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Outcomes of Integrated Agriscience Processes: A Synthesis of Research

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As the trend to integrate science and agriculture education has reemerged, so has the research related to the integration of science into secondary agricultural education. The American Association of Agricultural Education responded to this trend by creating a special interest group called "Strengthening Academic Learning through Agricultural Education." In 2005, Myers and Osborne developed the "Conceptual Model for Strengthening Academic Learning through Agricultural Education" to guide this group in identifying existing gaps in the literature and to help provide a directional path for future research. The purpose of this study was to use that conceptual model to review research, to make conclusions regarding the outcomes of efforts to integrate science and secondary agricultural education, and to identify gaps in the existing research. Recommendations and future questions for integrating science and agricultural education were posed by the authors.

Keywords: agriscience education, integrated agricultural education, synthesis of research

Introduction

The integration of science and agricultural education has been a point of discussion and practice since the genesis of secondary agricultural education. In the early 1900's, the Office of the Experimental Stations strongly supported the flow of information from the experimental stations to the classroom (Moore, 1988). During this time, schools developed and taught integrated curriculum; however, by the mid 1900's high school agricultural education programs began to focus more on vocational training than the distribution of scientific agricultural data (Hillison, 1996).

In the early 1980s, a federal trend to integrate science and agriculture in the high school agricultural education program reemerged (Phipps, Osborne, Dyer & Ball, 2007). In 1983, a report from the National Commission on Excellence in Education titled *A Nation at Risk* revealed that Americans performed poorly in basic science (National Commission on Excellence in Education, 1983). In response to the *A Nation at Risk* report, the National Commission on Secondary Vocational Education made six recommendations pertaining to curriculum in *The Unfinished Agenda: The Role of Vocational Education in High School* (National Commission on Secondary Vocational Education, 1984). Two of the six recommendations dealt with integration; and schools were encouraged to teach basic academic skills in vocational education. Even though this report recommended the integration of academic and vocational education, no specific methods or models for implementing integration were suggested (Stecher et al., 1994).

In 1988, the National Research Council in *Understanding Agriculture: New Directions for Education* stated the content of many agricultural education programs was found to be outdated and based on production agriculture. The report also identified integrated agricultural education as one solution for the national concern over inadequate science education in the United States. Recommendations for improving agricultural education in this report included revising curriculum to include the application of concepts from physical and biological science (National Research Council, 1988).

The Carl D. Perkins Vocational and Applied Technology Education Act Amendment of 1990 (Perkins II) was the first major piece of federal legislation encouraging educators to shift away from the traditional job skills orientation

of vocational education and move toward the use of vocational education to teach academics and other forms of thinking skills (Stecher et al., 1994). One of the key practices of the Perkins' initiative was the integration of vocational and academic curriculum (Miller, 1997). In a final report to the U.S. Congress regarding the 1998 Carl D. Perkins Vocational and Technical Act (Perkins III), the United States Department of Education (2004) recommended using curriculum development as a strategy to strengthen student academic performance and to improve vocational program performance.

In recent years, due to globalization and the exponential advances in science and technology, the science community and educational institutions are recognizing the need for more and better science instruction in K–12 programs. In 2007, the National Academy of Sciences (NAS) acknowledged the United States is losing its global leadership role in technology and science in the congressional report *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. One of the four recommendations was to vastly improve K–12 science education. In the 2009 summit report The National Academies of Science (2009) suggested we are now in an era of *scientific agriculture*. The group also suggested as the disciplines become intertwined consideration should be given to adding agriculture to the STEM (science, technology, engineering and mathematics) disciplines to create the acronym STEAM. The National Academies of Science further recommended colleges and universities reach out to high schools and youth programs to start building awareness in youth about these intertwined disciplines to recruit them into scientific agricultural disciplines.

As the trend to integrate science and agricultural education has escalated, so has research related to the integration of science into agricultural education. The American Association for Agricultural Education responded to this emerging trend by creating a special interest group called "Strengthening Academic Learning through Agricultural Education." In 2005, Myers and Osborne developed the *Conceptual Model for Strengthening Academic Learning through Agricultural Education* to guide this group in identifying existing gaps in the literature and to help provide a directional path for future research related to the integration of science and agricultural education. Their model was derived from a model for the study of classroom teaching created by Dunkin and Biddle in (1974). (See Figure 1.)

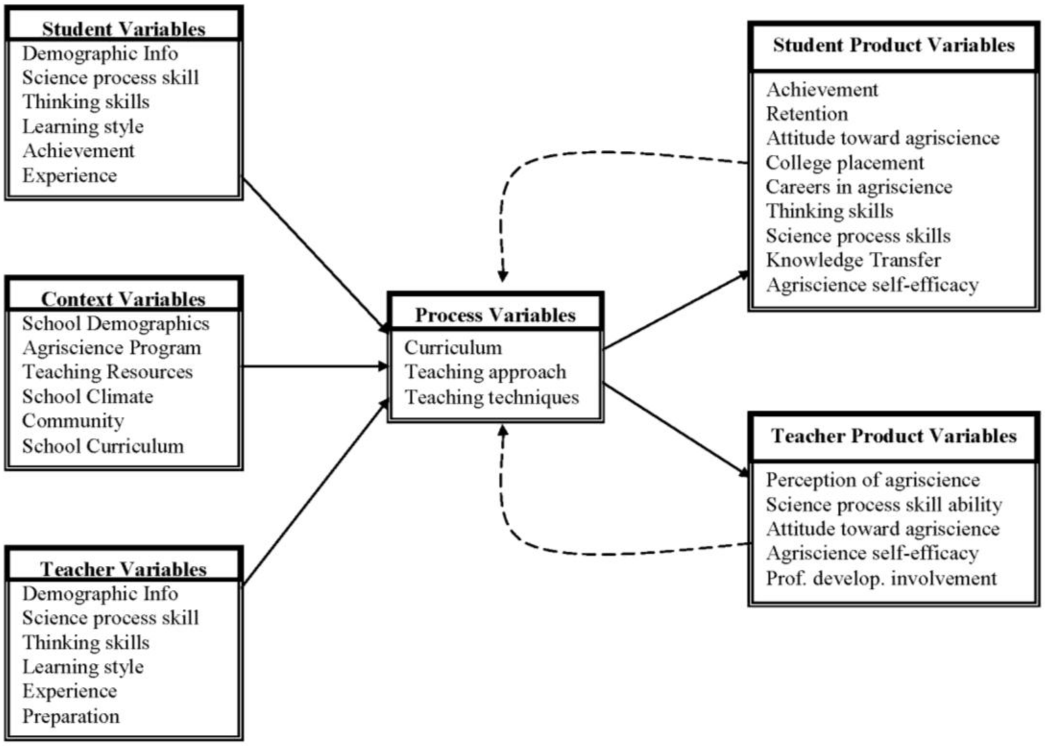

Figure 1. Conceptual model for strengthening academic learning through agricultural education research (Myers & Osborne, 2005).

In Figure 1, the process variables are possible models for integrating science and agricultural education. In a report prepared for the U.S. Department of Vocational Education, Stasz and Grubb (1991) stated "Integration means different things to different people and reform efforts vary widely, from fairly simple course changes to efforts that effectively restructure the high school" (p. 1). Many practitioners have developed models to integrate vocational and academic studies; however, the most common model of vocational and academic integration is the reinforcement model, which incorporates academic content into vocational courses (Roberson, 1997). This review of literature does not address the variations in models used to integrate science and secondary agricultural education. Instead the intention was to focus on the outcomes of efforts to integrate science and secondary agricultural education. As illustrated in Figure 1, these product variables are essential for revising existing processes.

Purpose/Objectives

The purpose of this study is to review the findings of research related to the integration of science and agricultural education in order to make conclusions regarding the outcomes of efforts to integrate science and secondary agricultural education and to identify gaps in the existing research.

The objectives of this study are to synthesize research related to the:

1. teacher product variables in the *Conceptual Model for Strengthening Academic Learning through Agricultural Education Research.*
2. student product variables in the *Conceptual Model for Strengthening Academic Learning through Agricultural Education Research.*

Procedures

Internet and library searches were used to acquire data for the study. Only works

published within the last 20 years were included in the findings section. Reference sources that were searched include proceedings of regional and national AAAE research meetings, *The Journal of Agricultural Education, The Journal of Vocational Education Research*, and keyword searches on the ERIC database to locate sources in other research disciplines.

Findings

The findings presented in this study reflect the work that has been done on the product variables of teachers and students as demonstrated in the previously explained conceptual model for strengthening academic learning through secondary agricultural education. The research discussed does not necessarily represent an exhaustive list of the work completed on the topic of integrated science in agricultural education.

Student Achievement

Roegge and Russell (1990) determined an integrated approach to teaching biology was superior to a more traditional approach with regard to student achievement. Students who were taught with an integrated approach had significantly higher levels of achievement in applied biology concepts and overall. Enderlin and Osborne (1992) compared the achievement of students enrolled in an integrated agriculture and science course to those in a traditional horticulture course in Illinois. The researchers found students in the integrated group performed better on measures of both agricultural and biological science knowledge. Newman and Johnson (1993) concluded pilot courses in their state were well received by students and teachers but more research was needed to determine if the student's science skills were increased by the pilot courses.

Chiasson and Burnett (2001) demonstrated that students enrolled in an agriscience curriculum outperformed non–agriscience students on the science component of the Louisiana graduate exit examination. More recently, Theriot and Kotrlik (2009) demonstrated being enrolled in agriscience had a statistically significant, although not practically significant positive effect on overall science achievement when compared to non–agriscience students on the Louisiana graduate exit examinations These findings are similar to a Georgia study which found a low positive correlation between the science achievement of agriscience students on a graduation test and the number of agriscience courses they had taken in high school (Ricketts, Duncan, & Peake, 2006). Flowers (2000) compared the achievement scores of agricultural education students to those in other vocational areas as well as college prep students. Results indicated substandard marks in reading and mathematics for agriculture students compared to other groups, but a substantial advantage in the area of life sciences.

Studies aimed at determining the achievement of students enrolled in integrated agriculture courses show agriculture students scored similar or better on science concepts than those in traditional science settings. Connors and Elliot (1995) found no significant differences in achievement on a standardized biology subject test between students who had and had not enrolled in agriscience courses. Similarly, in a study that compared students enrolled in a traditional biology course to those taught with agricultural applications, Warnick and Straquadine (1998) found the two groups performed equally on a Biology Core Test.

Student Retention

A review of agricultural education research literature did not yield any studies specifically addressed student retention in the context of academic integration. It is likely that such a study would have tremendous difficulty controlling for other variables. Broader work, however, can be applied to agricultural education and the concept of academic integration. Analyzing data from the National Educational Longitudinal Study of 1988, Plank (2001) asserted career and technical education courses, such as agriculture education, "when coupled with an academic load, may increase a student's commitment or attachment to high school" (p. 310). Plank further concludes a balance of CTE and academic courses rather than an extreme focus on either, is likely the best formula for keeping students in school.

Student Attitudes

When biology is taught using agriculture as the context, students have favorable perceptions of the agriculture industry (Balschweid, 2002), and understand biology concepts better in the contextualized approach than with other *traditional* biology courses (Balschweid, 2003).

Conroy and Walker (2000) highlighted the perceptions of students enrolled in a secondary aquaculture curriculum. The researchers collected qualitative data and found students believed the aquaculture curriculum contextualized what they were learning in other academic classes such as math and chemistry. Due to the deficiency of studies related to this product variable, further and more current research is needed to ascertain students' feelings toward integrated processes.

Student College Placement, Career Placement and Thinking Skills

Research related to the affects of integrated agriscience on the placement of agricultural education students in college and careers and their ability to think were not found in the current literature.

Student Science Process Skills

In a qualitative study of elementary students, Mabie and Baker (1996) reported integrated activities had a greater positive effect on science process skills when compared to alternative methods. Myers and Dyer (2006) examined the effect of laboratory delivery on the science process skill achievement of agriculture students. Although the treatment groups did not directly control for the level of integration present, the researchers found an investigative laboratory approach yielded higher science process skill gain scores than traditional methods with lesser degrees of integration. The notion that an integrated approach is beneficial for the acquisition of science process skills is in direct conflict to an earlier study done by Osborne (2000) which concluded students in a traditional prescriptive approach to laboratory had higher levels of science process skills than those in a more heavily integrated "investigative" approach.

Student Knowledge Transfer and Agriscience Self Efficacy

Research related to student knowledge transfer and student agriscience self efficacy, as a result of the integration of science into agricultural education, were not found in the current literature.

Teacher Perceptions and Attitudes

A considerable number of studies regarding academic and agricultural education curriculum integration relate to the perceptions of educators. Agriculture teachers and pre–service teachers are favorable to integrating academics into the agriculture classroom (Balschweid & Thompson, 2002; Myers & Washburn, 2007; Peasley and Henderson, 1992; Roberson, Flowers, & Moore, 2000; Thompson, 1998; Thompson & Balschweid, 2000; Thompson & Warnick, 2007; Thoron & Myers, 2010; Welton, Harbstreit, & Borchers, 1994; Wilson, Kirby, & Flowers, 2001). Science teachers are also in favor of integration, and recognize the benefit that real world context agriculture can provide (Osborne & Dyer, 1998; Warnick & Thompson 2007; Warnick, Thompson, & Gummer 2004). Other key players in education who are *on–board* with integration include principals (Johnson & Newman, 1993; Thompson, 2001), parents (Osborne, & Dyer, 2000), and guidance counselors (Dyer & Osborne, 1999; Johnson & Newman, 1993; Woodard & Herren, 1995).

With increased focus on academic content in a vocational classroom, comes increased rigor and expectations. This has led many to demand science credit for agriculture courses. Teachers overwhelmingly support granting science credit for completing integrated agriculture courses (Johnson, 1996).

Despite positive attitudes toward integration, integrated curricula has not achieved widespread implementation. Myers and Thompson (2009) highlight the need for a philosophical shift in the profession in order to *buy–in* to the idea on integrating math, science, and reading. This implies that although teachers may recognize integration as important, they need encouragement and assistance to adopt integrated curriculum in their classrooms.

Teacher Science Process Skill Ability

Despite the apparent lack of *content* training, researchers (Myers, Washburn, & Dyer, 2004; Hamilton & Swortzel, 2007) assert agriculture teachers possess the proper knowledge to perform and apply science integrated process skills. That is to say, agriculture teachers are equipped to teach in ways that science educators find most beneficial such as the inquiry approach. When coupled with the work done on the science process skills of students in agriculture education (Mabie & Baker, 1996; Myers & Dyer, 2006), it appears agriculture is ripe for adopting science process skills as a means to integrate the two disciplines.

Teacher Agriscience Self–efficacy

To aid in discovering why integrated practices are not necessarily commonplace in today's agricultural education classroom, researchers have probed teachers on their self–efficacy. Scales, Terry, and Torres (2009) analyzed the confidence and competence of agriculture teachers in Missouri and found although agriculture teachers were confident they could integrate science content, their low scores on a subject test in science demonstrate they may not be proficient to do so. This failure to demonstrate competence in science through a subject test was also demonstrated by Wilson et al. (2001). However, in that case the agriculture teachers accurately perceived their lack of knowledge.

Several studies have identified barriers that prevent greater adoption of integrated curriculum which may affect a teacher's self efficacy. Layfield, Minor, and Waldvogel (2001) identified a lack of equipment, funding, and in–service/teacher education training as critical barriers. Washburn and Myers (2008) found agriculture teachers think more can be done to prepare future teachers to integrate science, while a study of West Virginia agriculture teachers (Boone, Gartin, Boone, & Hughes, 2006) cited a lack of background knowledge as a barrier for integrating curriculum.

Balschweid, Thompson, and Cole (2000) reported pre–service teachers were actually *less* likely to integrate curriculum after having been exposed to integration in a student teaching role. Reasons the preservice teachers had for the decline in their perceived importance of integration pointed toward the amount of time involved in integrating material. Thoron and Myers (2010) found preservice teachers perceived lack of knowledge to be their biggest barrier from teaching agriscience. In addition they concluded pre–service programs need to require more science courses and to provide courses and cooperating teachers that model science and agriculture integration. Clearly, these studies demonstrate more can be done in our teacher preparation programs and in–service training to prepare agriculture teachers to integrate academics into their curriculum.

Professional Development Involvement

Several researchers (Balschweid et al., 2000; Boone et al., 2006; Scales et al., 2009; Thoron & Myers, 2010), in the context of evaluating the status of integrated curriculum in agricultural education, have called for increased support from pre–service teacher education and in–service opportunities to prepare teachers to integrate. Layfield et al. (2001) reported teachers view both pre–service teacher education and in–service opportunities as the right vehicles for additional training. Wilson and Flowers (2002) researched the effect of a seven day agriscience in–service training program on the confidence of agriculture teachers' ability to integrate scientific subject matter. The researchers found those who participated in the in–service had significant gains in their pre and post training confidence when compared to a control.

The ability of the agriculture teacher to cooperate with other academic teachers is key for successful team teaching or other collaborative exercises. Dormody (1993) developed a predictive model for resource sharing and collaboration between the agriculture teacher and the science department. The model emphasizes a positive view of science on behalf of the agriculture teacher and positive interpersonal relationships among collaborators. Conroy and Walker (2000) reported agriculture teachers cite territorial issues as barriers for increased attempts at integration, highlighting Dormody's (1993) need for positive interpersonal relationships with science department personnel. Several professional development opportunities have been carried out which pair science and agricultural educators in professional development; however, no research was found regarding the long term effects of the training on teacher collaboration and sharing of resources.

Conclusions/Recommendations

The National Research Agenda: 2007–2010 (Osborne, 2007), identified the need to provide a "rigorous, relevant, standards based curriculum in agricultural, food, and natural resources systems" (p. 8) making curriculum development trends a research priority. As a result of this agenda the "Strengthening Academic Learning through Agricultural Education" American Association for Agricultural Education special interest group developed a conceptual model which identified teacher and student product variables. This synthesis of research focused

exclusively on research regarding the teacher and product variables in this conceptual model. After a review of the findings, it becomes clear the profession needs to increase focus on more empirical research designs instead of the perception based descriptive studies dominating the literature. Nonetheless, the conclusions of this study are based on the body of research that does exist.

Research on student attitudes regarding integrated agriscience is limited. Those studies identified concluded students who have experienced an integrated process variable such as integrated curriculum possessed a more positive attitude about the integration of science and agricultural education. More attention should be given to examining these student attitudes which can affect student motivation, recruitment, and retention in agricultural education.

A somewhat positive relationship exists between student achievement and integrated agriscience processes. Most of the studies found compared test scores of students at the end of a process or course. In the future, new statistical software may be able to determine the influence of a particular teacher or course on student academic achievement using three years of end of course data (Wallis, 2008). More experimental studies rather than descriptive studies are needed to conclude that integrated science processes do affect student achievement in the sciences. In addition several of these studies were done in the early 1990s and current integrated processes need to be examined.

At this time a deficit exists in research regarding the effects of integrated agriscience processes on student retention, college placement, careers in agriscience and knowledge transfer. This deficiency is not uncommon in educational research because such studies are longitudinal and challenging to complete. Although the research regarding students' acquisition of science process skills through integrated curriculum is somewhat mixed, it seems agriculture teachers are capable of applying inquiry based approaches to the agriculture curriculum. More research is needed however, to better gauge the perceptions and confidence of agriculture teachers with regard to the implementation of science process skills.

Science teachers, principals, and guidance counselors generally value integrated agriscience processes. Agricultural education teachers value integrated curriculum and overwhelmingly support receiving science credit for their courses yet integration still has not been widely implemented.

A few studies have found agricultural teachers possess the self–efficacy needed in order to adopt integrated agriscience processes; however teachers recognize they lack the necessary knowledge. According to Weiner's attribution theory (Weiner, 1985) even though they possess self–efficacy, they will not carry the action out if they perceive an uncontrollable barrier exists. Unfortunately, teachers perceive many barriers to integrated agriscience processes such as a lack of equipment, funding, resource sharing, and time. Many researchers concluded pre–service and in–service programs should address these barriers and processes should be designed that reduce the intensity of the barrier. Professional development efforts have been made by state and national agencies such as the National Agricultural Education Council; however, little research exists regarding the outcomes of these professional development efforts.

This synthesis of research identified several areas of deficiencies pertaining to the integrated product variables (outcomes) of science integration in agricultural education. The following questions should be addressed by the agricultural education profession:

1. What integrated agriscience process variables are currently being used to integrate science and agricultural education?
2. What current integrated agriscience process variables are most effective in producing student and teacher product variables?
3. What long term effect do science and agricultural education processes have on student outcomes such as college placement, selection of a career in agriscience, and knowledge transfer?
4. Do agriscience integration processes increase student self–efficacy in agriculture and science?
5. Do agricultural education teachers possess the science content knowledge needed to implement integrated process variables?
6. What types of pre–service and in–service activities are most effective in getting teachers to implement integrated agriscience process variables?

7. Do teachers perceive there are different barriers to implementing different types of integrated process variables?
8. What determines teachers' attitudes toward implementing integrated agriscience?

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