

Assessing Agriculture Teachers' Capacity for Teaching Science Integrated Process Skills

Brian E. Myers
Shannon G. Washburn
James E. Dyer
University of Florida

Abstract

Since the release of the National Research Council's (1988) report, research in agricultural education has examined a variety of aspects of the professions' propensity for, and attitudes toward integrating scientific concepts in agriculture. Yet, after 15 years of research on the topic, little has been shown empirically regarding agriculture teachers' knowledge or ability to teach using a science as inquiry approach. This study was conducted to establish a base level of information of agriculture teachers' knowledge and ability in scientific integrated process skills. A secondary purpose was to determine the influence of selected teacher variables on science integrated process skills. Bandura's (1997) self-efficacy theory formed the theoretical framework for the study. Okey and Dillashaw's (1980) Test of Integrated Process Skills was used to measure the knowledge of basic science concepts among 40 purposively sampled teachers of agriculture. The results indicated that irrespective of learning style, years of teaching experience, area of teacher certification, or gender, agriculture teachers possess a solid background knowledge in the integrated process skills espoused by science educators to be essential to effective science instruction. Implications for future research and recommendations for professional practice are included.

Introduction

In its report, *Understanding agriculture: New directions for education* (National Research Council, 1988), the Committee on Agricultural Education in Secondary Schools called for the expansion of agricultural education curriculum to include scientific subject matter. This expansion was not a call to completely abandon agricultural education's vocational past, but rather the report called for the "teaching of science through agriculture" (p. 5). Fifteen years later, in an era of high stakes testing and public accountability mandates for educational funding, Agricultural Education is finding itself in a critical position to prove its value. The future of agricultural education in the schools may rest on the need for empirical evidence to verify how agricultural education assists in student development in science and other academic subject areas.

An increased emphasis on integrated science in agricultural education is not solely a response to political pressure. The scientific literacy needs of individuals entering careers in agriculture are increasing in importance. Employees in today's job market need to know how to learn, reason, think creatively, make decisions, and solve problems. Science education and agriscience education can contribute in an essential way to the development of these skills in agricultural education students (National Academy of Science, 1996).

One response of the agricultural education profession has been to offer school graduation credit in science for agricultural education coursework. In a national study of agriculture teachers, Dormody (1993) found that 34% taught agriculture courses for science credit during the 1990-91 academic year. In 1995, Connors and Elliot recommended that "Local school boards should study the possibility of offering science credit for agriscience and natural resource classes that contain a significant amount of science objectives" (p. 62). While the trend to offer science credit for agriculture courses has grown steadily, Enderlin and Osborne's (1992, p. 43) caution is noteworthy; "In order for students to receive quality science instruction from an agriculture course taught by an agriculture instructor, a systematic statewide effort must be made to develop scientifically literate secondary agriculture instructors who are competent in inquiry learning techniques in science."

Although the need for an expanded science emphasis in the agricultural education curriculum is generally agreed upon, the ability of current agricultural educators to meet this challenge has not yet been fully examined. Chiasson and Burnett (2001) found that Louisiana agriscience students scored significantly higher on the science portions of the 11th grade state standardized test than did non-agriscience students. These findings would suggest that agriscience teachers in Louisiana have the capacity to help students make meaningful connections between agricultural and scientific concepts. Additional studies have examined the training agriscience teachers have received to prepare them to integrate scientific concepts (Thompson & Schumacher, 1998; Thompson & Balschweid, 2000; Johnson, 1996). The majority of studies in the area of agriscience however, have examined only teacher attitudes and perceptions toward science integration (Balschweid & Thompson, 1999; Connors & Elliot, 1994; Dyer & Osborne, 1999; Layfield, Minor, & Waldvogel, 2001; Newman & Johnson, 1993; Peasley & Henderson, 1992; Thompson, 1998; Thompson &

Balschweid, 1999; Welton, Harbstreet, & Borchers, 1994). Although attitudes and perceptions are important, one and a half decades after the National Council's call, the time is ripe for further investigation into agriculture teacher's capacity to deliver quality science based instruction.

Conceptual/Theoretical Framework

As the agricultural education profession works to expand its research base regarding teacher capacity to deliver scientific concepts effectively, the work completed in this area by our colleagues in science education should be examined. The science education literature states that shifting to an emphasis of active science learning requires a shift away from traditional teaching methods (National Academy of Science, 1996). The report by the American Association for the Advancement of Science (AAAS) titled *Science for All Americans* (1990) emphasized that the teaching of scientific concepts should be consistent with the nature of scientific inquiry. Furthermore, the *National Science Education Standards* (National Academy of Science, 1996) state that inquiry is central to learning science.

The process skill approach (Chiappetta & Koballa, 2002), a commonplace method in the science education literature, could be employed by agriculture teachers in the effort to teach science as inquiry. This approach focuses on teaching broadly transferable abilities that are appropriate to many science disciplines and are reflective of the behavior of scientists (Padilla, 1990). Chiappetta (1997) states, "the acquisition and frequent use of these skills can better equip students to solve problems, learn on their own, and appreciate science" (p. 24). The science process skills can be classified as either basic or integrated (see Table 1). The basic science process skills are designed to provide a foundation for learning the more complex integrated science process skills (Padilla, 1990). Examples of integrated science process skills include skills such as formulating hypotheses, operationally defining, controlling, and manipulating variables, planning investigations, and interpreting data (Livermore, 1964).

The study was framed theoretically on Bandura's Theory of Self-Efficacy (1997). Self-efficacy is a person's beliefs concerning their capabilities to organize and implement actions necessary to learn or perform behaviors at designated levels. Although a person's beliefs about their capabilities are not the same as their actual ability, they are closely related. If a person has a low self-efficacy regarding a certain task or concept, their performance in that area is expected to be low (Bandura, 1997). Conversely speaking, higher ability levels would tend to increase self-efficacy levels and as a result increase the level of performance.

A review of literature failed to identify research that has investigated the competency level of agriculture teachers in the area of integrated science process skill. This information is needed in order to better assess the capability of secondary school teachers of agriculture to integrate science content into the agricultural education curriculum. The findings from this study could be utilized by both university agriculture teacher educators and by state staff in agricultural education in the development of professional development activities regarding agriscience skill development.

Table 1.

Basic and Integrated Science Process Skills

Process Skill	Definition
Basic Skills	
Observing	Noting the properties of objects and situations using the five senses
Classifying	Relating objects and events according to their properties or attributes
Space/time relations	Visualizing and manipulating objects and events, dealing with shapes, time, distance, and speed
Using numbers	Using quantitative relationships
Measuring	Expressing the amount of an object or substance in quantitative terms
Inferring	Giving an explanation for a particular object or event
Predicting	Forecasting a future occurrence based on past observation or the extension of data
Integrated Skills	
Defining operationally	Developing statements that present concrete descriptions of an object or event by telling one what to do or observe
Formulating models	Constructing images, objects, or mathematical formulas to explain ideas
Controlling variables	Manipulating and controlling properties that relate to situations or events for the purpose of determining causation
Interpreting data	Arriving at explanations, inferences, or hypotheses from data that have been graphed or placed in a table
Hypothesizing	Stating a tentative generalization of observations or inferences that may be used to explain a relatively larger number of events but that is subject to immediate or eventual testing by one or more experiments
Experimenting	Testing a hypothesis through the manipulation and control of independent variables and noting the effects on a dependent variable; interpreting and presenting results in the form of a report that others can follow to replicate the experiment

Note: From Chiappetta, E. L., & Koballa, T. R., Jr. (2002). *Science instruction in the middle and secondary schools* (5th ed.). Upper Saddle River, N.J: Merrill Prentice Hall.

Purpose and Objectives

The primary purpose of the study was to establish a base level of information of agriculture teachers' knowledge and ability in scientific integrated process skills. The specific objectives guiding the study were to:

1. Assess and describe in-service agriculture teachers' knowledge level of integrated process skills.
2. Determine the influence of learning style on integrated process skill.

3. Determine the influence of number of years of teaching experience on integrated process skill.
4. Compare integrated process skill to area of teacher certification (agriculture or science).
5. Determine the influence of gender on integrated process skill.

Procedures

The population for this study was composed of middle school and high school agriculture teachers in a state offering an agriscience course to freshmen students. An accessible sample consisting of all agriculture teachers ($n=40$) who participated in one of three, two-day regional workshops titled “Integrating Science Skills in Agriculture” was used.

Three instruments were utilized for data collection. Okey and Dillashaw’s Test of Integrated Process Skills (TIPS) (1980) was administered at the beginning of the workshop. The TIPS instrument is a 36 question, multiple-choice exam developed to measure integrated process skills of secondary students along five objectives. Objectives addressed by the TIPS instrument included: identifying variables, identifying and stating hypotheses, operationally defining, designing investigations, and graphing and interpreting data. Reliability of the TIPS instrument was established by the authors (Dillashaw and Okey) and reported to be 0.89 (Cronbach’s α).

A second instrument, the Gregorc Style Delineator (Gregorc, 1982a) was administered to assess the preferred learning styles of each teacher. The Gregorc instrument separates learning styles into combinations of four categories: Concrete Sequential, Concrete Random, Abstract Sequential, and Abstract Random. Scores of 26 or higher indicate a general preferred learning style in a particular category. Individuals may exhibit preferences in one or more categories, or may not exhibit a preference for any of the categories.

The Gregorc Style Delineator is a standardized instrument that has been used in educational research for approximately 20 years (Gregorc, 1982a). The developer of the instrument established validity and reliability of the Delineator. Gregorc (1982b) reported internal consistency using standardized alphas ranging from .89 to .93. Stability was reported using test-retest correlation coefficients ranging from .85 to .88.

Additional data relevant to the study were collected from teachers’ responses on a researcher-developed instrument designed to collect demographic data, including years of teaching experience, gender, and primary teaching certification area. According to Campbell and Stanley (1963), reliability is not a threat on items ascertaining demographic information. Validity on the demographic instrument was determined using an expert panel of university agricultural education faculty, state agricultural education staff, and middle school and high school teachers. Usable responses were gathered from 38 teachers, for a response rate of 95%.

Findings

The first objective was to assess and describe in-service agriculture teachers' knowledge level of integrated process skills. This objective was addressed by assessing agriculture teachers' knowledge level on the five objectives addressed by the TIPS instrument (Okey and Dillshaw, 1980). Descriptive statistics were analyzed for the total exam as well as by objective. Results are presented in Table 2.

The mean overall score out of 36 total points possible on the TIPS instrument was 29, or 89% correct, with a range from 24 to 33 correct responses. Analysis of the results by objective reveals that agriculture teachers in the sample performed best on the objectives "designing investigations" and "identifying and stating hypotheses." The objective "graphing and interpreting data" had a mean correct response of four out of six possible questions, a 67% correct response rate.

Table 2.
Mean TIPS Scores by Objective (n = 38)

Objective	Total Possible	Minimum Correct	Maximum Correct	Mean Correct	S.D.	Percent Correct
Identifying variables	12	6	12	9.76	1.87	81.3
Identifying and stating hypotheses	9	6	9	7.89	0.95	87.7
Operationally defining	6	3	6	4.92	0.91	82.0
Designing investigations	3	1	3	2.66	0.53	88.7
Graphing and interpreting data	6	2	6	4.03	0.85	67.2
Total score	36	24	33	29.26	2.66	88.7

The second objective was to determine the influence of learning styles on integrated process skill. Teachers' learning styles were assessed using the Gregorc Style Delineator (Gregorc, 1982a). Differences among TIPS total score and learning style (as delineated by Gregorc's instrument) were determined using one-way analysis of variance using a .05 alpha level determined a priori. No significant differences were found between TIPS score and learning style. Results are presented in Table 3.

Table 3.
Analysis of Variance for TIPS Score by Learning Style

Learning Style	<i>df</i>	<i>F</i>	<i>p</i>
Concrete Sequential	9	1.55	.18
Abstract Sequential	9	0.43	.91
Abstract Random	9	0.56	.82
Concrete Random	9	0.51	.86

The third objective was to determine the influence of number of years of teaching experience on integrated process skill. Years of teaching experience was self-reported by research participants. Teachers were assigned to one of four categories based on years of experience as follows: zero to three years, four to nine years, ten to fourteen years and fifteen

to thirty years. Differences among TIPS total score and years of teaching experience were determined using a one-way analysis of variance using a .05 alpha level. As indicated in Table 4, no significant differences were found between TIPS score and years of teaching experience.

Table 4.

Analysis of Variance for TIPS Score by Years of Teaching Experience

Years of Experience	<i>df</i>	<i>F</i>	ρ
0 – 3	9	0.84	.58
4 – 9	9	0.94	.51
10-14	9	0.48	.87
15-30	9	1.52	.19

The fourth objective sought to compare integrated process skill to area of teacher certification (agriculture or science). Five of the study participants reported holding their primary teaching certificate in science education, and the remaining 33 were certified in agriculture. At the time of the study, all study participants were employed as full time teachers of agriculture. Results of a *t* test revealed no significant difference at the .05 alpha level, $\rho = .10$, in TIPS scores based on area of teaching certification.

The fifth and final objective was to describe the influence of gender on integrated process skill. Analysis of *t* test results revealed no significant difference in TIPS scores based on gender at the .05 alpha level, $\rho = .13$.

Conclusions

Science integrated process skills have been identified in the science education literature as an effective inquiry method of teaching science. While agricultural education has made the claim for years that science is an integrated component of agricultural education, few studies have examined agriculture teachers' level of scientific knowledge or their capacity for teaching scientific concepts. The primary purpose of the study was to establish a base level of information of agriculture teachers' knowledge and ability in scientific integrated process skills. A secondary purpose was to determine the influence of selected teacher variables on science integrated process skills.

The purposive sample of this study provided data on agriculture teachers with an expressed interest in integrating science into agriculture in their instruction. These teachers responded correctly to 89% of the questions on the Test of Integrated Process Skills and thereby exhibited a positive level of ability in integrated science knowledge. The conclusion can be drawn that either in their preparation, or in their professional development, the teachers in this study have acquired the requisite knowledge to perform and apply integrated process skills. While data are not available for a comparable cohort of science teachers, the findings of this study would suggest that the study participants have the knowledge required to instruct their students in the integrated process skills.

Based on what is known about learning styles (Gregorc, 1982a), one would assume that dominant concrete sequential and concrete random learners, as problem oriented people, would perform more proficiently in scientific concepts than would abstract random or concrete random learners. The findings of this study do not support this assumption. This could be the result of the relatively small degree of variance and the relatively high TIPS scores. Another possible conclusion is that individuals who perform well in science-related areas are drawn to agriculture due to the natural relationship between science and agriculture.

Anecdotal evidence would suggest that more recent college graduates would exhibit a higher level of proficiency in integrated science process skills than individuals further removed from the formal application of such skills in a college setting. Among the group of teachers in this study, no significant differences were found based on number of years of teaching experience. It can therefore be concluded that teachers in this study have either retained knowledge gained during their formal education, or that they have acquired and use knowledge of integrated process skills on a more regular basis.

Five of the teachers involved in the study earned their teaching certification in science before securing positions as teachers of agriculture. The remaining 33 held their primary teaching certificate in agriculture. In this time of nationwide shortages of agriculture teachers, this phenomenon is not unique. Often concern is expressed as to the level of preparedness of secondary area certification teachers to offer courses in agriculture. Conversely, members of the science education community can be skeptical of the preparation of agriculture teachers to offer science credit for agriscience courses. Using integrated process skill as the measure, no differences appear to exist between the two groups. The conclusion can be reached that teachers certified in both science and agriculture have the propensity for teaching science as inquiry, as measured by the Test of Integrated Process Skills.

Although anecdotal evidence suggests that males have a higher level of achievement in science-related areas than do females, this study did not support that assertion. Based upon the TIPS scores of the 15 females and 23 males who participated in the study, it can be concluded that no differences exist in integrated science process skills based upon the gender of the teachers.

Irrespective of learning style, years of teaching experience, area of teacher certification (science or agriculture), or gender, and based upon the results of this study, it can be concluded that agriculture teachers in this study possess a solid foundation in the integrated process skills espoused to be essential to effective science instruction.

Implications

Since the release of the National Research Council's (1988) report, *Understanding Agriculture: New Directions for Education*, research in agricultural education has examined a variety of aspects of the professions' propensity for, and attitudes toward integrating scientific concepts in agriculture. Yet, after 15 years of research on the topic, little has been

shown empirically regarding agriculture teachers' knowledge or ability to teach using a science as inquiry approach. This study was conducted in an attempt to begin an examination of a seldom-researched phenomenon.

The implications of the study are primarily for further research as the sample size and purposive nature of the sample studied prohibit generalization of the findings beyond the sample. Nevertheless, the study verified that agriculture teachers with an expressed interest in science have appropriate levels of knowledge to teach scientific concepts. The research base strongly supports a positive attitude within the profession toward the integration of science in agriculture (Balschweid & Thompson, 1999; Connors & Elliot, 1994; Dyer & Osborne, 1999; Layfield, Minor, & Waldvogel, 2001; Newman & Johnson, 1993; Peasley & Henderson, 1992; Thompson, 1998; Thompson & Balschweid, 1999; Welton, Harbstreet, & Borchers, 1994). Bandura's theory of self-efficacy suggests that interest and knowledge are likely indicators for positive performance. Future research is warranted to determine whether the theory is supported relative to integrated science in agriculture.

Additional research along these lines has the potential to support or refute the continuation of the trend to offer agriculture courses for science credit. Furthermore, questions related to science teachers offering agriculture courses for science credit are increasing in frequency. This study neither supports nor denies the notion that teachers trained in science or agriculture are capable of teaching in areas outside their primary certification area. Additional inquiry into the frequency of teacher application of these concepts in teaching situations would further develop the knowledge base relative to the appropriateness of agriculture teachers offering science credit.

Recommendations

Pre-service agriculture teacher preparation programs are in a unique position to contribute to the science concept knowledge and performance of agriculture teachers. If not already being done, effective science instruction methods should be infused into agriculture teaching methods courses as a way to bolster the scientific rigor of future agriculture teachers and simply to enhance their effectiveness.

In areas where science credit for agriscience courses is common, in-service teacher education programming should emphasize the importance of integrated process skills in the infusion of science into agriculture. Furthermore, agriculture teachers offering science credit should be equipped with the latest information regarding outcomes measured on standardized exams in science and encouraged to infuse those outcomes into their curricula.

Agriscience curriculum development projects should reflect accurate and appropriate scientific concepts to provide the theoretical reinforcement for agricultural concepts. In addition, curricular activities should promote active learning that incorporates integrated process skills into the daily routine of agricultural education students.

Generalization of these findings is limited because of the clinical nature of this study and the small purposive, accessible sample. Further research is needed to understand the phenomena under study and to attempt generalization through replication of findings.

References

- American Association for the Advancement of Science. (1990). *Science for All Americans*. New York: Oxford University Press.
- Balschweid, M., & Thompson, G. (1999). *Integrating science in agricultural education: Attitudes of Indiana agricultural science and business teachers*. Paper presented at the 26th Annual National Agricultural Education Research Conference, Orlando, FL.
- Bandura, A. (1997). Self-efficacy. *Harvard Mental Health Letter*, 13(9), 4(3).
- Campbell, D. T., & Stanley, J. C. (1963). *Experimental and Quasi-Experimental Designs for Research*. Boston: Houghton Mifflin.
- Chiappetta, E. L. (1997). Inquiry-based science. *The Science Teacher*, 22-26.
- Chiappetta, E. L., & Koballa, T. R., Jr. (2002). *Science instruction in the middle and secondary schools* (5th ed.). Upper Saddle River, N.J: Merrill Prentice Hall.
- Chiasson, T. C., & Burnett, M. F. (2001). The influence of enrollment in agriscience courses on the science achievement of high school students. *Journal of Agricultural Education*, 42(1), 61-71.
- Connors, J. J., & Elliot, J. (1994). The influence of agriscience and natural resources curriculum on students' science achievement scores. *Journal of Agricultural Education*, 36(3), 57-63.
- Connors, J. J., & Elliot, J. (1995). Teacher perceptions of agriscience and natural resources curriculum. *Journal of Agricultural Education*, 35(4), 15-19.
- Dillashaw, F. G., & Okey, J. R. (1980). Test of integrated process skills for secondary science students. *Science Education*, 64(5), 601-608.
- Dormody, T. J. (1993). Science credentialing and science credit in secondary school agricultural education. *Journal of Agricultural Education*, 34(2), 63-70.
- Dyer, J. E., & Osborne, E. W. (1999). The influence of science applications in agriculture courses on attitudes of Illinois guidance counselors at model student-teaching centers. *Journal of Agricultural Education*, 40(4), 57-66.

- Enderlin, K. J., & Osborne, E. W. (1992). *Student achievement, attitudes, and thinking skill attainment in an integrated science/agriculture course*. Paper presented at the 19th Annual National Agricultural Education Research Meeting, St. Louis, MO.
- Gregorc, A. F. (1982a). *An adult's guide to style*. Columbia, CT: Gregorc Associates, Inc.
- Gregorc, A. F. (1982b). *Gregorc style delineator: Development, technical and administration manual*. Columbia, CT: Gregorc Associates, Inc.
- Johnson, D. M. (1996). Science credit for agriculture: Perceived support, preferred implementation methods and teacher science course work. *Journal of Agricultural Education*, 37(1), 22-30.
- Layfield, K. D., Minor, V. C., & Waldvogel, J. A. (2001). *Integrating science into agricultural education: A survey of South Carolina teachers' perceptions*. Paper presented at the 28th Annual National Agricultural Education Research Conference, New Orleans, LA.
- Livermore, A. H. (1964). The process approach of the AAAS Commission of Science Education. *Journal of Research in Science Teaching*, 2, 271-282.
- National Academy of Science. (1996). *National science education standards*. Washington, DC: National Academy Press.
- National Research Council. (1988). *Understanding agriculture: New directions for education*. Washington, DC: Committee on Agricultural Education in Secondary Schools, Board of Agriculture.
- Newman, M. E., & Johnson, D. M. (1993). Perceptions of Mississippi secondary agriculture teachers concerning pilot agriscience courses. *Journal of Agricultural Education*, 34(3), 49-58.
- Padilla, M. J. (1990). The science process skills. *Research Matters - to the Science Teacher*(9004).
- Peasley, D. D., & Henderson, J. L. (1992). Agriscience curriculum in Ohio agricultural education: Teacher utilization, attitudes, and knowledge. *Journal of Agricultural Education*, 33(1), 37-45.
- Thompson, G. (1998). Implications of integrating science in secondary agricultural education programs. *Journal of Agricultural Education*, 39(4), 76-85.
- Thompson, G. W., & Balschweid, M. M. (2000). Integrating science into agriculture programs: Implications for addressing state standards and teacher preparation programs. *Journal of Agricultural Education*, 41(2), 73-80.

Thompson, G. W., & Balschweid, M. M. (1999). Attitudes of Oregon agricultural science and technology teachers toward integrating science. *Journal of Agricultural Education*, 40(3), 21-29.

Thompson, G. W., & Schumacher, L. G. (1998). Selected characteristics of the National FFA Organization's agriscience teacher of the year award winners and their agriscience programs. *Journal of Agricultural Education*, 39(2), 50-60.

Welton, R. F., Harbstreet, S., & Borchers, C. (1994). *The development of an innovative model to enhance the knowledge and skill levels in basic sciences for secondary agriscience teachers*. Paper presented at the 21st Annual National Agricultural Education Research Meeting, Dallas, TX.