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MODERNIZING THE AGRICULTURAL EDUCATION CURRICULUM: AN ANALYSIS OF AGRICULTURAL EDUCATION TEACHERS' ATTITUDES, KNOWLEDGE, AND UNDERSTANDING OF BIOTECHNOLOGY

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Abstract

In 1917, the Smith-Hughes Act encouraged the development of an agricultural education curriculum that spread innovative farming techniques throughout the nation. During the last half of the 20th century, however, many programs failed to keep pace with rapidly changing technologies. In a major study funded by the National Academy of Sciences (National Research Council, Board on Agriculture, Committee on Agricultural Education in Secondary Schools, 1988), much of the focus and content of many vocational agriculture programs was found to be outdated. The authors challenged the profession to broaden the relevance and scope of the agricultural education curriculum to better prepare students for the study of agriculture. One response to this challenge was to infuse more science and technology into the agricultural education curriculum. The purpose of this descriptive research study was to provide information on the attitudes and knowledge of biotechnology by agricultural education teachers in West Virginia. A major finding of the study was the agricultural education teachers possessed a positive attitude towards biotechnology, but lacked the resources and knowledge to incorporate the subject matter into their curriculum. Teachers perceive themselves with more knowledge on biotechnology topics traditionally associated with agriculture (animal reproduction, hybridization) and less knowledge on topics associated with other fields (environmental biotechnology, human genomics).

Introduction/Theoretical Framework

The Challenge

Following the passage of the Smith-Hughes Act of 1917, the vocational agriculture curriculum evolved into one that "…helped to spread knowledge throughout farming regions about how and when to use agricultural innovations..." (National Research Council, Board on Agriculture, Committee on Agricultural Education in Secondary Schools, 1988, p. 56). This innovative approach, however, failed to keep pace with the rapidly changing technologies during the last half of the 20th century. As the use of modern biotechnological techniques was accelerating in the 70s and 80s, agricultural education was at a major crossroad. In a major study funded by the National Academy of Sciences, much of the focus and content of many vocational agriculture programs was found to be outdated. The authors challenged the profession to broaden the relevance and scope of the agricultural education curriculum (Figure 1) to better prepare students for the study of agriculture in post secondary schools and colleges and for current and future career opportunities in agricultural sciences (National Research Council, Board on Agriculture, Committee on Agricultural Education in Secondary Schools, 1988). One response to this challenge was to infuse more science and technology into the agricultural education curriculum. Agriscience, bioscience, and ag-technology became buzzwords that reflected the infusion of biotechnology and genetic engineering into the agricultural education curriculum (National Council on Vocational Education, 1990). The techniques of biotechnology are among the most complex and widely applied innovations of our time; however, many are already applied to agriculture in more ways than most of us suspect (Smith, 1989). While the concept of integrating more science into the agricultural education curriculum has been widely accepted, a major question arose. Did agricultural education teachers have the knowledge, understanding, and attitudes about biotechnology to properly implement the concepts into the high school curriculum?

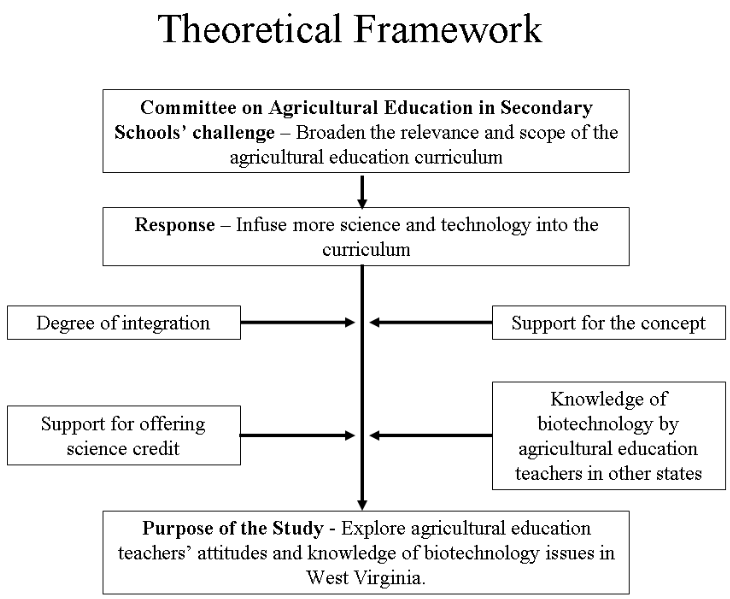

Figure 1. Theoretical Framework

Degree of Science Integration

Science related competencies have always been a part of the agricultural education curriculum (Binkley and Tulloch, 1981). Concepts and principles of chemistry, biology, genetics, physiology, and zoology are readily applied to plant and animal studies (Moss, 1985). While the science related competencies have been a part of agricultural education, there is little national evidence to show the degree to which they were being taught (Martin, Rajasekaran & Void, 1989). There is limited evidence, however, of local integration of science into the agriculture curriculum. Dormody (1992) found a majority of agriculture and science departments were sharing resources. Agriculture teachers in the study predicted this trend would increase in the future. Participation in programs such as the AgriScience Institute and Outreach Program increased cooperation and resource sharing between agriculture and science teacher participants (Whent, 1994). Illinois high school science teachers felt that agriculture programs should become more science based (Osborne & Dyer, 1998). Participation in an integrated agriculture and science curriculum by pre-service teachers resulted in a more positive attitude about integrating science into the agriculture curriculum and increased their willingness to attend workshops about integration of science. The teachers believe that integrating science assisted students in better understanding science concepts and their application to agriculture (Balschweid, Thompson, & Cole, 2000).

Support for the Concept

A review of the relevant literature revealed an overwhelming support for infusing biotechnology concepts into high school science curricula. Biotechnology is appropriate for both the general and advanced high school biology curricula (Zeller, 1994). Introducing students to biotechnology, not only provided an understanding of the principles and techniques involved, but raised awareness of the ethical dilemmas associated with the concepts (Ahmed, 1996). Students need a solid scientific foundation to make informed decisions about important biological and technological issues (Chowning, 2002). While the concept of infusing biotechnology concepts into high school science curricula has been widely accepted, implementation is not without problems. One of the most difficult problems for institutions to overcome in developing a technologically integrated curriculum is the lack of technical experience on the part of the teaching faculty (Mattoon, 1998). In addition, the analysis of issues in bioethical contexts is controversial and can be related to an individual's feelings and beliefs (Conner, 2000).

Support for Science Credit

Research has shown that agriculture teachers strongly support the concept of offering science credit for agriscience (Johnson, 1996). In fact, nearly one-half of the agriculture science teachers in Oregon indicated students received science credit for agriculture classes (Thompson & Balschweid, 1999). The concept of granting science credit for agriscience courses has administrator, guidance counselor, and science teacher support (Johnson & Newman, 1993). While the infusion of agriculture into the science curricula and vice versa is mutually beneficial to both programs, the concepts of science credentialing and science credit are more likely to be used to benefit agriculture programs (Dormody, 1993). Students enrolled in agriscience and natural resources performed as well on standardized science tests as their counterparts who had not enrolled (Conners & Elliot, 1995). Overall, offering science credit provides additional benefits to the students, enhances program benefits, increases enrollment, and improves science content of the program (Johnson, 1996).

Biotechnology Knowledge by Agricultural Education Teachers

In a study of North Carolina agricultural educators, Wilson, Kirby, and Flowers (2002), discovered the agricultural educators felt they lacked biotechnology knowledge, supported its importance, and recognized the benefits of integrated curriculum in agricultural education. The agricultural educators perceived that funding, equipment, and teacher knowledge were the largest barriers to adopting integrated science curriculum. They further discovered that agricultural educators were most likely to teach biotechnology if they have less years of teaching experience, have attended some biotechnology training, and perceived that the curriculum will fulfill their program needs.

Statement of problem

North Carolina agriculture teachers lacked sufficient knowledge of biotechnology issues to include the topic in their curriculum (Wilson et al., 2002). If the profession plans to continue to educate its students in the agriculture sciences (Binkley & Tulloch, 1981), biotechnological concepts must be included in the agriscience curriculum (Zeller, 1994; Ahmed, 1996; Chowning, 2002). Although secondary career and technical education receives federal funding through the Carl Perkins Act, the administration and organization of the programs remain a function of individual State Departments of Education. Because biotechnological concepts should be a part of the agriculture curriculum and the administration and organization of educational programs are unique to each state, it is important to determine if the findings in North Carolina are representative of other states. Research has shown that without knowledge of biotechnological concepts, teachers can not incorporate the concepts into their curricula (Mattoon, 1998; Conner, 2000). Although regional and/or national research efforts in this area should be undertaken, resources limited the research efforts to West Virginia.

Purpose and Objectives

The purpose of the study was to describe agricultural education teachers' attitudes and knowledge of biotechnology issues in West Virginia. The following research questions provided direction for the study. (1) What were the attitudes of West Virginia's agricultural education teachers toward biotechnology? (2) What level of knowledge and understanding was demonstrated by agricultural education teachers in West Virginia regarding biotechnology? (3) What relationships existed between selected teacher demographic variables and biotechnology attitudes and knowledge levels?

Methods/Procedures

A descriptive survey research method was used to collect data from high school agricultural education instructors in West Virginia. Descriptive research asks questions about the nature, incidence, or distribution of variables; it involves describing but not manipulating variables" (Ary, Jacobs, & Razavieh, 2002, p. 558). It was the aim of this research to discover "what exists" in the areas of biotechnology among agricultural education teachers in West Virginia. A descriptive research design was appropriate for determining the knowledge level, attitudes, and implementation of the study population.

Population of the Study

The population for the study included the 95 agricultural education teachers employed in West Virginia during the 2000-2001 school year. The population frame was established using the West Virginia secondary agriculture teacher directory. Because of the small number in the target population, a census was used, therefore, the target population became the accessible population.

Instrumentation

An existing instrument previously used in North Carolina was modified for the investigation (Kirby, 1990). The questionnaire was developed according to recommendations by Dillman (2000) and organized into two major sections. Section I focused on the perceived level of knowledge and attitudes that teachers possess concerning biotechnology issues and teaching biotechnology. The final section requested demographic information of the participants including years of experience and highest degree held.

The revised instrument was presented to a panel of experts consisting of teacher educators at West Virginia University to establish content and face validity. A panel of teachers serving on the West Virginia Program and Policy committee was used to pilot test the instrument. They were administered the questionnaire and the data were used to establish the instrument's reliability. The reliability of the three constructs: knowledge of biotechnology issues, attitudes toward biotechnology, and responsibilities of agricultural education teachers relative to biotechnology was found to be exemplary at .89, .85, and .88 respectively (Robinson, Shaver, & Wrightsman, 1991). Because the instrument was found to be reliable and the researchers desired a census of the entire population of teachers, the data collected during the pilot test was included in the final analysis.

Data Collection

Dillman's (2000) suggestions for constructing survey instruments, cover letters, and follow-up strategies were implemented. A survey with cover letter was mailed to each of the agricultural education teachers in the state. A stamped, self-addressed envelope was provided for return of the instrument. A follow-up letter was sent two weeks after the original to remind those who had not yet responded that their cooperation was essential. Ary et al. (2002) recommend three options "to determine the extent to which respondents differ from the nonrespondents" (p. 408). The authors utilized option two and compared late respondents to early respondents. No significant differences were found between responses of early and late respondents on knowledge of biotechnology (F = .165) attitudes toward biotechnology (F = 1.069) and teacher responsibilities (F = .086). Since differences were not found between early and late respondents, "and late respondents are believed typical of nonrespondents," then the researchers assumed "the respondents were "an unbiased sample of the recipients" and thus generalized to the total group (Ary et al., 2002, p. 408).

Analysis of Data

Data were analyzed using SPSS 11.0 for Windows. Descriptive analyses appropriate for the respective scale of measurement were performed on the data including measures of central tendency (mean, median, or mode) and variability (frequencies or standard deviation). Appropriate measures of association (Pearson product moment correlation, Phi, Cramers V, Kendall tau B, Kendall's tau C) were also used to examine relationships between selected teacher demographic variables and biotechnology attitudes and knowledge levels. A Chi-square test was used to compare nominal and ordinal level variables.

Results/Findings

Demographics of the Sample Group

Information was received from 62 teachers (65.3%). Of the teachers reporting, the mean for years taught was 16. The highest degree earned included 31 (50%) respondents with a B.S. degree, 29 (46.8%) held a M.S. degree, and 1 (1.6%) held a Ph.D.

Level of Biotechnology Knowledge

The responses to 18 Likert items were combined and averaged to establish a summated score for agricultural education teachers' knowledge of biotechnological issues. Teachers were asked to rate their knowledge of each of the 18 biotechnology topics using a 4 point Likert scale (1 = no knowledge, 2 = heard about, but very little knowledge, 3 = read about, possess some knowledge, and 4 = applied, knowledgeable). Descriptive data on the items contained in the summated knowledge score were reported in Table 1.

Animal reproduction was the only topic that a majority of the agricultural education teachers (73.7%) perceived themselves as having "applied knowledge." Approximately one-third of the respondents indicated "applied knowledge" on growth hormones (36.2%), hybridization (35.1%), resistant plant species (25.9%), and plant tissue culture (29.1%). Between 10 and 20 percent of the teachers had "applied knowledge" of biotechnology ethics (19.4%), cloning (15.0%), genetically modified food (15.0%), genetic engineering (13.6%), microbial biotechnology (12.1%), electrophoresis (11.9%), food biotechnology (10.0%), and environmental biotechnology (10.0%). Less than 10 percent of the respondents indicated "applied knowledge" about gene splicing (8.3%), recombinant DNA (8.3%), transgenic species (5.4%), human genomics (3.5%), and bioremediation (3.3%).

Table 1
Agricultural Education Teachers' Knowledge of Biotechnology Issues

	No Knowledge		Little Knowledge		Some Knowledge		Knowledgeable	
Topics	*f*	%	*f*	%	*f*	%	*f*	%
Animal Reproduction	1	1.8	2	3.5	12	21.1	42	73.7
Growth Hormones (bST/pST)	2	3.4	9	15.5	26	44.8	21	36.2
Hybridization	5	8.8	9	15.8	23	40.4	20	35.1
Plant Tissue Culture	4	7.3	9	16.4	26	47.3	16	29.1
Resistant plant species	2	3.4	11	19.0	30	51.7	15	25.9
Biotechnology Ethics	1	1.6	14	22.6	30	48.4	12	19.4
Cloning	2	3.3	11	18.3	38	63.3	9	15.0
Genetically modified food	4	6.7	11	18.3	36	60.0	9	15.0
Genetic Engineering	2	3.4	15	25.4	34	57.6	8	13.6
Microbial Biotechnology	11	19.0	19	32.8	21	36.2	7	12.1
Electrophoresis	22	37.3	19	32.2	11	18.6	7	11.9
Food Biotechnology	9	15.0	11	18.3	34	56.7	6	10.0
Environmental Biotech.	8	13.3	14	23.3	32	53.3	6	10.0
Gene Splicing	4	6.7	23	38.3	28	46.7	5	8.3
Recombinant DNA	12	20.0	18	30.0	25	41.7	5	8.3
Transgenic species	12	21.4	26	46.4	15	26.8	3	5.4
Human Genomics	14	24.6	25	43.9	16	28.1	2	3.5
Bioremediation	30	50.0	22	36.7	6	10.0	2	3.3

Scale: 1 = No knowledge, 2 = Heard about, but very little knowledge, 3 = Read about, possess some knowledge, 4 = Applied, knowledgeable

Using the four-point Likert scale, the average summated score for the knowledge of biotechnological issues construct was 2.58 with a standard deviation of .63. Agricultural education teachers who responded to the questionnaire possessed some knowledge of biotechnological issues. A Pearson product moment coefficient of correlation was calculated to determine if a relationship existed between years of teaching experience and knowledge of biotechnological issues. The relationship (r = .027) was not significant.

The interval scale data for the knowledge of biotechnological issues construct was forced into an ordinal measurement scale (Elifson, Runyon & Haber, 1982) to examine the relationships between the construct and highest degree held. The following scale was used: 3.5 – 4 (knowledgeable), 2.5 – 3.49 (some knowledge), 1.5 – 2.49 (little knowledge), and < 1.5 (no knowledge). A Chi-square test revealed no significance difference in knowledge of biotechnological issues between Bachelor of Science degree holders (χ =3.00, df = 3) and Master of Science degree holders (χ =1.867, df = 3).

Attitudes toward Biotechnology

Teachers were asked to express their attitudes toward 10 biotechnology topics using a 4 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree). The responses were combined and averaged to establish a summated score for agricultural education teachers' attitudes toward biotechnological issues. Descriptive data on the individual items contained in the summated attitude score are included in Table 2.

Table 2
Agricultural Education Teachers' Attitudes toward Biotechnology Issues

	Strongly Disagree		Disagree		Agree		Strongly Agree	
Topics	*f*	%	*f*	%	*f*	%	*f*	%
Cross breeding to produce hybrids is not morally wrong.	4	6.5	13	21.0	16	25.8	29	46.8
Biotechnology should be a topic in an agriscience class.	1	1.6	5	8.2	31	50.8	24	39.3
I believe that local, state, & federal money should be used to enhance the teaching of biotechnology.	1	1.6	5	8.1	36	58.1	20	32.3
I support the genetic engineering of feed crops.	3	4.8	10	16.1	29	46.8	20	32.3
I support biotechnology for environmental purposes.	0	0.0	6	9.8	36	59.0	19	31.1
I support the use of biotechnology for human medicine.	4	6.5	11	17.7	28	45.2	19	30.6
I support the genetic engineering of food crops.	3	4.8	13	21.0	29	46.8	17	27.4
Biotechnology should be taught by AG-ED Teachers.	2	3.2	9	14.5	36	58.1	15	24.2
I support the genetic engineering of animals.	3	4.8	18	29.0	29	46.8	12	19.4
Cloning living organisms is not morally wrong.	6	9.8	10	16.4	38	62.3	7	11.5

Scale: 4 = Strongly agree, 3 = Agree, 2 = Disagree, 1 = Strongly disagree

Over two-thirds of the respondents agreed (agree or strongly agree) with each of the 10 attitudinal statements. Over ninety percent of the respondents agreed that "biotechnology should be a topic in an agriscience class" (90.3%), "local, state, and federal money should be spent to enhance the teaching of biotechnology" (90.2%), and "genetic engineering of feed crops should be supported" (90.2%). The agreement for the other items included: "support the use of biotechnology for environmental purposes" (82.3%), "support the use of biotechnology for human medicine" (79.0%), "support the genetic engineering of food crops" (75.8%), "biotechnology should be a class taught by AG-ED teachers" (74.2%), "support the genetic engineering of animals" (73.8%), "crossbreeding to produce hybrids is not morally wrong" (72.6%), and "cloning living organisms is not morally wrong" (66.1%).

Using a four-point Likert scale, the average summated score for the attitudes toward biotechnological issues construct was 2.92 with a standard deviation of .47. Agricultural education teachers who responded to the questionnaire possessed a positive attitude toward biotechnological issues. A Pearson product moment coefficient of correlation was calculated to determine if a relationship existed between years of teaching experience and knowledge of biotechnological issues. The relationship (r = -.037) was not significant.

The interval data for attitudes toward biotechnological issues construct was forced into an ordinal measurement scale (Elifson et al., 1982) to examine the relationships between the construct and highest degree held. The following scale was used: 3.5 – 4 (strongly agree), 2.5 – 3.49 (agree), 1.5 – 2.49 (disagree), and < 1.5 (strongly disagree). A Chi-square test revealed no significance difference in attitudes toward biotechnological issues between Bachelor of Science degree holders (χ = 2.191, df = 3) and Master of Science degree holders (χ = 1.941, df = 3).

Biotechnology Issues and Teacher Responsibilities

Teachers were asked the relationship between their job responsibilities and biotechnology issues. The responses to 10 Likert items were combined and averaged to establish a summated score for agricultural education teachers' biotechnological job responsibilities. Teachers rated their agreement on the topics using a 4 point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree). Descriptive data on the individual items contained in the summated knowledge score are reported in Table 3.

Table 3
Agricultural Education Teachers' Responses to: "It is the job of agricultural education teachers to…"

	Strongly Disagree		Disagree		Agree		Strongly Agree	
Topics	*f*	*%*	*f*	*%*	*f*	*%*	*f*	*%*
Teach high school students about biotechnology	1	1.6	5	8.1	45	72.6	11	17.7
Educate farmers/agriculturists about biotechnology	1	1.6	10	16.1	43	69.4	8	12.9
Educate public policy makers about biotechnology	2	3.2	21	33.9	33	53.2	6	9.7
Develop biotechnology instructional materials	1	1.6	10	16.1	46	74.2	5	8.1
Distribute publications about biotechnology	6	9.7	25	40.3	26	41.9	5	8.1
Involve students in biotechnology related SAE's	1	1.6	9	14.5	48	77.4	4	6.5
Educate consumers about biotechnology	4	6.5	25	40.3	29	46.8	4	6.5
Sponsor meetings related to biotechnology	2	3.2	37	59.7	19	30.6	4	6.5
Conduct biotechnology research	10	16.1	29	46.8	20	32.3	3	4.8
Develop publications about biotechnology	7	11.3	37	59.7	16	25.8	2	3.2

Scale: 4 = Strongly agree, 3 = Agree, 2 = Disagree, 1 = Strongly disagree

Over eighty percent of the respondents agreed (agree or strongly agree) with four of the job responsibilities. The responsibilities included: teach high school students about biotechnology (90.3%), involve students in biotechnology related SAE's (83.9%), educate farmers and agriculturists about biotechnology (82.9%), and develop biotechnology instructional materials (82.3%). A majority of the respondents agreed with an additional three responsibilities including: educate public policy makers about biotechnology (62.9%), educate consumers about biotechnology (53.2%), and distribute publications about biotechnology (50.0%). A majority of the respondents failed to agree on three responsibilities including: sponsor meetings related to biotechnology (37.1%), conduct biotechnology research (37.1%), and distribute publications about biotechnology (29.0%).

Using a four-point Likert scale, the average summated score for the agricultural education teachers' responsibilities toward biotechnological issues construct was 2.64 with a standard deviation of .46. Agricultural education teachers who responded to the questionnaire indicated they had responsibilities related to biotechnological issues. A Pearson product moment coefficient of correlation was calculated to determine if a relationship existed between years of teaching experience and knowledge of biotechnological issues. The relationship (r = .090) was not significant.

The interval scale variable, responsibilities toward biotechnological issues, was forced into an ordinal measurement scale (Elifson, Runyon & Haber, 1982) to examine the relationships between the construct and highest degree held. The following scale was used: 3.5 – 4 (strongly agree), 2.5 – 3.49 (agree), 1.5 – 2.49 (disagree), and < 1.5 (strongly disagree). A Chi-square test revealed no significance difference in attitudes toward biotechnological issues between Bachelor of

Science degree holders (χ = 1.407, df = 3) and Master of Science degree holders (χ = 4.037, df = 3).

Conclusion/Recommendations

Conclusions

Agricultural education teachers in West Virginia had limited knowledge of biotechnology topics. This finding was consistent with the work of Wilson et al. (2002). Teachers perceived themselves as having more knowledge of biotechnology topics that have traditionally been associated with agriculture (animal reproduction, hybridization) and less knowledge on topics that are associated with other fields (environmental biotechnology, human genomics).

Agricultural education teachers in the target population were split on their attitudes about biotechnological issues. They agreed that biotechnology issues had a place in the high school classroom and the agricultural industry. The overall support dissipated as the "extremes" of biotechnology were introduced.

Agricultural education teachers in the target population were split over their role in biotechnology issues. Teachers agreed that it was their role to educate their high school and adult students, develop biotechnology instruction materials, and educate policy makers and consumers. They were not as strong in their support of sponsoring meetings, conducting research, and developing publications on biotechnology issues.

Recommendations

Recommendation 1. State supervisors and agricultural education faculty in West Virginia should provide training for all agriculture science teachers on biotechnological content materials and infusing the content into agriscience curricula. This could be accomplished through in-service trainings, grants, workshops, and other incentives.

Recommendation 2. Agricultural education faculty should examine the agriculture content portion of the preservice education to determine if appropriate knowledge of biotechnological topics is included. If the preservice education is deficient, agricultural education faculty should change the preservice requirements and/or work with their College of Agriculture peers to insure that new teachers entering the teaching profession have adequate knowledge of biotechnology issues.

Recommendation 3. State supervisors and agricultural education faculty should make available, through purchase or development, curriculum resources on biotechnological topics. In addition to inservice training, curriculum materials on biotechnology should be purchased and made available directly to the local programs and/or through a loan program at the state curriculum materials center.

Recommendation 4. This study should be replicated on a region and/or national basis. If the profession is going to meet the National Academy of Sciences challenge, the research must be expanded to a national scope.

Recommendation 5. A study should be completed to determine the support from state supervisors and other key stakeholders to include biotechnology issues in the current agricultural education curriculum. Without the support of state supervisors and other key stakeholders, all efforts to incorporate biotechnology into the agriscience curricula will fail.

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