AGRICULTURAL SCIENCE TEACHERS' BARRIERS, ROLES, AND INFORMATION SOURCE PREFERENCES FOR TEACHING BIOTECHNOLOGY TOPICS

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

Abstract

The purpose of this study was to determine barriers, roles, and information source preferences for teaching agricultural biotechnology topics. Agricultural science teachers were described primarily as 37 year-old males who had taught for 12 years, had bachelor's degrees, and had lived or worked on a farm or ranch. Equipment was perceived as the only major barrier to teaching biotechnology. Administration acceptance and community support were considered minor barriers. Teachers acknowledged responsibilities for educating consumers, farmers, and students about biotechnology and involving students in biotechnology-related SAE projects. Teachers disagreed that it was their role to develop instructional materials and lesson plans on biotechnology. Workshops, video tapes, and the Internet constituted teachers' preferred biotechnology information sources. No significant relationships were found between years of teaching experience (teachers with 15 or more years and teachers with less than 15 years of teaching experience) and perceived barriers, beliefs, or information sources. Similarities between teachers allows for new strategies to be shared among all teachers, without a need for tailoring materials to specific teacher age groups.

Introduction

Biotechnology is at the forefront of agriculture, allowing the industry to make remarkable strides in producing a high quality food product at a reduced cost, with less negative impact on the environment (Johnson, 1999). Most agricultural educators would agree that biotechnology is by far the most innovative technology we have seen in agriculture in the last 100 years. Why then are secondary agricultural science students not being taught more biotechnology topics in the agricultural science classroom? Most would agree also that the determining factor in classroom content is the individual agricultural science teacher. So, why are teachers not teaching more biotechnology as part of the agricultural science curriculum?

Paired with the importance of biotechnology to our industry is increasing pressure to teach more science fundamentals throughout the secondary curriculum. High stakes testing, along with long-term career success of our students, should be motivation enough to incorporate more biotechnology into the agricultural science curriculum; however, observational reports suggest that teachers are not teaching or incorporating these principles into their existing curriculum. There is widespread agreement that agricultural science teachers in secondary schools need to integrate more science into their agricultural education curriculum, not only to improve the academic content of their courses, but also to adequately prepare their students for diverse careers available in the area of science and technology (Sikinyi & Martin, 2002). Thompson and Balschweid (2000) suggested that agricultural science teachers collaborate with science teachers to integrate science into the agricultural science curriculum. They further suggested that an added benefit of this model is that students enrolled in science courses may gain additional information and understanding of agriculture.

The public has varying degrees of understanding and information concerning agricultural biotechnology. Individuals who are unfamiliar with or uneducated in the various aspects of agricultural biotechnology have a tendency to fear many biotechnological developments (Reese & Arrington, 1993). Community-wide education is necessary to combat fear of the unfamiliar. "Agricultural education is the premier vehicle for contextualized teaching and learning within any community setting", and should be meeting "both the demands of the agriculture industry, as well as students" (Shelley-Tolbert, Conroy, & Dailey, 2000, p. 60).

Kirby (2002) concluded that over the next 50 years, a very sophisticated science will impact agriculture. Students must understand the risks and benefits even if they are not directly involved in some of the processes. Kirby believed that through service learning, agricultural education students can impact public opinion about world hunger and the role of biotechnology in the food, fiber, and natural resource systems. Public perception and acceptance of agricultural biotechnologies will spur the success or failure of the agricultural biotechnology industry and product development (Reese & Arrington, 1993), therefore, agricultural science teachers "must be able to assess their environments and make necessary changes to meet the needs of their students and communities" (Shelley-Tolbert et al., 2000, p. 59). As voiced by Kirby, quality agricultural education programs respond to student, industry, and community needs. Those needs now span a global environment. Teachers and teacher educators must take steps to address this issue.

Studies show that agricultural educators have positive attitudes toward biotechnology, both personally and professionally, but indicate a need for incorporating biotechnological subject matter into classroom curricula (Hughes et al., 2001; Iverson, 1998). Wilson, Kirby, and Flowers (2002) found that agricultural educators in North Carolina correctly assessed their lack of adequate knowledge to successfully teach biotechnology concepts. Further study showed that agricultural educators who possess a high level of self-perceived knowledge and ability to teach biotechnology skills, issues, and content may be more willing to adopt the new curriculum (Wilson & Flowers, 2002). Iverson found that agricultural science teachers had more interest than knowledge about biotechnology, and both preservice and inservice education relating to biotechnology should be made available.

Educators may all agree on the integration of science concepts and the opportunities available through teaching biotechnology as part of the typical agricultural science curriculum; however, if teachers are not taking the initiative to teach these concepts, the benefits of biotechnology may be lost on students, and ultimately consumers. Therefore, it is important to examine teachers' perceptions of the barriers limiting the teaching of biotechnology, their beliefs about their roles in teaching biotechnology, and their information source preferences for learning about biotechnology.

Purpose and Objectives

The purpose of this study was to determine agricultural science teachers' barriers, roles, and information source preferences for teaching agricultural biotechnology topics. The objectives were to:

1. Determine agricultural science teachers' perceptions of barriers prohibiting the teaching of agricultural biotechnology topics.
2. Determine agricultural science teachers' beliefs about their roles in teaching agricultural biotechnology topics.
3. Determine agricultural science teachers' information source preferences for receiving biotechnology information.
4. Determine if relationships existed between agricultural science teachers' perceptions of barriers, roles, information source

preferences, and selected demographics.

Methods and Procedures

Descriptive survey methods with a correlational design were used in this study. 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 demographics, while explained fully in this study, are found in another paper (Mowen, Roberts, Wingenbach, & Harlin, 2007).

The population of interest was all agricultural science teachers in Texas (*N* = 1590). The sampling frame was derived from a convenience sample of teachers who attended the final session at the 2004 State Agricultural Science Teachers Conference (*n* = 964). Although not equivalent to random sampling, the researchers' opinion is aligned with Gall, Gall, and Borg (2003) who argued that "inferential statistics can be used [to generalize findings to the population] with data collected from a convenience sample if the sample is carefully conceptualized to represent a particular population" (p. 176). Based on previous knowledge of the population, the researchers believed the sample to be representative of the population of interest. Readers are encouraged to examine all data to make their own judgments.

All data collection occurred on August 5, 2005. A total of 274 responses were collected; however, incomplete data reduced the usable number of responses to 270. Given that data were collected using a one-shot approach, without an accurate list of those present, follow-up procedures with non-respondents was not possible. Therefore, nonresponse error, considered a threat to external validity, was handled by comparing respondents to the known population (Miller & Smith, 1983). Population data could not be found to make comparisons with the sample, but similar characteristics (gender, age, and race) between the sample and population were confirmed by teacher educators who all had more than 30 years experience with Texas agricultural science teachers.

A modified version of the instrument, *Attitudes, Knowledge, and Implementation of Biotechnology* (Hughes, 2001), was used to create the research instrument; wording changes, question sequencing, and layout constituted the modifications. Content and face validity were established (Hughes) previously by a panel of experts (teacher educators) at West Virginia University.

The instrument, *Agriculture Science Teachers' Attitudes and Implementation of Biotechnology*, contained three multi-part questions (for the results reported in this paper) measuring agricultural science teachers' perceived barriers to teaching biotechnology (four levels, nine barriers), beliefs about their roles in teaching biotechnology (four levels, ten items), and information source preferences (four levels, 14 items) for receiving agricultural biotechnology information. A final section of the instrument was used to collect demographic information.

Responses in the barriers scale (measuring agricultural science teachers' perceived barriers to teaching agricultural biotechnology topics) were recorded on a four-point (1 = Not at All, 2 = Minor, 3 = Moderate, or 4 = Major) Likert-type scale. An overall barrier score was needed to determine if a relationship existed between perceived barriers and other variables (role and/or selected demographics), hence the barriers scale was summed for additional data analyses. Reliability, as a measure of internal consistency, was administered to the summed barriers scale using Cronbach's alpha coefficient (Cronbach, 1951); the test revealed an alpha coefficient of .79, indicating the data set was reliable.

Selected agricultural science teachers reported their beliefs about their roles in teaching agricultural biotechnology topics. Respondents used a four-point (1 = Strongly Disagree…4 = Strongly Agree) Likert-type scale to record their agreement levels with ten belief statements that all began with, "*It is my job to…*" Sample concluding responses included: (a) conduct biotechnology research, (b) develop instructional materials and lesson plans on biotechnology, (c) educate consumers about biotechnology, and (d) involve students in biotechnology-related SAE projects. An overall teaching role belief score was needed to determine if relationships existed between role beliefs and other variables (barriers and/or selected demographics); the role belief scale was summed for additional data analyses. Cronbach's alpha coefficient (Cronbach, 1951) was applied to the summed role belief scale revealing an alpha coefficient of .91, indicating the summed data set was reliable.

Agricultural science teachers indicated their agreement levels to 14 information source preferences, which all began with, "*I prefer to receive biotechnology information from…*" Respondents used a four-point (1 = Strongly Disagree…4 = Strongly Agree) Likert-type scale to record their responses. Sample information sources included (a) agricultural magazines, (b) CD-ROMs, (c) Cooperative Extension Service, and (d) other agricultural science teachers. An overall information source preference score was needed to determine if relationships existed between sources and selected demographics; the information source scale was summed for additional data analyses. Cronbach's alpha coefficient (Cronbach, 1951) was applied to the summed information source scale revealing an alpha coefficient of .86, indicating the data set was reliable.

The demographic section contained seven questions pertaining to education level, age, years of agricultural 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.

For the purpose of this study, agricultural science teachers were divided into two groups based upon their years of experience in teaching agricultural science. The groups consisted of teachers with 15 or more years of teaching experience and teachers with less than 15 years of teaching experience. The rationale for this decision stemmed 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 semester-based courses 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 taught agricultural science classes only under the current curriculum model. Teachers with 15 or more years of experience have taught agriscience classes in the prior format of Ag I, II, III, and IV, and with the current curriculum model. If relationships existed between teaching experience and teachers' beliefs, perceptions of barriers, or preferences of information sources on biotechnology, it was expected to occur within the years of teaching experience sub-groups.

Descriptive statistics were derived for each section and the instrument as a whole. Demographic data were analyzed using percentages and frequencies. Significant relationships between selected variables were examined using bivariate analyses; a significance level of .05 was established *a priori*.

Findings

A total of 274 agricultural science teachers responded to the questionnaire. Two hundred eleven respondents were male (78%) and 59 were female (22%). Four respondents did not identify their gender. Respondents' ages ranged from 21 to 64 years. The average age of the participants was 37.4 years (SD = 11.04). Teaching experience ranged from 0 to 38 years with an average of 12.3 years (SD = 10.08) in teaching agricultural science classes.

When respondents were asked to classify their scientific knowledge as low, average, or high, 208 respondents (77.3%) indicated that their scientific knowledge was average. Twenty-one teachers indicated their scientific knowledge was low (7.8%) and 40 (14.9%) stated that their scientific knowledge was high. One hundred seventy-nine respondents indicated they had Bachelor's degrees (66.8%), while 88 (32.8%) had Master's degrees, and one person indicated he/she had a Doctorate (.4%) at the time of this study. Thirty percent of respondents specified that they had attended a biotechnology class or workshop since graduating from college. Ninety-one percent of the participants indicated they had lived or worked on a farm or ranch.

Objective 1

Teachers were provided a list of potential barriers (Table 1) and asked to indicate their perceived barriers to teaching agricultural biotechnology topics using a four-point (1 = Not at All, 2 = Minor, 3 = Moderate, or 4 = Major) Likert-type scale. Equipment was perceived as the only major barrier to teaching biotechnology (*M* = 3.54, *SD* = .78). Six factors were considered moderate barriers with mean ratings from 2.51to 3.50. Administration acceptance (*M* = 2.29, *SD* = .89) and community (*M* = 2.18, *SD* = .89) were considered minor (*M* = 1.51-2.50) barriers.

Table 1
Barriers Related to Teaching Biotechnology (N = 274)

Barriers	*M*	*SD*
Equipment	3.54	.78
Classroom/Lab Space	3.26	.90
Time	3.11	.86
Instructional materials	3.10	.89
Textbooks	3.06	.91
Teacher Knowledge	2.72	.83
Students' Academic Ability	2.70	.85
Administration Acceptance	2.29	.89
Community	2.18	.89

Note. Scale: 1 = Not at All, 2 = Minor, 3 = Moderate, 4 = Major

Objective 2

Teachers were given a list of ten roles and asked to indicate their level of agreement (Table 2) that each role was part of their job responsibility as a teacher. Participants agreed that it was their job to educate consumers about biotechnology (*M* = 2.58, *SD* = .76), educate farmers and agriculturalists about biotechnology (*M* = 2.66, *SD* = .75), involve students in biotechnology-related SAE's (*M* = 2.78, *SD* = .69), and teach high school students about biotechnology (*M* = 2.99, *SD* = .66). Participants disagreed that the remaining six jobs were their responsibility.

Table 2
Beliefs About Job Responsibilities Related to Biotechnology (N = 274)

Belief Statements It is my job to:	*M*	*SD*
Teach high school students about biotechnology	2.99	.66
Involve students in biotechnology related SAE's	2.78	.69
Educate farmers and agriculturalists about biotechnology	2.66	.75
Educate consumers about biotechnology	2.58	.76
Educate public policy makers about biotechnology	2.39	.79
Sponsor meetings related to biotechnology	2.23	.74
Develop instructional materials and lesson plans on biotechnology	2.22	.76
Distribute publications about biotechnology	2.16	.81
Conduct biotechnology research	1.88	.72
Develop publications about biotechnology	1.77	.66

Note. Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree

Objective 3

Given a list of 14 information sources, teachers were asked to indicate their level of agreement that each item was a preferred source of information for them (Table 3). Teachers agreed that every source listed was a source they preferred for receiving biotechnology information. Workshops received the highest agreement level (M = 3.19, SD = .60), followed by video tapes (M = 3.10, SD = .56), and Internet (M = 3.09, SD = .56). The lowest agreement levels were for newspapers (M = 2.70, SD = .69) and slide sets (M = 2.61, SD = .73). Sources were divided into three types: print, technology-based sources, and face-to-face. When means were recalculated, there were no significantly greater preferences for one source type over another.

Table 3
Participating Teachers' Agreement with Biotechnology Information Source Preferences (N = 274)

Sources I prefer to receive biotechnology information from…	*M*	*SD*
Print Sources:	14.54	2.18
Lesson Plans	3.02	.63
Textbooks	3.00	.58
Agricultural Magazines	2.97	.57
Scientific Journals	2.83	.73
Newspapers	2.70	.69
Technology-based Sources:	11.85	1.80
Video Tapes	3.10	.56
Internet	3.09	.56
CD-ROMS	3.07	.68
Slide Sets	2.61	.73
Face-to-Face Sources:	14.87	2.30
Workshops	3.19	.60
Other Agricultural Science Teachers	2.96	.56
University Professors	2.93	.69
University Courses	2.90	.73
Cooperative Extension Service	2.86	.64

Note. Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree

Objective 4

Teachers were divided into groups based on years of teaching experience; 171 teachers (62.4%) had taught for less than 15 years. The remaining 98 teachers (36.4%) had 15 years or more of teaching experience. Relationships between interval-type variables were reported as Pearson correlation coefficients, while relationships between ordinal and interval variables were reported as Spearman rho correlations (Hinkle, Wiersma, & Jurs, 1994). Relationships were described using the standards established by Davis (1971).

No significant relationships were found between teachers' perceived barriers to teaching biotechnology or beliefs about their roles for teaching biotechnology when correlated with teaching experience (Table 4). However, significant low associations occurred between teachers' beliefs about their roles and print- and technology-based sources. A significant moderate association occurred between teachers' beliefs about their roles and face-to-face sources. As expected, significant substantial associations occurred between the three types of sources for biotechnology information.

Table 4
Relationships Between Agricultural Science Teachers' Barriers, Roles, Information Source Preferences and Years of Teaching Experience (N = 274)

Variables	1[a]	2	3	4	5	6
1. Years of Teaching Experience[a]	1.00	.01	-.04	-.05	-.03	-.10
2. Barriers[b]		1.00	-.08	-.02	.00	.05
3. Roles[c]			1.00	.29*	.21*	.31*
4. Print Sources[d]				1.00	.60*	.63*
5. Technology-based Sources[d]					1.00	.53*
6. Face-to-Face Sources[d]						1.00

Note. Four-point Likert-type scales for each section were summed to determine agricultural science teachers' overall perceived barriers, roles, and information source preferences.
[a]Years of teaching experience were categorized as teachers with 15 or more years of experience versus teachers with less than 15 years of experience; Ordinal variables were reported as Spearman rho correlation coefficients.
[b]Barriers to teaching biotechnology scores ranged from 11-36; Interval variables were reported as Pearson correlation coefficients.
[c]Beliefs about roles in teaching biotechnology ranged from 9-40; Interval variables were reported as Pearson correlation coefficients.
[d]Information source preferences ranged from 3-20; Interval variables were reported as Pearson correlation coefficients.
$*p < 0.05$

Conclusions and Recommendations

Objective one was to determine agricultural science teachers' perceptions of barriers prohibiting the teaching of agricultural biotechnology topics. Findings indicated that the major perceived barrier for this group of respondents was a lack of necessary equipment. Administration acceptance and community support were considered minor barriers. When helping this group of teachers incorporate more biotechnology into their classrooms, it is important to focus on ways to acquire necessary equipment. Thompson and Balschweid (2000) cited similar barriers to teaching more science in the agricultural science curriculum. Are agricultural science classrooms outdated in comparison to science classrooms at the same schools? Additional research may help agricultural educators at all levels understand the complex relationship between science/biotechnology curriculum integration and public support for the appropriate equipment necessary for teaching those concepts.

If teachers had appropriate equipment and materials for teaching biotechnology, would they incorporate it into their existing curriculum? Thompson and Balschweid (2000) suggested that collaboration with science teachers may prove successful in reducing these barriers. Pragmatically, it would be most helpful to identify the type of equipment and specific teaching materials that are most beneficial for teaching biotechnology in secondary agricultural science courses. These questions certainly warrant additional study.

Objective two of this study was to determine agricultural science teachers' beliefs about their roles in teaching agricultural biotechnology topics.

Respondents acknowledged responsibilities for educating consumers, farmers, and students about biotechnology, and for involving students in biotechnology-related SAE projects; a congruency shared with Kirby's (2002) work. Their disagreement with other roles (e.g., educating public policy makers, sponsoring biotechnology meetings, distributing biotechnology publications, or conducting biotechnology research) indicated a perceived immediate role as biotechnology information source providers in their local communities, but they did not feel pressured into more proactive roles. This finding is disconcerting, given the widely accepted notion that all citizens are responsible for the rearing/educating of future generations (U.S. Department of Education, n.d.). The authors believe more research is needed to determine if agricultural science teachers lack confidence in their roles as community leaders (e.g., educating public policy makers about biotechnology topics), or lack sufficient biotechnology knowledge to adequately educate others (policymakers, opinion leaders, non-agricultural groups, etc.) to form unbiased opinions about biotechnology and its impact on communities nationwide.

Objective three was to determine agricultural science teachers' information source preferences for receiving biotechnology information. Findings indicated that all of the listed information sources were acceptable, but teachers preferred workshops, video tapes, and the Internet more so than other sources. Coincidently, they disagreed that it was their role to develop instructional materials and lesson plans on biotechnology, indicating an expectation of ready-made biotechnology resources for their classrooms. Their information source preferences can be capitalized upon by attracting teachers to new and more information about biotechnology through ready-made instructional materials. This finding concurs with those of Thompson and Balschweid (2000) who suggested multiple methods for providing information (from collaboration to inservice, and workshops) in order to help teachers feel more comfortable integrating science into the curriculum. Also, there was clear indication that instructional material providers should seek out biotechnology experts who can assist with developing user-friendly biotechnology materials for agricultural science classrooms.

Objective four was to determine if relationships existed between agricultural science teachers' perceptions of barriers, roles, information source preferences, and selected demographics. Teachers were sorted into two groups based on their years of teaching experience. Perceived barriers, roles, and information source preferences of teachers with 15 or more years of teaching experience were compared to those of teachers with less than 15 years of teaching experience. No significant relationships existed between teaching experience and barrier perceptions, beliefs, or information source preferences. These findings indicate that all teachers were interested in technology-based information sources, and face-to-face and print sources. Teachers also had similar feelings about their roles in teaching biotechnology and the barriers prohibiting their teaching of biotechnology topics. When developing biotechnology curriculum, it is possible to target all teachers with the same materials because of their similar information source preferences.

The similarities between teacher sub-groups, when considering their perceived barriers, roles in teaching others about biotechnology, and preferred information sources, allows for new strategies to be shared equally, without the need for creating educational materials for specific teacher sub-groups; a particularly salient point when budget constraints mandate greater efficiency in public education at all levels. Many states now place greater emphasis on teaching current science-related topics in public schools. Stakeholder groups, particularly vociferous parents, may always challenge agricultural science teachers to provide the most current, up-to-date curricula for their sons and daughters. The researchers would be remiss to negate the findings about preferred information sources for biotechnology and agricultural science teachers' beliefs about their roles for teaching biotechnology to others.

It is recommended that this study be replicated with a true random sample at state, regional, and national levels to gain further insights into agricultural science teachers' perceptions of barriers, roles, and information sources for teaching biotechnology-related topics. First, a true random sample may reveal differences in perceived barriers, teaching roles, and/or preferred information sources, dependent upon population densities. Do urban-based programs have greater inclusion of current agricultural topics (viz., biotechnology) in their curricula, or is such a condition found in rural-based programs? What effect do population density, media coverage, and stakeholder groups have on local agricultural science program curricula? Second, educators and school administrators at the state, regional, and national levels may have differing opinions on the importance of teaching biotechnology-related topics in local programs. What effects would those opinions have on the inclusion of current agricultural science topics in our local programs? Do those opinions affect state and/or national financial support of local agricultural science programs? There are many avenues of continued and important investigation for this topic.

References

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*, 297-334.

Davis, J. A. (1971). *Elementary survey analysis*. Englewood Cliffs, NJ: Prentice-Hall.

Gall, M. D., Gall, J. P., & Borg, W. R. (2003). *Educational research: An introduction* (7th ed.). Boston: Allyn and Bacon.

Hinkle, D., Wiersma, W., & Jurs, S. (1994). *Applied statistics for the behavioral sciences*. Boston: Houghton Mifflin.

Hughes, J. E. (2001). Attitudes, knowledge, and implementation of biotechnology and agriscience by West Virginia agricultural education teachers. *Master's Abstract International, 40*(1), 16. (UMI 1404634)

Hughes, J. E., Boone, H. N., Gartin, S. A., Odell, K. S., Lawrence, L. D., & Dailey, R. A. (2001). Attitudes and knowledge of biotechnology by West Virginia agricultural education teachers. *55th Annual AAAE Eastern Research Conference Proceedings*, 55.

Iverson, M. J. (1998). *Assessing information sources on biotechnology used by teachers of agriculture in the public schools—A tri-state study.* Paper presented at the annual meeting of the Southern Association of Agricultural Scientists Agricultural Communications Section, Little Rock, AR.

Johnson, B. (1999). *Genetically modified crops and other organisms: Implications for agricultural sustainability and biodiversity.* Paper presented at the Agricultural Biotechnology and the Poor Conference, Washington, D.C.

Kirby, B. M. (2002). Science in the agriculture education curriculum. *The Agricultural Education Magazine, 74*(5), 4.

Miller, L. E., & Smith, K. L. (1983). Handling nonresponse issues. *Journal of Extension, 21,* 45-50.

Mowen, D. L., Roberts, T. G., Wingenbach, G. J., & Harlin, J. F. (2007). Agricultural science teachers' biotechnology knowledge and attitudes. *Journal of Agricultural Education, 48*(1), 42-51.

Reese, P., & Arrington, L. (1993). Perceptions of agricultural biotechnology and potential effects on agricultural education. *Proceedings of the Annual Southern Regional Education Research Meeting*, 225- 233.

Shelley-Tolbert, C. A., Conroy, C. A., & Dailey, A. L. (2000). The move to agriscience and its impact on teacher education in agriculture. *Journal of Agricultural Education. 41*(4), 51-61.

Sikinyi, T., & Martin, R. A. (2002). Biosciences enliven the agricultural education curriculum. *The Agricultural Education Magazine, 74*(5), 8-9.

Texas Education Agency. (1968). *Basic curriculum for vocational agriculture in Texas production agriculture*. Austin, Texas: Author.

Texas Education Agency. (1987). *Basic curriculum for new semester courses in agricultural science & technology*. Austin, Texas: Author.

Thompson, G. W., & Balschweid, M. A. (2000). Integrating science into agriculture programs: Implications for addressing state standards and teacher preparation programs. *Journal of Agricultural Education, 41*(2), 73-80.

U.S. Department of Education. (n.d.). *Archived Information: Sec. 102. National Education Goals*. Retrieved November 22, 2005, from http://www.ed.gov/legislation/GOALS2000/TheAct/sec102.html

Wilson, E. & Flowers, J. (2002). Secondary educators' confidence in teaching agricultural biotechnology after training. J*ournalof Natural Resources and Life Sciences Education. 31*, 131-135.

Wilson, E., Kirby, B., & Flowers, J. (2002). Factors influencing the intent of North Carolina agricultural educators to adopt agricultural biotechnology curriculum. *Journal of Agricultural Education. 43*(1), 69-81.

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

GARY J. WINGENBACH is an Associate Professor in the Department of Agricultural Leadership, Education, and Communications at Texas A&M University, MS 2116, 218 Scoates Hall, College Station, TX 77843-2116. E-mail: g-wingenbach@tamu.edu.

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

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