A Research-Based Process to Improve Science Skills of Teacher Education in Agriculture Program Graduates

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Abstract

Quality teacher education programs must ensure that their graduates have competence in both the content that they plan to teach and supporting content. For secondary agriculture teachers, the range of supporting content is great; however, many teachers believe that what they teach is more relevant to science than other academic subjects (Conroy & Walker, 2000; Johnson, 1996a; Johnson, 1996b). Teacher education in agriculture programs may find it difficult to suggest or require additional science coursework given the already crowded courses of study that must be completed for graduation and certification in most states. In addition, there is no certainty that additional science courses will result in the type of understanding needed by the agriculture teacher in order to provide relevant and meaningful science instruction, and to promote transfer of learning. Application of science principles through technical agriculture coursework and instruction may be a better approach to provide teacher education in agriculture program graduates with maximum instruction and reinforcement of basic science skills. This National Science Foundation study consisted of a series of interviews with representatives of the academic departments in the College of Agriculture and Life Sciences at Cornell University. The intent of the interviews was to engage in discussions with faculty in the various departments about which courses offered in their respective departments would provide maximum instruction and reinforcement of science basic skills, and to solicit their input on other changes that may be needed to the program requirements. Results of the interviews have been used to develop a set of program options, with core courses in four or five areas that vary depending on the option. The resulting options should enable program graduates to not only meet the needs for improved science instruction, but to also be more responsive to emerging industry and workplace needs.

As a process, the interviews and subsequent discussions, as well as the analysis of the results yielded several benefits. First, it will be easier for program graduates to be dual certified in agriculture and one of the sciences beyond general science. This will make them more marketable, particularly in rural areas of the state. Second, we believe the availability of options in food science, environmental science, business/marketing, agriscience, and engineering will increase the likelihood of recruitment of majors in related departments into the certification program. A third and most important benefit of the process has been the development of relationships across campus that were previously not in place. Not only will this improve recruitment, but it can provide additional resources for program implementation in the future.

Introduction and Theoretical Framework

It is as important for teachers to possess subject matter to “teach with” as it is for them to know the subject(s) they will teach. According to the National Council for Accreditation of Teacher Education (NCATE) Standards, a quality teacher education program will ensure that candidates attain both the "academic competence in the content that they plan to teach" and "theoretical and practical knowledge" through studies, courses, and experiences in the liberal arts and sciences (NCATE, 1997, p. 16). The content available in and supportive of the teaching specialty seems to be endless, but there are criteria for selection that relate to the content that is taught in the schools as well as content that will extend and enrich meaning (Cruickshank, 1985). This notion is especially important for agricultural education with the increasing emphasis placed on integration of science and mathematics in the agriculture curriculum (Conroy, 1997); Johnson, 1966a; Johnson, 1996b). Johnson (1996a) and Conroy and Walker (2000) also found that many agriculture teachers do not feel academically prepared to teach science and mathematics skills. The question of how to enhance the preparation of preservice teachers is not one that is easily addressed.

In 1988, the National Research Council recommended several important changes to teacher education in agriculture in order to ensure an "adequate supply of teachers with the broader range of interests and teaching skills that may be needed in future agriculture courses of the type recommended in [its report]" (NRC, 1988, p. 47). Several of the Council's recommendations were related to the content that should be required for certification to teach agriculture:

- Strengthen instruction in science, technology, economics, agribusiness marketing and management, international agriculture, and public policy.
- New methods to teach agribusiness marketing and management, principles of science, public policy, and international agriculture.
- Formal linkages with colleges of agriculture and education to develop new inservice programs and to establish better links with colleagues in other colleges such as experts in science education, etc.

Conroy (1997) found that, while many agriculture teacher preparation programs agreed with the recommendations, few were doing much to incorporate them. A follow-up study conducted in 1998-99 revealed that teacher educators recognized that reforms in the preservice curriculum were needed in order to ensure that program graduates are able to meet the demands of the future (Conroy & Kelsey, 2000). These demands include more science-based instruction in school-based agriculture programs.

<u>Science Education Reforms Relevant to Agricultural Education</u>

Reform activities in science education have focused on Piaget's theories of children's natural development processes and how children structure knowledge. In the constructivist classroom setting, instructional activities generate spontaneous interests that encourage children to structure new knowledge as a natural extension of knowledge they already possess. This contrasts to traditional teaching methods of unloading "adult-organized content" onto children, which can even occur in situations of well-intentioned laboratory exercises or problem-solving activities (Kamii & DeVries, 1993; Sarason, 1993). Central to the ability of teachers to facilitate the "knowledge as construction" science classroom is a deep understanding of the subject matter being addressed (Cohen, 1990). These important changes in science education methodology and their requisite of content understanding cannot be ignored by teacher education in agriculture faculty, particularly when approximately 34% of agriculture teachers, nationwide, stated they teach at least one course for science credit (Dormody, 1993).

According to Tetenbaum and Mulkeen (1986), the foci for improvement of teaching and teachers has been on salaries, career structures, standards, and evaluation, rather than teacher preparation. Even though such noted educational researchers as Boyer (1983), Darling-Hammond (1984), and Goodlad (1984) concluded that teacher education programs were inadequate, their structure and content has remained largely unchanged since World War II (Tetenbaum & Mulkeen, 1986). Specific to teacher education in agriculture, Conroy's 1997 research showed that programs had made few, if any, changes to their requirements during the 10 years following the publication of the National Research Council's recommendations in 1988. Tetenbaum and Mulkeen (1986) also stated that political leaders have chosen to promote routes to alternative certification rather than tackle the problems in teacher education. While proponents of these alternative routes believe they will attract more quality people into teaching, opponents are adamant that this "back door" approach will expose children to persons well prepared in academic specialties, but who lack fundamental understandings of learning theories, teaching methods, or the important interpersonal dimensions unique to teaching (Dunne & Hannah, 1985). The emerging shortage of secondary agriculture teachers makes this problem an important one for the profession to address.

In summary, research on teacher education strongly supports both pedagogical competency and a high level of knowledge in a content area. With the current emphasis on agriscience education, secondary agriculture teachers will need to demonstrate an understanding of the fundamental science and mathematics principles that undergird modern agricultural practices in order for them to teach for understanding in their classrooms. This understanding will require more than a simple facts-based knowledge set (Cohen, 1990; Conroy, 1999). In his book, The Case for Change: Rethinking the Preparation of Educators, Seymour Sarason (1993) contrasted *reforms* in education, which are primarily focused on changes in administrative and teacher behaviors, to *prevention*, which is focused on a notion of cause and effect. In other words, according to Sarason (1993), if you really want to improve education in the long term, you must improve how teachers are prepared.

Statement of the Problem

Prior to this study, preservice students enrolled in Cornell's Teacher Education in Agriculture Program [now the Teacher Education in Agriculture, Mathematics and Science Program (TEAMS)] were required to earn a minimum of 36 semester credits in technical agriculture for certification to teach in New York State. All students completed a core of courses that included a minimum of six credits in each of four areas: Agricultural, Resource and Managerial Economics; Agricultural and Biological Engineering; Plant/Crops/Soil Science; and Animal Science. In addition, students earned a minimum of 12 additional credit hours in a specialty area. Course suggestions for the core were based on a review of the course catalog and the experience of the teacher education faculty, none of whom had taught secondary agriculture in the past 15 years. There was no knowledge of the actual technical agriculture or supporting science content for any of the courses beyond what was listed in the course catalogs. Identifying science content supportive of the teaching of agriculture and ways to better incorporate it into the preservice curriculum could help ensure that graduates are prepared to extend and enrich the meaning of the agriculture content presented to their students.

Purpose and Objectives

This study was part of a larger research project funded by the National Science Foundation to investigate the processes and procedures for integration of the Teacher Education in Agriculture and the Teacher Education in Science and Mathematics programs at Cornell University. The purpose of this portion of the study was to develop and implement a procedure that would enhance the science competencies of graduates of the newly formed TEAMS Program at Cornell. This was accomplished through meeting the following objectives: 1) Determine which courses offered by the College of Agriculture and Life Sciences could provide instruction and/or reinforcement in basic science skills, and 2) Restructure the preservice program core technical agriculture requirements to ensure that students would have maximum exposure to instruction and reinforcement in key supporting mathematics and science content. A third objective was to provide a critique of this process as a model of a research-based process to reform preservice teacher education in agriculture to improve the science skills of graduates.

Methods and Procedures

This study employed both quantitative and qualitative techniques—gathering descriptive information, two focus groups, and individual interviews (Patton, 1990)—and was conducted in three phases. Phase I (Objective 1) involved the development of a list of basic skill taxonomies for science modified from those published by the University of Arizona in 1991. This phase also involved the validation of the taxonomies through use of a focus group of 17 secondary agriculture teachers. They were first asked to rate each skill as “High Need,” “Needed,” “Low Need,” or “Not Needed” to the instruction of agriculture at the secondary level. This activity was followed by a discussion of the taxonomies. The focus group participants were purposefully selected (Gall, Borg & Gall, 1996; Patton, 1990) due to their involvement with the National Council for Agricultural Education’s Reinventing Agricultural Education for the Year 2020 project in New York and the development of secondary program standards for agriculture programs in New York. All of them also taught courses for science credit in their respective schools, or were in the process of planning to do so. In addition, a group of seven preservice teachers enrolled at Cornell University completed the rating activity and participated in a follow-up focus group discussion. The extensive list of skills was collapsed into more broad categories, wherever possible, to reduce data but not eliminate any crucial content with resulting information utilized for Phase II.

Phase II (Objective 1) involved interviews conducted during the period April 1 through June 30, 1998, with 15 individuals representing 12 of the 15 academic departments in the College of Agriculture and Life Sciences at Cornell University. Two underlying assumptions guided this phase of the study. First, it was believed that adding more traditional science classes to the TEAMS program requirements (e.g., biochemistry, organic chemistry) would not necessarily provide agriculture teacher education students with the proper instruction and reinforcement of supporting content. Second, it was also believed that, due to their applied nature, the best source for the supporting science content would be courses offered within the academic departments of the College of Agriculture and Life Sciences.

Department Chairs in each department of the College were contacted, provided an overview of the purpose of the project, and asked to recommend individuals who would be most knowledgeable about the content of courses in the respective departments. The recommended individuals were contacted by e-mail, advised of the purpose of the project, and asked for an appointment time for an interview. All but three agreed to participate. The interview protocol consisted of a series of activities lasting approximately 90 minutes. First, interviewees were given an overview of agricultural education in the public schools and the teacher education program at Cornell University. They were then provided with a modified version of the basic skill taxonomies representing broad science knowledge areas and asked to identify courses in their respective departments in which these areas were either taught or reinforced. They were also asked to indicate if it was assumed that students would enter their courses already having mastered certain basic skills. Third, they were provided with a copy of the technical agriculture requirements for certification at the time of the study and asked to comment about any listed courses.

The interviews were concluded with the interviewees' summaries of the courses offered by their departments that would help graduates of the teacher education program attain both agriculture content and enhance their acquisition of supporting science content. All interviews were audiotaped, transcribed, summarized, and analyzed using guidelines for analysis of qualitative interview data (Gall, Borg & Gall, 1996; Seidman, 1991). Interviewees were provided with written summaries of the information they provided and asked to review and comment on its accuracy. Further reliability was ensured through triangulation of the data relative to general comments about the teacher education program and cross-member checks. Phase III (Objective 2) consisted of the development of preservice teacher education in agriculture requirements and options that would meet the needs for enhanced science content based on the survey and interview results. Objective 3 will be addressed throughout the Results, Conclusions, and Implications sections.

Results and Discussion

Of the 488 basic science skills, 89 (18.2%) were rated by participants as "High Need", 259 (53.1%) were rated as being "Needed," 140 (28.7%) were rated as "Low Need," with none being rated as not needed. This summary of the rankings was calculated based on a minimum of 60% of Phase I participants placing a skill in any category. Those skills (348 total) ranked as highly needed or needed as a competence to teach agriculture as a science were considered appropriate for use with interviews with faculty in the academic departments of the College. The 348 skills were collapsed into seven broad categories (e.g., classifies, describes/explains) with content specific sub-categories for discussion purposes.

Academic participants included individuals housed in the following departments: Agricultural, Resource and Managerial Economics (ARME); Agricultural and Biological Engineering (ABEN); Animal Science; Biometrics; Communications; Floriculture; Food Science; Fruit and Vegetable Science; Natural Resources; Plant Breeding; Rural Sociology; and Soils, Crops, and Atmospheric Sciences (SCAS). The results of the interviews are presented in two sections: 1) General Observations, and 2) Observations about Current Program Requirements.

General Observations

Of the 15 persons interviewed, all but two were extremely helpful and interested in what we were trying to do. The two individuals who presented a "challenge" were persons involved in departments heavily focused on laboratory research with little involvement in undergraduate instruction. They also expressed concern that the University was offering what they considered to be "vocational courses in agriculture such as mechanics and floral design." These individuals also raised questions as to why it was so important to "look at process and methods in teacher education and preparation" instead of focusing on technical agriculture content. Of the 15 persons interviewed, only two had worked with individuals in the Education Department and those individuals were also the most knowledgeable about secondary agriculture programming in New York.

Use of the science skill taxonomies presented a challenge for individuals involved in some of the social science areas. The use of the taxonomies also led to some unique observations by individuals in the technical agriculture fields. Aside from the obvious lack of "soft skills" in the list, there were challenges presented by the interpretation of the science terminology, but individuals seemed to enjoy "massaging" the terms to fit within their own paradigm. For example, the two persons interviewed in ARME defined work as "labor, people, and management;" electricity as the "electrical utility industry;" and laboratory instruments as "computers." Individuals in Rural Sociology had a similar problem, but found the exercise to be interesting. The Horticulture faculty member considered a shovel to be a laboratory instrument, diseases were identified as plant diseases, and formulation of solutions was linked to hydroponics. It is important to note awareness of these issues on the part of the teacher education faculty assists in the development of instructional activities focused on how to plan for effective transfer of knowledge and skills (Cohen, 1990; Lee, 1996).

Only one major—Soils, Crops and Atmospheric Sciences—assumed that individuals entered their program with high levels of science knowledge, particularly chemistry. Faculty indicated that chemistry was a prerequisite for all but one course in the department. In a related discussion, most individuals stated that there was a great variation in mathematics competencies among the agriculture students and it was not unusual to have to review and reteach basic math skills in any given course offered within the department/major.

Observations about Current Program Requirements

Several courses required as part of the current core were identified as inappropriate for persons engaged in teaching a skill and/or for their relative science content. The Horticulture course suggested as an option under plant/soil sciences was viewed as too "basic" and not providing the hands-on experiences important for future teachers. The faculty from Animal Science stated that the production- and management-oriented classes recommended in the core were "okay, but not for someone interested in specializing in animal science." He recommended courses in animal biology, nutrition, and genetics to replace those in the current core and stressed the importance of the environment in relation to agriculture, recommending a three-course sequence for agricultural education students. The general consensus was that the production-oriented courses provided the hands-on occupational-type skills, but very little in terms of science instruction. Two individuals in ARME suggested that two courses in the current core should be deleted because of the pre-requisites; they also questioned the relevance of one suggested course for agricultural educators as it is heavily focused on economic theories. The discussions led to an awareness of a unique dilemma. For students who enter the program with little background in traditional agriculture production, how do they acquire the necessary occupational skills while also gaining the necessary science background to effectively design and implement a program of agriscience instruction?

One of the more interesting discussions involved the core requirements for two traditional mechanics courses—woodworking and metal fabrication. The ABEN faculty member's perception of these courses was that they were "taken by students mainly for fun" and lacked rigor and purpose. He did believe that they may be appropriate for a particular type of agriculture teacher in a community in which mechanics was still a needed a viable program offering, but questioned whether that was going to meet the needs of the industry as he sees it. He also suggested that one suggested course be deleted because of its high level of physics. This confusion about the basic purpose of agricultural education permeated the interviews and discussions. What is it (agricultural education)? Does/should it exist in the 21st century strictly to prepare workers for the agriculture industry, or does it—and can it—serve a much more broad purpose in the communities where secondary agriculture programs are housed?

The SCAS faculty member supported the current soils science core requirements, but several of the suggested electives were considered to contain very challenging mathematics. Three additional courses were suggested, all of which have chemistry prerequisites and assume computer literacy. The Plant Breeding faculty member was concerned that students were not required to take a course in plant breeding or genetics, and suggested two course offerings, both of which contain a lot of science instruction. She also suggested an introductory statistics class as necessary to the understanding of relevant research information.

Currently, rural sociology classes are not required in the core, but can substitute for one economics class. The Rural Sociology faculty member suggested several courses that he felt provided reinforcement in basic mathematics, but indicated that courses offered within his department did not address science skills in the "true sense." Several of the interviewees also made suggestions that a business mathematics class would be useful. The current core also does not include natural resources or environmental science classes. The individual from the Natural Resources department suggested a group of core courses that would be critical for an agricultural education student specializing in the environmental sciences. Four courses, in particular, were identified as courses that would provide the maximum instruction and reinforcement in the science basic skills from the taxonomies, with other suggestions to build breadth and depth of both science and the content area. The same process was effective when discussing Food Science courses. Individuals interested in a specialization could take a core of four courses that, like the environmental sciences, would maximize science reinforcement with advanced courses also suggested. All students enrolled in the Food Science major or minor must have chemistry, physics, and other science skills, as well as two semesters of calculus.

The Biometry and Statistics faculty member was interested in the project and had some working knowledge of the teacher education program. She stated she "is not convinced that agricultural education students need higher-level math classes" (beyond algebra and introductory calculus). Several interesting course suggestions came from this discussion, primarily focused on learning calculus in ecological modeling, case study approaches to learning, and statistical thinking. Communications faculty also believed they had some course offerings that are appropriate and should be required for agricultural education majors. These included courses in: writing public information, listening skills, leadership, newswriting, and science writing.

Results of Phase III

The original intended use for the results of the data analysis involved a redesign of the core requirements for technical agriculture for certification. It became clear; however, that the development of one set of core requirements with a multitude of course options might result in enhanced science and skills for program graduates, but might also lead to less depth within the content area. Further analysis of the interview data revealed that many of the faculty believed that the present and future job market would necessitate a move away from the traditional core areas of animal science, plant science, agricultural mechanics, and farm management. They saw the agricultural industry as something much more broad, with employment options in areas as diverse as genetic engineering and journalism. In order to address the depth issue, to provide focus for the program, and to think about meeting future industry needs, a decision was made to reconsider the generic core program beyond just its basic course requirements.

Program concentration options were created based on the information gleaned from the interviews: General Agriculture, Agricultural Science, Agricultural and Biological Engineering, Agricultural Business and Marketing, Environmental Science, and Food Science. Four to five core areas were maintained, depending on the option, but the courses in each area are now based on systems thinking (food processing and marketing are a large part of the agriculture industry in the region) and content needs for the particular concentration. As an example, the Food Science option will require the following course selections as outlined in Table 1. The preservice teacher who selects the Food Science option must also complete an additional 12 credit hours of Food Science coursework; two courses must be in sequence, and six hours must be at the 300-400 level. This contrasts to the information listed in Table 2 for the Agricultural and Biological Engineering option as another example. The ABEN option also requires 12 additional credits of concentration in Agricultural and Biological Engineering with the same requirements for depth.

Table 1.
Core Technical Agriculture Requirements for Food Science Option

Core area	# hours	Areas of emphasis or selection
Agricultural Resource and Managerial Economics (ARME)	3	Marketing
Agricultural and Biological Engineering (ABEN)	3	Science and technology of environmental management
Plant and soil sciences	4	Basic soil science
Animal science	4	Basic animal science
Food science	13-15	Introductory food science Science and technology of food processing Food choices and issues Food processing Product development Sensory evaluation of food Food chemistry

Table 2.
Core Technical Agriculture Requirements for Agricultural and Biological Engineering Option

Core area	# hours	Areas of emphasis or selection
Agricultural Resource/Managerial Economics (ARME)	3	Business management
Agricultural/Biological Engineering (ABEN)	12	Metal fabrication Wood construction Renewable energy systems Hydrology and the environment Aquaculture systems
Plant and soil sciences	4	Basic soil science
Animal science	4	Basic animal science
Agriculture and Natural Resources Management	3	Environmental conservation Natural resources management Demographic analysis Rural areas in metro society Concepts of product development (food science)

Pilot use of these options began in the Fall 1999 semester and will continue with the goal of ongoing discussions with members of the technical agriculture faculty. In addition, it is anticipated that the development of these options will improve our ability to recruit technical agriculture majors into education for the certification program. This is especially important given the impending shortage of qualified secondary agriculture teachers.

Conclusions and Implications

The results of this study cannot be generalized beyond the program under investigation, and it is left to the individual reader to determine if findings are applicable to his/her respective situation (Gall, Borg & Gall, 1996). For our purposes, we anticipate utilizing the new options for certification to teach agriculture as a guide for students in their course selection. We believe that students will have sufficient choices of courses within the options, especially for the 12 credits of specialization beyond the core. This will enable them to custom-design a program that will not only ensure their maximum preparedness to teach and reinforce basic science concepts, but to have a program that fits their needs and interests, as well.

One unintentional, yet desired benefit we believe will result from these changes is the tremendous potential for dual certification in agriculture and one of the sciences (biology, chemistry, physics, or earth science), which is relatively easy for students who are technical agriculture majors and pursuing education/certification as a minor or through electives. Further examination of the interview data reveals important information about the types of science courses required for majors in the various technical agriculture areas. Using the examples from Food Science above, the faculty member interviewed related that all students enrolled in a Food Science major or minor must take biology, chemistry, and physics, as well be competent in basic science (laboratory) skills. They must also take two semesters of college calculus. Just meeting the science requirements for the respective majors will result in students being well on their way to science certification in addition to agriculture.

Both the Food Science and ABEN faculty identified critical thinking and writing as important process skills for students enrolled in their programs who plan to enter industry employment after graduation, but felt they were also very important for agricultural education students enrolled in a teacher preparation program. The ABEN faculty member also had very strong opinions that future agricultural education students—regardless of their majors—should be exposed to the types of critical thinking about the environment in which students in his department frequently engage.

A Critique of the Process

The value of this process is three-fold. First, the goal of developing guidelines for technical agriculture course selection and program requirements that would ensure students have maximum instruction and reinforcement in science skills was accomplished to the extent that is possible within an applied area as diverse as agriculture. At the very least, the new options and course selection guidelines were developed through a knowledge- and research-based process that utilized input from the individuals with the most knowledge of course content within the individual departments. Having the discussions focused on basic skill instruction and reinforcement as opposed to specific occupational skills and content was useful. While it initially proved to be a difficult thing to do it ultimately became easier with practice and helped focus discussions on the more broad industry needs and generic process skills required of teachers. In a sense, the focus of the discussions turned from “teaching agriculture” to “teaching students.”

Second, the beginning of discussions between members of the agricultural education faculty and faculty in the academic departments will, we believe, have far-reaching benefits beyond meeting the goals of this study. Nearly all of the individuals interviewed have made subsequent contact with us to inquire about the results of our work, and several have requested follow-up discussions. Brochures and posters highlighting teaching opportunities and the newly designed teaching options have been distributed to all departments in the College. The next step should logically be the development of “minors” or “options” within the technical agriculture majors that would permit further collaboration and joint interactions of faculty and students. The ability to recruit more technical agriculture teachers will not only address the teacher shortage, but will help guarantee that future teachers possess the highest academic capabilities.

Third, while it is only prophetic at this point, we believe the potential to increase the numbers of individuals who are dual certified in both agriculture and one of the sciences (biology, chemistry, physics, or earth science) will help maintain and improve agricultural program offerings in rural areas. According to rural superintendents to whom we have spoken, they find these types of teachers to be very attractive to them. In situations where they cannot justify the employment of a second agriculture teacher, they might be able to hire someone to teach several agriculture courses in addition to working in the science department. The fact that the science certification is in an area of specialization beyond general science will also improve the agriscience instruction and legitimize those courses being offered for science credit in areas where disputes have arisen about the credibility of those courses. This may also serve to improve agriculture program offerings through availability of more in-depth agriscience courses and increase enrollments of higher achieving students in those courses.

Summary and Recommendations for Future Research

The process we undertook to examine our certification program requirements was useful as it led to not only a list of suggested courses which will help our graduates acquire better science knowledge and skills, but also to several other important outcomes. As outlined above, we have begun the process of establishing partners across the College who will assist us in the identification and recruitment of persons who show potential to be secondary agriculture teachers. The process we undertook was time-consuming but has already resulted in positive outcomes for our students, program, and our Department.

We are not certain how useful the science skill taxonomies were to the actual process, although they did, in fact, lead to several interesting discussions. It is recommended that, if this process is replicated, serious attention should be given to the best use, and procedures for use, of the taxonomies… or whether they are necessary to the discussions. In addition, we believe this process would be useful for teacher education programs in other content areas, or for non-certification programs, obviously using different sets of skills taxonomies or their equivalent.

The next step in the research process for us will be the design and implementation of a study to assess the impact of the changes we’ve made—to both the content and pedagogical requirements of our program. A portion of this study, sponsored by the National Science

Foundation, was begun in 1999, but much remains to be done in regards to assessing how the changes may actually improve science instruction in public school agriculture classrooms.

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A Research-Based Process to Improve Science Skills of Teacher Education in Agriculture Program Graduates

A Critique

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Contribution and Significance of Research

A casual content analysis of newspaper and television news will verify the importance of teacher preparation in the United States. Conroy and Trumbull have boldly ventured into a complex inquiry that has transformational implications for the preparation of teachers of agriculture. Accurate knowledge coupled with new methods and formal relationships shaped the basis of the teacher education design. The assumption that the approach should be anchored in constructivist principles was implicit in the premise.

Procedural Considerations

The authors purport to employ both quantitative and qualitative techniques. The three objectives focused on model building and restructuring the science and mathematics experiences in an agricultural teacher preparation program. The constructivists' research procedures engaged 15 faculty from twelve departments at Cornell University. Two of the 15 faculty acknowledged experience in working with the Education Department. The authors also judged these two faculty were "the most knowledgeable about secondary agriculture programming in New York" (p.5). Perhaps the insights from a group of "outside experts" would also be appropriate in the model building and restructuring process.

Questions for Consideration

How can the confusion about the basic purposes of agricultural education be reconciled?

How did the perceived philosophies of the faculty group influence the curriculum? Using an interpretive perspective, how do you reconcile value and worth among differing philosophies?

Given the purpose of the inquiry, what were the areas of consensus among the 17 secondary agriculture teachers and the twelve faculty?

Is 36 hours of technical agriculture adequate to develop a thorough understanding of science, mathematics, and agricultural science, given a bachelor's degree of 136 hours?

What methods will be used to assess the effect of the curriculum change on science instruction?

Should production tasks or science principles be used to create the curriculum framework? How does the constructivists design fit in the new framework?

What are the job opportunities and career implications for secondary agriculture teachers who select focused options, such as food science, as minors?