologies and higher-level skills to be employable.

Integrating science and agriculture was shown to have several positive effects on agriculture programs and participants. According to Dyer and Osborne (1999), more positive views toward agricultural education were held by faculty and staff working in a school with an agriculture program that taught applied science concepts. Thompson and Balschweid (2000) found that students were better prepared in science after completing a course in agricultural education that integrated science. The benefit is twofold as research shows that students learned more about agriculture when science concepts are included in the instruction (Thompson & Balschweid). These findings were strongly supported by the research of Chiasson and Burnett (2001) who found that when taking the Graduate Exit Examination, agriscience students scored significantly higher on the science portion than did non-agriscience students.

Strong evidence existed to encourage the integration of science in agricultural education courses, but the level of integration was controlled by the instructor. Balschweid and Thompson (2002) discovered that agriculture teachers felt that lack of funding, lack of equipment, and increased planning time were barriers to integrating science into agriculture classes. Other significant barriers were the lack of science competence among agricultural educators and the lack of in-service learning opportunities for teachers (Balschweid & Thompson). These findings concurred with the conclusions of Wilson and Flowers (2002), who found that agricultural educators who had a high self-perceived level of knowledge about biotechnology were more willing to teach curriculum related to biotechnology. In contrast, Wilson, Kirby, and Flowers (2002) reported that nearly half of the agricultural science teachers in their study were unable to pass the knowledge test created for high school students in an agricultural biotechnology course.

The principles of biotechnology serve as excellent educational tools, but to determine how effectively biotechnology is being or can be taught, we should learn what agricultural science teachers know about biotechnology. What are their attitudes toward biotechnology? What biotechnology topics are being taught in Texas agricultural science classes?

Purpose and Objectives

The purpose of this study was to explore agricultural science teachers' knowledge levels and attitudes toward biotechnology topics. The objectives were to:

1. Describe agricultural science teachers' knowledge and teaching of biotechnology topics.
2. Describe agricultural science teachers' attitudes toward specific biotechnology topics.
3. Determine if a relationship existed between agricultural science teachers' knowledge and attitudes of biotechnology.
4. Determine if differences existed in knowledge levels or attitudes toward biotechnology between agricultural science teachers based on years of teaching.

Methods and Procedures

Descriptive survey methods with a correlational design were used to examine agricultural science teachers' knowledge of biotechnology topics and their attitudes toward those topics. The descriptive methods approach was chosen because it was best suited for the population of interest: participating agricultural science teachers who attended the final session of the 2004 Texas State Agricultural Science Teachers Conference. This population was chosen because the final session of the Texas State Agricultural Science Teachers Conference was a general session with large attendance of agricultural science teachers, which created an opportunity to collect data

from a large number of teachers who may have had the knowledge desired for this study. Selecting this population allowed for collection of data from agricultural science teachers interested in improving their biotechnology knowledge and experience to enhance their classroom teaching. Due to the nature of this population, caution is warranted against generalizing the results beyond those studied herein.

For the purpose of this study, agricultural science teachers were divided into two groups based upon the number of years teaching agricultural science. The teacher groups consisted of teachers with 15 or more years of teaching experience and teachers with less than 15 years of teaching experience. The rationale behind this decision stems from documented changes in the teaching of agricultural science in the 1980's. Documentation from the Texas Education Agency confirms the restructuring of agriculture courses from production agriculture I, II, III, and IV courses (Texas Education Agency, 1968) into a semester-course format with increased emphasis on agribusiness and emerging technologies (Texas Education Agency, 1987). It was anticipated that any teacher with less than 15 years of teaching experience would have only taught agricultural science classes using the current curriculum model. Teachers with 15 or more years of experience taught vocational agriculture classes in the prior format of Ag I, II, III, and IV as well as with the current curriculum model. If differences existed between teachers' knowledge levels or attitudes toward teaching biotechnology in the agricultural science classroom, it was expected those differences would occur between these sub-groups, based on their preparation for teaching and initial experiences upon entering the teaching profession.

Paper-based instruments were used to collect the data after obtaining approval to conduct the study through the Texas A&M University Institutional Review Board. Some descriptions of methods and resultant demographics, while explained fully in this study, are found in another paper (Mowen, Roberts, Wingenbach, & Harlin, 2006).

All data collection occurred on August 5, 2004, when 274 responses were collected. A modified version of the instrument, *Attitudes, Knowledge, and Implementation of Biotechnology* (Boone, Gartin, Boone, & Hughes, 2006; Hughes, 2001), was used to create the research instrument; wording changes, question sequencing, and layout constituted the modifications. Content and face validity were established previously by a panel of experts (teacher educators) at West Virginia University.

The instrument, *Agriculture Science Teachers' Attitudes and Implementation of Biotechnology*, contained three sections: agriculture science teachers' self-perceived knowledge levels (four levels, 18 topics), attitudes toward agricultural biotechnology topics (nine statements), and demographic information.

Responses to the level of knowledge scale (measuring agricultural science teachers' self-perceived knowledge levels of 18 agricultural biotechnology topics) were recorded using descriptors from research done by Hughes (2001), across four-levels, with a range of: (1) No knowledge; (2) Heard of it, but have very little knowledge; (3) Read about it, possess some knowledge; or, (4) Applied, and knowledgeable. Reliability, as a measure of internal consistency for the summed level of knowledge scale, revealed an alpha coefficient of .86, indicating the summed scale was reliable.

Participants were asked to indicate if they had or were teaching one or more of the 18 agricultural biotechnology topics. The topics corresponded to their self-reported levels of knowledge about each respective item. The 18 topics were: (a) Animal Reproduction, (b) Bioremediation, (c) Biotechnology Ethics, (d) Cloning, (e) Electrophoresis, (f) Environmental Biotechnology, (g) Food Biotechnology, (h) Gene Splicing, (i) Genetic Engineering, (j) Genetically-Modified Food, (k) Growth Hormones (bST, pST), (l) Human Genomics, (m) Hybridization, (n) Microbial Biotechnology, (o) Plant Tissue Culture, (p) Recombinant DNA, (q) Resistant Plant Species, and (r) Transgenic Species.

Participants were asked to indicate their agreement to nine statements that measured attitude toward agricultural biotechnology

practices and issues on a four-point (1 = Strongly Disagree; 4 = Strongly Agree) Likert-type scale. Sample statements included (a) Biotechnology should be a topic in an agriculture science class, (b) I believe that local, state, and federal money should be spent on teaching biotechnology, and (c) I support using biotechnology for environmental purposes. Cronbach's alpha coefficient (Cronbach, 1951) for the summed attitude scale revealed an alpha coefficient of .77.

The demographic section contained seven questions pertaining to education level, age, years of agriculture science teaching experience, gender, agricultural background (have you ever lived/worked on a farm/ranch), and attendance in biotechnology classes/workshops since college graduation. In addition, respondents were asked to rate (low, medium, or high) their level of scientific knowledge.

Demographic data were analyzed using descriptive statistics. Analysis of variance was used to determine significant differences between knowledge levels, attitude and teacher experience. Pearson-product moment correlation was used to determine relationships between knowledge levels and attitude toward biotechnology topics (Gall, Gall, & Borg, 2003). A significance level of .05 was established *a priori*.

Results

Two hundred seventy-four agriculture science teachers completed the questionnaire. Most respondents were male (78.1%); four respondents did not identify their gender. Respondents' ages ranged from 21 to 64 and averaged 37.4 years (*SD* = 11.04). Teaching experience ranged from zero to 38 with an average of 12.3 years (*SD* = 10.08) in teaching agricultural science classes. When participants were asked if they had lived or worked on a farm or ranch, 91% indicated an affirmative response.

One hundred seventy-nine respondents indicated they had Bachelor degrees (66.8%), while 88 (32.8%) had a Masters degree and one person indicated that he/she had a Doctorate (.4%) at the time of this study. Thirty percent of respondents indicated that they had attended a biotechnology class or workshop since graduating from college. When examining teachers based on experience, 26.5% of the younger teachers (< 15 years teaching experience) had attended a biotechnology workshop, while 36.7% of their more experienced (15+ years teaching) colleagues had attended a similar workshop.

Objective One

Teachers provided a self-assessment of their knowledge levels related to 18 specific biotechnology topics using a four-point Likert-type scale (1 = no knowledge; 2 = heard of it, but have very little knowledge; 3 = read about, possess some knowledge; or 4 = applied, and knowledgeable). Additionally, teachers indicated if they taught those same topics. A summary of the findings can be seen in Table 1.

Table 1
Agricultural Science Teachers' Knowledge and Teaching of Biotechnology Topics (N = 274)

	Knowledge Level		Taught in Class	Correlation
Biotechnology Topics	*M*	*SD*	*%*	*r*
Animal Reproduction	3.71	.58	85	-.05
Cloning	2.95	.68	54	.48*
Growth Hormones (bST, pST)	2.94	.81	54	.53*
Hybridization	2.93	.87	56	.55*
Genetically Modified Food	2.83	.77	50	.52*
Food Biotechnology	2.82	.79	48	.56*
Resistant Plant Species	2.80	.83	42	.51*
Genetic Engineering	2.66	.75	37	.49*
Biotechnology Ethics	2.62	.86	40	.46*
Plant Tissue Culture	2.59	.89	32	.54*
Environmental Biotechnology	2.49	.89	32	.57*
Gene Splicing	2.49	.79	24	.44*
Recombinant DNA	2.29	.89	17	.55*
Microbial Biotechnology	2.28	.89	12	.14
Transgenic Species	2.13	.92	16	.65*
Human Genomics	2.12	.84	12	.24*
Electrophoresis	1.71	.89	6	.51*
Bioremediation	1.64	.77	5	.52*
Summed Scale Mean	2.62	.61		

Note. Scale: 1 = no knowledge, 2 = heard of it, but have very little knowledge, 3 = read about, possess some knowledge, 4 = applied, and knowledgeable.
* $p < .05$.

Agricultural science teachers were most knowledgeable about animal reproduction (M = 3.71, SD = .58). Not surprisingly, 85% of the teachers indicated they taught animal reproduction. This group of respondents reported having little knowledgeable about two topics, electrophoresis and bioremediation (M = 1.71, SD = .89 and M = 1.64, SD = .77, respectively). These two topics were least taught (6% and 5%, respectively). Teachers' knowledge levels varied from very little to some knowledge for the remaining 15 topics. The summed scale mean for all biotechnology topics was 2.62 (SD = .61) indicating some level of knowledge. As would be expected, there were positive correlations (r = .24 to .65) between the percentage of teachers who taught each topic and teacher knowledge levels for all but two topics, animal reproduction (r = -.05) and microbial biotechnology (r = .14).

Objective Two

Teachers indicated their level of agreement on nine biotechnology statements using a Likert-type scale (1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree). Mean agreement levels for each of the statements are reported in Table 2. Teachers were generally in agreement with all the statements (M = 2.91 to M = 3.52). The summed scale mean for attitude toward biotechnology was 3.11 (SD = .39).

Table 2
Agricultural Science Teachers' Attitudes Toward Biotechnology (N = 274)

Statements	*M*	*SD*
Cross breeding to produce hybrids is morally wrong.[a]	3.52	.61
Biotechnology should be a topic taught in agriculture science class.	3.17	.55
I support the genetic engineering of feed crops.	3.15	.51
I support using biotechnology for human medicine.	3.13	.58
I support the genetic engineering of food crops.	3.11	.53
I support biotechnology for environmental purposes.	3.11	.51
Biotechnology should be a class taught by agriculture science teachers.	2.97	.65
I believe that local, state, and federal money should be spent on teaching biotechnology.	2.94	.66
I support the genetic engineering of animals.	2.91	.65
Summed Scale Mean	3.11	.39

Note. Scale: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree.
[a]Statement was worded positively on questionnaire and reverse-coded for data analysis.

Objective Three

To determine if a relationship existed between agricultural science teachers' knowledge about biotechnology and attitudes toward biotechnology, correlation analysis was performed on the summed scale means for knowledge and attitudes. A low, positive correlation ($r = .27$, $p < .01$) was found between the two means (Davis, 1971).

Objective Four

Agricultural science teachers were divided into groups, based on years of teaching (those with less than 15 years, and those with 15 or more years). Based on this division, 171 teachers (62.4%) had taught less than 15 years while 98 teachers (36.4%) had 15 years or more years of teaching experience.

Table 3 shows agricultural science teachers with less than 15 years of teaching experience had some knowledge of biotechnology ($M = 2.56$, $SD = .63$). Teachers with 15 or more years of experience were slightly more knowledgeable ($M = 2.70$, $SD = .56$). However, ANOVA results revealed no significant difference between the groups ($F_{(1,259)} = 3.30$, $p = .07$).

Also depicted in Table 3, agricultural science teachers with less than 15 years of experience had favorable attitudes toward biotechnology ($M = 2.88$, $SD = .33$), while their more experienced colleagues had slightly less favorable attitudes ($M = 2.84$, $SD = .42$). As with knowledge levels, there was no significant difference between the groups ($F_{(1,267)} = .65$, $p = .42$).

Table 3
Differences in Knowledge Levels or Attitudes Toward Biotechnology Between Agricultural Science Teachers Based on Years of Teaching Experience (N = 274)

	< 15 Years Experience (*N* = 171)		15+ Years Experience (*N* = 98)			
	M	*SD*	*M*	*SD*	*F*	*p*
Biotechnology Knowledge[a]	2.56	.63	2.70	.56	3.30	.07
Attitudes toward Biotechnology[b]	2.88	.33	2.84	.42	.65	.42

[a]Scale: 1 = no knowledge, 2 = heard of it, but have very little knowledge, 3 = read about, possess some knowledge, 4 = applied, and knowledgeable.
[b]Scale: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree.

Conclusions and Recommendations

The average agricultural science teacher in this study was a 37-year-old male who had taught for 12 years. He had a bachelor's degree and had lived or worked on a farm or ranch. He had not attended any biotechnology related workshops or classes since he graduated from college. The teachers in the current study are similar to those examined by Wilson et al. (2002), who were male, 39 years old, and had just over 13 years of teaching experience. One inconsistency between the two samples was the percentage who had attended a biotechnology workshop (30% in the current study versus 67% in the Wilson et al. study).

The first objective of this study was to describe agricultural science teachers' knowledge levels of specific biotechnology topics. Agricultural science teachers in the current study had some knowledge of biotechnology. However, great variation existed between specific topics. Teachers were most knowledgeable about animal reproduction and least knowledgeable about

electrophoresis and bioremediation. Only five topics were taught by at least one-half of the teachers: animal reproduction, cloning, growth hormones (bST, pST), hybridization, and genetically modified food. Interestingly, despite a smaller percentage of teachers who had attended biotechnology workshops, the teachers in the current study had greater self-reported knowledge levels than did the teachers in the Wilson et al. (2002) study. This discrepancy warrants further investigation.

Significant relationships were found between self-perceived knowledge levels of teachers in specific biotechnology topics and the likelihood that said topic was taught in the classroom. Such relationships supported the idea that teachers were more likely to teach biotechnology topics if they had more personal knowledge of biotechnology principles or that teachers were more likely to have greater knowledge if they taught the topic. It is recommended that for this group of teachers, training be offered in areas that teachers were least knowledgeable. Such training may offer these teachers an opportunity to increase their knowledge and the likelihood of teaching more biotechnology topics in the classroom.

Objective two was to describe teachers' attitudes toward biotechnology. Based on the findings of the current study, this group of respondents exhibited favorable attitudes toward biotechnology. Given the prevalence of biotechnology present in the multi-faceted life sciences that agriculture encompasses, it is not surprising that these teachers had favorable attitudes. This conclusion is consistent with the findings of Wilson et al. (2002) who found that North Carolina agricultural science teachers responded favorably about the importance of teaching biotechnology.

Objective three was to determine if relationships existed between agriculture science teachers' knowledge levels and attitudes toward biotechnology topics. It was concluded that a weak relationship existed between the knowledge of this group of respondents and their attitudes toward biotechnology. However, given that these agricultural science teachers had generally favorable attitudes toward biotechnology, the data may not have provided sufficient variation to explore fully this relationship. It is recommended that this study be replicated with a true random sample at the state, regional, and national level to gain insights into the relationship between agricultural science teachers' knowledge levels and attitudes toward biotechnology.

Objective four was to determine if differences existed between teachers' knowledge levels or attitudes toward teaching biotechnology in the agriculture science classroom, based on their teaching experience. Results indicated no differences in knowledge or attitudes, implying that respondents who had 15 or more years of teaching experience (and were prepared in their pre-service programs to teach traditional Ag I, II, III, and IV courses) had developed and maintained knowledge of emerging technologies, such as biotechnology, relating to agriculture. Accordingly, when it came to these agricultural science teachers, you could "teach old dogs new tricks."

However, only 36% of the more experienced teachers in this group had attended a workshop on biotechnology. The discrepancy between knowledge level and workshop attendance raises the question, if teachers are not getting new knowledge from workshops, where and how are they getting it? This important question warrants further investigation. It has implications to countless agricultural education university faculty members who routinely develop and deliver inservice workshops for agricultural science teachers in their respective states.

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DIANA L. MOWEN is a Graduate Assistant in the Department of Agricultural Leadership, Education, and Communication at Texas A&M University, MS 2116, 104A Scoates Hall, College Station, TX 77843-2116. E-mail: dmowen@aged.tamu.edu.

T. GRADY ROBERTS is an Assistant Professor in the Department of Agricultural Leadership, Education, and Communication at Texas A&M University, MS 2116, 104A Scoates Hall, College Station, TX 77843-2116. E-mail: groberts@tamu.edu.

GARY J. WINGENBACH is an Associate Professor in the Department of Agricultural Leadership, Education, and Communication at Texas A&M University, MS 2116, 104A Scoates Hall, College Station, TX 77843-2116. E-mail: g-wingenbach@tamu.edu.

JULIE F. HARLIN is an Assistant Professor in the Department of Agricultural Leadership, Education, and Communication at Texas A&M University, MS 2116, 104A Scoates Hall, College Station, TX 77843-2116. E-mail: j-harlin@tamu.edu.