ASSESSING MISSISSIPPI AEST TEACHERS' CAPACITY FOR TEACHING SCIENCE INTEGRATED PROCESS SKILLS

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Abstract

The purpose of this study was to determine AEST teachers' capacity to teach science integrated process skills. Twenty teachers attending a summer workshop completed three instruments to assess their capacity to teach integrated process skills, determine their preferred learning styles, and determine their confidence (self-efficacy) to teach science. Overall, AEST teachers exhibited a satisfactory level of ability in their capacity to teach integrated process skills. AEST teachers also had a high self-efficacy as far as their capacity to teach science concepts to their students. While AEST teachers preferred to learn through reflection, through the use of visuals, through sequential activities, and by sensing, those teachers that were reflective learners had a higher capacity to teach science integrated process skills than those teachers who were active learners.

Introduction

The pressure of increased state standards in education, particularly in science, has generated concern among many agricultural educators leading to the re-evaluation of the local high school agricultural education curriculum. Increased high school graduation requirements have put pressure on these programs by limiting opportunities for students to enroll in elective courses. Furthermore, because of the increased demand for improved science education, new and innovative methods of presenting scientific materials have been sought out and implemented in public schools throughout the nation (Connors & Elliot, 1995).

There is also a need to make today's society more scientifically literate. Project 2061 (American Association for the Advancement of Science (AAAS), 1989) defined scientific literacy as the connection among ideas in the natural and social sciences, mathematics, and technology. Many jobs require workers to know and apply math and science concepts to be able to properly fulfill the duties set before them. To make students more scientifically literate, more academic subjects must be joined together to give students more knowledge of the world (National Research Council (NRC), 1988). Integrating science and agriculture was one way to help students become more literate.

In 1988 the report *Understanding Agriculture: New Directions for Education* concluded that there was a need for scientific subject matter to be integrated into the agricultural education curriculum (NRC, 1988). While some agricultural educators have attempted to incorporate more science into their courses, others have been reluctant to change traditional agriculture programs because of the belief that too much science would threaten the program (Whent, 1992). However, research findings (Chiasson & Burnett, 2001; Thompson & Balschweid, 2000) have supported the claim that integration of science into the agriculture curricula was a more effective way to teach science.

The agricultural education profession has responded to societal pressures by offering courses in which students could earn science credit towards high school graduation. While many states are starting to offer more agriculture courses for elective science credit (Dormody, 1993; Connors & Elliott, 1995), there is a concern about the not only the quality of such courses, but also with the preparation of agriculture teachers teaching such courses. Enderlin and Osborne (1992) commented that "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 teachers who are competent in inquiring learning techniques in science" (p. 42).

Many benefits exist for integrating science concepts into the agricultural education curricula. Students taught by integrating agriculture and scientific principles have demonstrated higher achievement than did students taught by traditional approaches (Chiasson & Burnett, 2001; Roegge & Russell, 1990). Educators hoped that integrating science into vocational programs would not only help students acquire more options and achieve higher state standards, but that it would support the growth in the vocational classes as well (Thompson & Balschweid, 2000). The importance of integrating science into vocational courses would help students retain knowledge and utilize complex problem-solving skills learned through analysis and application (Connors & Elliot, 1994). The American Association for the Advancement of Sciences (1993) recommended that what students learn in school should be connected through interdisciplinary links, real-world connections and connections to the world of work.

Agriscience teachers have positive attitudes towards integrating science into agriculture classes. Balschweid and Thompson (2002) found that most agriculture teachers were prepared to integrate biological and physical science concepts into agriculture, but that lessons required more preparation than before they integrate scientific concepts into the curriculum. Thompson (1998) found that agriscience teachers believed that integrating science into curriculum assists students in better understanding science concepts and their applications to agriculture. Balschweid and Thompson (2002) also found that teachers thought students were better prepared in science after they completed an agricultural education course that integrated science.

The fact that the integration of science and agriculture helps students expand their knowledge motivates most teachers to work at integrating the two subjects into their curriculum (Balschweid & Thompson, 2002). Thompson (1998) concluded that agriscience teachers perceived that program enrollment could increase as agriscience teachers integrate more science into their curriculum. Teachers listed increased program credibility as an important benefit for integrating science into programs. This supported findings made by Johnson (1995) that offering science credit for agriculture courses would increase enrollment, benefit students, and enhance program image.

If high school students are to gain more knowledge in science through the completion of agricultural education classes, and if theses classes are to count as elective science credits towards high school graduation, then agriscience teachers must help students to achieve these skills. Furthermore, agriscience teachers must possess these science skills themselves and be confident in their ability to teach science concepts if they are to be successful in preparing students to be more scientifically literate.

Mississippi has been leading the charge in promoting the integration of science into high school agriculture courses through a program called Agricultural and Environmental Science and Technology (AEST). This program consists of one introductory course called Concepts of Agriscience Technology, four specialized elective courses (Science of Agricultural Plants, Science of Agricultural Animals, Science of Agricultural Environments, and Science of Agricultural Mechanization), and a capstone course in Agribusiness. Schools having an AEST program offer two of the four specialized courses based on local needs. It is possible for students to earn up to three elective science credits upon completing AEST courses, depending on which courses a local school offers. This will allow student to earn more science credits not only towards high school graduation, but towards entrance in a state university in thus Southern state.

Conceptual and Theoretical Framework

The conceptual framework for this study was based in the process skill approach (Chiappetta & Koballa, 2002) that stresses the acquisition of investigative skills that are often associated with scientific inquiry. Process skills are defined as a set of broadly transferable abilities that are appropriate to many science disciplines and reflective of the behavior of scientists (Padilla, 1990). Process skills can be either basic or integrated. Basic process skills include observing, inferring, measuring, communicating, classifying, and predicting. Such basic skills help provide a foundation for integrated process skills. Integrated process skills, the primary focus of this study, include controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models (Padilla, 1990). These skills and their definitions are presented in Table 1.

Two theoretical frameworks were used in this study. One theoretical framework was based on Bandura's Theory of Self Efficacy (1997). Self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves, and behave (Bandura, 1997). There are those people who have strong self-efficacy and those who doubt their capabilities in difficult situations. People with strong self-efficacy tend to approach difficult task as challenges to be mastered. These people approach threatening situations with assurance in themselves and little doubt about their capabilities to over come the problem. This type of outlook is seen to produce personal accomplishments, reduce stress, and lower vulnerability to depression. Those people who have low self-efficacy tend to have low aspirations and weak commitment to the goals they choose to pursue. These people easily develop stress and depression (Bandura, 1997).

A second theoretical framework was based on the Felder-Soloman (1993) Learning Styles Model and the Index of Learning Styles (ILS). A learning style is defined as a "cognitive, affective, and physiological trait that serves as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (Keefe, 1982, p. 44).

The agricultural education profession has started looking at teachers' capacity to teach integrated process skills. A study by Myers, Washburn, and Dyer (2004) investigated Florida's agriscience teachers' capacity to teach science integrated process skills in the classroom and the influence of learning styles on the teaching of integrated process skills. While the researchers found that teachers had acquired the knowledge to perform and apply integrated process skills, learning styles had little to no influence on their capacity to teach such skills. However, the researchers did not examine teacher's confidence (self-efficacy) in teaching science related concepts. As more states are allowing agriculture classes to count for science credit, agriculture teachers will be responsible for ensuring that agriculture lessons contain sufficient science concepts and that students have the science skills to pass standardized state tests. Yet little is known about the teachers' confidence to teach science concepts in agriculture classes. It is not known if agriculture teachers have the capacity to teach integrated process skills, skills that high school students need to achieve higher science achievement levels.

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 purpose of this study was to determine Mississippi AEST teachers' capacity to teach science integrated process skills. The following research objectives guided this study:

1. Determine the knowledge level of science integrated process skills of AEST teachers.
2. Determine the self-efficacy for teaching science of AEST teachers.
3. Determine the influence of self-efficacy in AEST teachers on teaching science integrated process skills.
4. Determine the learning styles of AEST teachers.
5. Determine the influence of learning style on science integrated process

Methods and Procedures

A descriptive-correlational research design was utilized for the study. Borg and Gall (1996) define descriptive studies as studies used to find out “what is”. Correlational studies include research that attempts to discover or clarify relationships through the uses of correlation coefficients. Correlational studies tell the research the relationship between two variables but they cannot be used to determine whether A causes B, B causes A, or whether a third variable causes both A and B (Borg & Gall, 1996).

The target population of this study was all Mississippi AEST teachers at the end of the 2005-2006 school year. A current list of teachers provided by the Mississippi Department of Education identified 51 potential participants. The accessible sample for this study consisted of those AEST teachers who participated in the GIS/GPS Applications in Agriculture Workshop June 11- 14, 2006 at Mississippi Delta Community College. Short notice of the workshop was given so only half of the teachers that were supposed to attend were able to participate in the workshop. Twenty four teachers attended the workshop and were considered the accessible sample for the study.

Three instruments were utilized for data collection. Okey and Dillashaw’s Test of Integrated Process Skills (TIPS) (1980) was administered to each AEST teacher. The TIPS instrument is a 36 multiple choice question exam developed to measure integrated process skills along five objectives. These objectives are identifying variables, identifying and stating hypotheses, operationally defining, designing investigations and graphing and interpreting data. Reliability of the TIPS instrument was established by Dillashaw and Okey and reported to be 0.89 (Cronbach’s alpha).

A second instrument, the Index of Learning Styles (Felder & Solomon, 1993), was administered to assess the preferred learning styles of each teacher. The ILS separates learning styles into four dimensions:

- “*sensing* (concrete, practical, oriented toward facts and procedures) or *intuitive* (conceptual, innovative, oriented toward theories and underling meanings);
- *visual* (prefer visual representations of presented material, such as pictures, diagrams, and flow charts) or *verbal* (prefer written and spoken explanations);
- *active* (learn by trying things out, enjoy working in groups) or *reflective* (learn by thinking things through, prefer working alone or with one or two familiar partners);
- *sequential* (linear thinking process, learn in incremental steps) or *global* (holistic thinking process, learn in large leaps).”

The instrument consists of 44 questions designed to access preferences on the 4 dimensions. Each learning style dimension has associated with it 11 forced-choice items, with each option corresponding to one or the other categories (Felder & Spurlin, 2005). Felder and Spurlin (2005) found that reliability and validity data justified a claim that the ILS is a suitable instrument for assessing learning styles. The principal results that bear on the reliability and validity of the Felder-Solomon ILS are as follows:

- Test retest correlation coefficients for all four scales of the instrument varied between 0.7 and 0.9 for an interval of four weeks between test administrations and between 0.5 and 0.8 intervals of 7 months and 8 months. All coefficients were significant at the 0.05 level or better.

- Cronbach alpha coefficients were all greater than the criterion value of 0.5 for attitude surveys in three of four studies and were greater than that value for all but the sequential-global dimension in the fourth study. The values of the coefficients for each dimension in all but the latter study were remarkably consistent with one another.

The final instrument used in this study is the Science Teaching Efficacy Belief Statement developed by Riggs and Enochs (1990). This instrument contains 25 items that were rated on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). Construct validity was determined based on the established correlation with teaching efficacy beliefs or their hypothesized relationship with science teaching efficacy beliefs. Validity coefficients were significantly correlated with at least one scale in the study and were positive, supporting construct validity of the scales (Riggs & Enochs, 1990). Reliability of the instrument was determined on two separate factors, one called personal science teaching efficacy (PSTE) (with a Cronbach's alpha of .92) and the second factor labeled science teaching outcome expectancy (STOE) (with a Cronbach's alpha of .77).

Data were collected at the GIS/GPS Applications in Agriculture workshop conducted at Mississippi Delta Community College June 11-14, 2006. A packet consisting of an informed consent form and the three coded instruments were given to each teacher upon registration at the workshop. Teachers returned the completed instruments to the workshop coordinator at the conclusion of the workshop, who then returned the completed instruments to the researcher. The total number of returned instruments was 20 out of 24 teachers who attended the workshop. This yielded an 83 percent response rate.

Data were analyzed using SPSS 13.0. Frequencies, percentages, means, and standard deviations were used to categorize and organize data. Pearson correlation coefficients and t-test were used to determine relationships between selected variables in the study.

Findings

The first objective was to determine the knowledge level of science integrated process skills of AEST teachers based on the results of the TIPS instrument (Okey & Dillashaw, 1980). Descriptive statistics were analyzed for the overall exam as well as by objectives. Results are presented in Table 2.

The mean overall score out of 36 total possible points on the TIPS instrument was 26.65, or 74 percent correct (s.d. = 6.01), with a range from 17 to 34 correct responses. AEST teachers in the sample performed best on the objectives "Operationally Defining" with a 79.2 percent correct response rate and "Identifying Variables" with a 75.8 percent correct response rate. The objective "Designing Investigations" had the lowest correct response rate of 66.7 percent.

Table 2
Mean TIPS Scores by Objective (n = 20)

Objective	Total Possible	Minimum Correct	Maximum Correct	Mean Correct	SD	Percent Correct
Identifying variables	12	4	12	9.10	2.34	75.8
Identifying and stating hypotheses	9	4	9	6.75	1.55	75.0
Operationally defining	6	2	6	4.75	1.37	79.2
Designing investigations	3	0	3	2.00	1.02	66.7
Graphing and interpreting data	6	2	6	4.05	1.27	67.5
Total Score	36	17	34	26.65	6.01	74.0

The second objective was to determine the self-efficacy of AEST teachers for teaching science based on the results of the Science Teaching Self-Efficacy Belief Statement (Riggs & Enoch, 1990). Table 3 shows the range of efficacy scores of AEST teachers. Scores range from 79 to 107, with the overall mean being 90.3 (s.d. = 6.73).

The third objective was to determine the influence of self-efficacy on teaching science integrated process skills. Using a Pearson correlation coefficient, the correlation was calculated to be r = -.13. According to Davis (1971), there is a low, negative relationship between teachers' self efficacy scores and their capacity to teach science integrated process skills.

Table 3
Science Efficacy Scores of Mississippi AEST Teachers (n = 20)

Scores	Frequency	Percent
79.00	2	10.0
84.00	1	5.0
86.00	2	10.0
88.00	3	15.0
89.00	4	20.0
91.00	1	5.0
92.00	2	10.0
94.00	1	5.0
96.00	1	5.0
98.00	1	5.0
101.00	1	5.0
107.00	1	5.0

The fourth objective was to determine the influence of learning styles on integrated process skills. Table 4 shows that 60 percent of the respondents' scores indicated a reflective learning style while 40 percent indicated an active learning style. Ninety percent of the respondents' scores indicated a visual learning style while 10 percent indicated a verbal learning style. Sixty-five percent of the respondents' scores indicated a sequential learning style while 35 percent indicated a global learning style. Ninety percent of the respondents' scores indicated a sensing learning style while 10 percent indicated an internal learning style.

Table 4
Number of Active/Reflective, Sensing/Intuitive, Visual/Verbal, and Global Sequential Learning Styles of Mississippi AEST Teachers

Learning Style	Frequency	Percent
Active/Reflective		
Active	8	40
Reflective	12	60
Sensing/Intuitive		
Sensing	18	90
Intuitive	2	10
Visual/Verbal		
Visual	7	35
Verbal	13	65
Global/Sequential		
Global	2	10
Sequential	18	90

Significant differences were found in one of the four groups (Table 5). There was a significant difference between teachers' scores on the TIPS and having an active/reflective learning style (t = -2.50).

Table 5
t- test for TIPS scores by Learning Style

Learning Style	n	Mean	SD	t
Active/Reflective				
Active	8	23.0	6.26	-2.50*
Reflective	12	29.1	4.64	
Sensing/Intuitive				
Sensing	2	29.0	1.41	.572
Intuitive	18	26.4	6.30	
Visual/Verbal				
Visual	18	26.5	6.30	-.205
Verbal	2	27.5	3.53	
Global/Sequential				
Global	7	23.4	6.24	-1.87
Sequential	13	28.4	5.35	

* $p < .05$

Conclusions and Recommendations

Mississippi AEST teachers responded correctly to 74 percent of the questions on the Test of Integrated Process Skills (TIPS), exhibiting a satisfactory level of ability in their capacity to teach integrated process skills. The percentage of correct responses in this study, both overall and on each objective, were lower than the results reported by Myers, Washburn, and Dyer (2004) in the study on Florida agriscience teachers. These results suggested that AEST teachers have some of the knowledge required to instruct their students in the integrated process skills.

Mississippi AEST teachers scored higher on the TIPS objectives “Identifying Variables”, Operationally Defining”, and “Identifying and Stating Hypotheses.” Teacher scores were lower on the objectives dealing with “Designing Investigations” and “Graphing and Interpreting Data”. These results are somewhat similar to those as reported by Myers, Washburn, and Dyer (2004). In their study, teachers scored higher on “Identifying and Stating Hypotheses.” In both studies, teachers were weaker on “Graphing and Interpreting Data.” It can be inferred that more time needs to be spent in professional development workshops and specialty classes on designing, graphing and interpreting data so that AEST teachers can be better equipped to teach their students in these areas.

Regarding their capacity to teach science to students, Mississippi AEST teachers have a high self-efficacy as far as their capacity to teach science to their students. However, there is a low negative relationship between teacher self-efficacy and their capacity to teach integrated process skills.

Regarding the preferred learning styles of AEST teachers, Mississippi AEST teachers prefer to learn through reflection, through the use of visuals, through sequential activities, and by sensing. Furthermore, Mississippi AEST teachers that are reflective learners have a higher capacity to teach science integrated process skills than those teachers who are active learners.

Based on the conclusions of the study, the following recommendations are offered:

1. Colleges preparing teachers for high school agricultural education programs should investigate incorporating more science based courses in instruction to enhance agricultural teachers' effectiveness.

2. This study should be replicated in five years as more agricultural programs in the state are turning to a more science based program with more courses being offered that will allow students to earn elective science credits by completing agricultural education courses and programs.

3. This study should be replicated in other states that are using programs similar to AEST or who are offering agricultural education courses for elective science credits to compare results.

4. A study should be conducted to evaluate the knowledge level of AEST students to conclude if they are learning the science skills needed to graduate from the AEST program.

5. Results from this study should be presented to agriculture teachers at workshops and/or conferences, posted on the agriculture teachers' website, and used to plan teacher professional development workshops. This should help teachers realize that they have the capabilities, confidence, and capacity to teach their students science concepts.

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