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# Science Integrating Learning Objectives: A Cooperative Learning Group Process

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## Abstract

The integration of agricultural and science curricular content that capitalizes on natural and inherent connections represents a challenge for secondary agricultural educators. The purpose of this case study was to create information about the employment of Cooperative Learning Groups (CLG) to enhance the science integrating learning objectives utilized in secondary agriculture programs. The objectives of the study were to determine if CLGs were an effective means for increasing: a) the number of science integrating learning objectives utilized in agriculture courses; and b) the number of science integrating learning objectives that require higher levels of cognitive processing in agriculture courses. Overall, the findings revealed that the CLG process lead to an increase in the total number of science integrating learning objectives and an increase in the number of science integrating learning objectives that require higher levels of cognition. Matched-sample *t* tests revealed that the increases in the number of science integrating learning objectives and objectives that require higher levels of cognition were statistically significant. It is recommended that researchers investigate methods for improving the specification, revision, and implementation of science integrating learning objectives used to guide student learning experiences in secondary agricultural programs of study.

Keywords: agricultural education; science integration; cooperative learning

Historically, secondary agricultural programs of study have been considered to be separate from the academic subjects that tend to be recognized as the core of the U.S. educational system (Gordon, 2008; Thompson, 1996). From a conceptual perspective, secondary agricultural programs of study have traditionally focused on curriculum and instructional practices which were based on the industry specific skills and technologies that would assist students in transitioning into skilled wage employment or entrepreneurship (Gordon, 2008; Stewart, Moore, & Flowers, 2004). However, as the educational reform movement has moved forward and broadened its agenda, its tendrils have extended deeply into the realm of agriculture education (Stearn & Stearns, 2006). One of the main outcomes of that reach has been to provide an impetus for reimaging what secondary agricultural education is and what it might become for future populations of students (DeLuca, Plank, & Estacion, 2006; Warnick & Thompson, 2007).

One of the central themes embedded within the movement to adapt secondary agricultural education to the future needs of students is to utilize agriculture as a context for a broader set of student outcomes (Stearn & Stearns, 2006; Stewart, Moore, & Flowers, 2004). One facet within that broader set of student outcomes is to utilize secondary agricultural programs of study as a space in which science content can be contextualized. This strategy has been explicitly encouraged since the enactment of the 1990 amendments to the Carl Perkins Act which stated that the basic federal grant to individual states for vocational education be spent on programs that "integrate academic and vocational education" (Carl D. Perkins Vocational and Applied Technology Education Act Amendments, 1990, p. 6). The explicit inclusion of science content experiences as an essential component of agricultural programs of study represents an important change in how secondary

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agricultural education is popularly conceptualized (Gordon, 2008; Stearn and Stearns, 2006). The legislative outcomes also serve as evidence that the inclusion of science content in secondary agricultural programs of study has gained credibility and prominence (Brister & Swortzel, 2007; Castellano, Stringfield, & Stone, 2003; Rojewski, 2002).

Today, individual secondary agriculture programs may focus on a diverse array of subject areas such as electrical systems, GIS technology, horticulture, and green construction. The variety of possible subject areas within secondary agriculture programs creates a context in which there exists a multitude of opportunities for the integration of agricultural and science content (Balschweid & Thompson, 2002; Hillison, 1996). Research findings indicate that the most effective agricultural and science content integration emerges as an outcome of classroom and laboratory experiences that foster contextualized learning environments (Ricketts, Duncan, & Peake, 2006; Stone, Alfeld, Pearson, Lewis, & Jensen, 2005). Research findings also indicate that the central strength of agricultural and science content integration is grounded in the fact that, by definition, agricultural programs and courses of study offer opportunities to link learned knowledge and skills directly with authentic applications (Castellano, Stringfield, Stone, 2003).

As Myers and Washburn (2008) note, a number of prominent researchers (Balschweid & Thompson, 2002; Balschweid, Thompson, & Cole, 2000; Conroy & Walker, 2000; Enderlin & Osborne, 1992; Mabie & Baker, 1996; Parr, Edwards, & Leising, 2006; Persinger & Gliem, 1987; Roegge & Russell, 1990; Stone, Alfeld, Pearson, Lewis, & Jensen, 2005; Young, Edwards, & Leising, 2009) have begun to establish a solid knowledgebase within the area of agricultural and science content integration. However, Myers and Washburn (2008) also point out that much more research needs to be enacted to form a more comprehensive understanding of agriculture and science content integration. In particular, more research needs to be conducted that assists in defining the following two concepts: 1) how is agricultural and science content integration being operationalized within secondary agricultural programs of study; and 2) how do integrated agricultural and science content learning experiences affect overall student achievement (Edwards, 2004; Myers & Washburn, 2008). This study will address the concept of how agricultural and science content is being integrated and more specifically it will focus on the process integration.

Heretofore, there has been little research completed that addresses agricultural and science content integration as a process (Edwards, 2004; Myers & Washburn, 2008; Spindler, 2013). As Edwards (2004) noted, the research base regarding how teachers think about and conduct curriculum integration in secondary schools is, for the most part, undeveloped. More specifically, very little information exists in the literature regarding how secondary agriculture teachers make sense of agricultural and science content integration, particularly with respect to the creation of learning objectives that will guide the instructional activities utilized to engage students (Scott & Sarkees-Wircenski, 2008; Warnick & Thompson, 2007).

It is clear that the existing research literature does little to assist in understanding the process of agricultural and science content integration based upon the experiences and perspectives of secondary agriculture teachers (Fetcher & Zirkle, 2009). In fact, only one recent study frames agricultural and science content integration as process which may be experienced by agriculture teachers. Further, there is a dearth of research findings that illustrate specific methods, actions, supports, and resources which facilitate the process of agricultural and science content integration (Edwards, 2004; Stearn & Stearns, 2006; Washburn & Myers; 2010).

Much of the research regarding agricultural and science content integration has focused on perceptions of its merit and worth rather than on questions of how the process is or might be carried out (Ricketts, Duncan, & Peake, 2006; Spindler, 2010; Warnick & Thompson, 2007). Research needs to be enacted that will assist in identifying, developing, and connecting the phenomena that are the building blocks of the mechanism that initiates, drives, and sustains the agricultural and science content integration process (Washburn & Myers, 2010).

## Theoretical Framework

Social interdependence arises when individuals share common goals and the outcomes each individual experiences are dependent on the actions of others to which they are connected (Deutsch, 1962; D.W. Johnson & Johnson, 1989). As defined by Deutsch (1962) there are two types of social interdependence: 1) positive social interdependence, exists when there is a positive correlation among individuals' goal attainments and individuals perceive that they can only attain their goals if the other individuals with whom they are cooperatively linked attain their goals; and 2) negative social interdependence, exists when there is a negative correlation among individuals' goal attainments and individuals perceive that they can only attain their goals if the other individuals with whom they are competitively linked fail to attain their goals. A condition of no interdependence exists when there is no correlation among the goal attainments of individuals and individuals perceive that their goal attainment is independent from the actions of others (Deutsch 1949a).

Deutsch constructed social interdependence theory based on two central concepts, the first concept was related to the type of interdependence between people in a specified context and the second concept was related to the type of actions enacted by the people involved (Johnson & Johnson, 2005). Social interdependence theory then is based on the conception that how participants' goals are structured determines the ways they interact and the resulting interaction pattern determines the outcomes of the situation (Deutsch 1949; Johnson & Johnson, 2009). Another outcome of Duetsch's work was the conception of three psychological processes that emerge from interdependence: 1) substitutability; 2) cathexis; and 3) inducibility (Deutsch, 1949). Substitutability is the degree to which the actions of one person substitute for the actions of another person. As a result of substitutability the effective actions of collaborators reduce the drive to complete a task. Cathexis is an investment of psychological energy in objects outside of oneself and it may have either positive or negative valences. Duetsch posited that in cooperative contexts, effective actions are cathected positively and bungling actions are cathected negatively. Inducibility is the openness to being influenced by and to influencing others. Positive interdependence creates greater openness to influence and negative interdependence tends to create resistance to influence.

Synthesizing the research surrounding social interdependence that took place over a thirty year period, Johnson & Johnson (2009), were able to modify and extend social interdependence theory in two distinct ways: 1) they were able to identify and validate variables that mediate the effectiveness of cooperation; and 2) by investigating numerous independent variables they were able to expand the scope of the theory. Based upon their research investigating the implementation of cooperation, Johnson and Johnson (2009) have posited that five variables mediate the effectiveness of cooperation: 1) positive interdependence; 2) individual accountability; 3) promotive interaction; 4) appropriate use of interpersonal social skills; and 5) group processing.

The five mediating variables that have been forwarded by Johnson and Johnson (2005, 2009) have been framed as the five essential tenets for cooperation. Cooperation consists of actions that support working or acting together for common purpose or benefit (Harris, 2010). Much of the research on Cooperation has been undertaken in educational and business settings where it has been utilized as an instructional and process facilitation strategy. It has been found that when collaborative processes employ structured cooperative group interactions the productivity of each individual is optimized (Mader & Smith, 2009). Further, research has demonstrated that collaborations that appropriately employ the five tenets of cooperation are more likely to attain preferred outcomes and outputs (Kunchenbrandt, Eyssel, & Seidel, 2013).

Given the robust nature of the evidence supporting cooperation as a as a form of collaboration, it is likely that the five tenets of cooperation could be employed to organize the process of revising and adapting the science learning objectives in secondary agricultural programs of study. The purpose of this case study was to create information about the employment of Cooperative Learning Groups (CLG) intended to improve the integration of science learning objectives within secondary agriculture programs of study. The objectives of the study were to determine if CLGs were an effective means for increasing: a) the number of science integrating learning objectives utilized in agriculture courses; and b) the number of science integrating learning objectives that require higher levels of cognitive processing in agriculture courses. The following null hypotheses were used to guide the study:

1. $H_0$: There will be no difference in the number of science integrating learning objectives within the agriculture teachers' courses of study before and after the engagement of the cooperative learning group process ($H_{0number}$: $\mu_{pre} = \mu_{post}$).
2. $H_0$: There will be no difference in the number of science integrating learning objectives that require higher levels of cognition within the agriculture teachers' courses of study before and after the engagement of the cooperative learning group process ($H_{0higher}$: $\mu_{pre} = \mu_{post}$).

## Methods

The sixteen individuals that participated in the current case study were state certified agriculture teachers working in urban, suburban, and rural comprehensive schools and area career and technical centers in the state of New York. The criterion sample utilized for the current case study was selected from a population of thirty-six agriculture teachers that participated in a previous study regarding science integration within CTE programs. In the previous research study, the researcher utilized Bloom's revised taxonomy (Krathwohl, 2002) as a means to classify CTE and science integrating learning objectives operationalized within CTE programs of study. The potential participants for the current study were selected from those agricultural education programs that were found to be integrating science learning objectives.

In order to recruit potential participants to the study, a cover letter describing the study and a link to an informational webpage where the agriculture teachers could indicate their willingness to participate was mailed and emailed to potential participants. The mail and email documents explained the purpose and importance of the study, the value of their participation, and the data collection methods. After receipt of the initial reply email or submission through the research study webpage, working dates and times with the agriculture teachers were arranged using email.

Once working date arrangements were made the researcher assisted each agriculture teacher to develop a Cooperative Learning Group (CLG) consisting of two to three additional individuals at their school to work on improving the integration of science within at least one agriculture course of study. In addition to the agriculture teacher, most of the CLG groups consisted of: a) an administrator that worked with curriculum, instructional improvement, or CTE programming; and 2) one or two science teachers that taught biology, chemistry, or physics. The study occurred over a five month period and the CLGs were free to work on the project at their convenience. In return for their cooperation the agriculture teachers and CLG group members each received a $50.00 prepaid VISA gift card. Funding to support the research project was provided through a small grant program.

Although the CLGs actually worked on a range of phenomena, the information collected for this study specifically addresses the science learning objectives utilized by the agriculture teachers. As part of the study the CLGs were asked to attempt to increase the relative amount of science content integrated in the agricultural course of study and create more opportunities for students to engage in complex open ended science learning experiences. In order to assist the CLGs in making progress towards examining and adapting the science integrating learning objectives within the agriculture teacher's course of study the researcher taught a two hour workshop that introduced and demonstrated the use of Bloom's revised taxonomy (Anderson, Krathwohl, Airasian, Cruiskshank, Mayer, Pintrich, Raths, & Wittrock, 2001) to the CLGs. Bloom's revised taxonomy is an effective tool for writing, organizing, and analyzing learning goals and objectives (Blumberg, 2009). Bloom's revised taxonomy (Anderson, Krathwohl, et al. 2001) allows researchers and educators to conceptually chunk large amounts of complex information in order to bring more precision to applied practice. One of the critical strengths of the revised taxonomy is that it can be employed as a syntactic logic tool at the macro level for curriculum planning and program assessment and at the micro level for lesson planning and student assessment (Cannon & Feinstein, 2005).

In the revised taxonomy, learning objectives can be represented using a two-dimensional taxonomic table (Anderson, Krathwohl, et al. 2001). Table 2 illustrates the four dimensions or types of knowledge that are categorized on the vertical axis within the two-dimensional taxonomic table of the revised taxonomy and Table 3 illustrates the six levels of cognitive processing that are illustrated on the horizontal access of the table. The intersection of the four categories of the knowledge dimension and six categories of the cognitive process dimension form twenty-four discrete cells (Table 4) which afford educators the opportunity to more precisely classify learning objectives based upon the specific facets of the intersecting dimensions. (Krathwohl, 2002).

Table 2

*The Structure of the Knowledge Dimension of Bloom's Revised Taxonomy*

A. Factual knowledge: The basic elements students must know to be acquainted with a discipline or solve problems within it.
  Aa. The knowledge of terminology
  Ab. The knowledge of specific details and elements
B. Conceptual knowledge: The interrelationship among the basic elements within a larger structure that enable them to function together.
  Ba. Knowledge of classifications and categories
  Bb. Knowledge of principles and generalizations
  Bc. Knowledge of theories, models, and structures
C. Procedural knowledge: How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.
  Ca. Knowledge of subject-specific skills and algorithms
  Cb. Knowledge of subject-specific techniques and methods
  Cc. Knowledge of criteria for determining when to use appropriate procedures
D. Metacognitive knowledge: Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.
  Da. Strategic knowledge
  Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge
  Dc. Self-knowledge

Note. Adapted from Anderson, Krathwohl, et al. (2001). p. 29.

Table 2 demonstrates that within Bloom's revised taxonomy (Anderson, Krathwohl, et al. 2001) the four types of knowledge are: a) factual; b) conceptual; c) procedural; and d) metacognitive. Factual knowledge is considered to be knowledge of terminology, facts, and basic elements of more complex knowledge, e.g., people, events, locations, or dates (Anderson, Krathwohl, et al. 2001). Conceptual knowledge reflects a deeper understanding of content and how it is connected to larger systematic perspectives (Blumberg, 2009). Procedural knowledge often involves processes or methods and the criteria utilized to make decisions regarding key steps and procedures (Anderson, Krathwohl, et al. 2001). Metacognitive knowledge involves being self-aware of personal cognitive strengths and challenges. Metacognitive knowledge is also related to knowledge of general strategies for learning and knowledge about how, when, and why to employ particular learning strategies (Blumberg, 2009).

Table 3 illustrates that within Bloom's revised taxonomy (Anderson, Krathwohl, et al. 2001) the six levels of cognitive processing form a hierarchy based upon differences in complexity and range from least complex to most complex: 1) remember; 2) understand; 3) apply; 4) analyze; 5) evaluate; and 6) create (Anderson, Krathwohl, et al. 2001). The revised taxonomy lists additional verbs within each of the six levels which more clearly delineate their nature. For example, level 2 titled understand, includes more measureable verbs such as interpret, classify, and compare. In particular, it is the measureable verbs that more precisely characterize the breadth and depth of each of the cognitive process levels.

Table 4 illustrates the taxonomic table that can be used, in conjunction with the information reflected in Tables 2 and 3, to classify learning objectives. Any individual learning objective will fall under one of the six discrete categories of cognitive processing and at the same time will also be linked to one of the four discrete categories of knowledge dimension. The object in a learning objective statement is used to determine whether the learning objective is supporting factual, conceptual, procedural, or meta-cognitive knowledge acquisition and the verb in a learning objective statement is used to determine which cognitive process dimension is being applied in the learning process: remembering, understanding, applying, analyzing, evaluating, or creating.

Table 3

*The Structure of the Cognitive Process Dimension of Bloom's Revised Taxonomy*

1.0 Remember: Retrieving relevant knowledge from long-term memory.
    1.1 Recognizing, identifying
    1.2 Recalling, retrieving
2.0 Understand: Constructing meaning from instructional messages including oral, written, and graphic communication.
    2.1 Paraphrasing, translating
    2.2 Interpreting, illustrating, instantiating
    2.3 Classifying, categorizing, subsuming
    2.4 Summarizing, abstracting, generalizing
    2.5 Inferring, concluding, extrapolating
    2.6 Comparing, contrasting, matching
    2.7 Explaining, constructing models
3.0 Apply: Carrying out or using a procedure in a given situation.
    3.1 Executing, performing
    3.2 Implementing, carrying out
4.0 Analyze: Breaking material into its constituent parts and determining how the parts relate to one another and to an overall structure or purpose.
    4.1 Differentiating, discriminating, distinguishing
    4.2 Organizing, integrating, structuring
    4.3 Attributing, deconstructing
5.0 Evaluate: Making judgments based on criteria and standards.
    5.1 Checking, detecting, monitoring, testing
    5.2 Critiquing, judging
6.0 Create: Putting elements together to form a novel, coherent, and functional whole; reorganizing elements into a new pattern or structure.
    6.1 Generating, hypothesizing
    6.2 Planning, designing
    6.3 Producing, constructing

Note. Adapted from Anderson, Krathwohl, et al. 2001. p. 67-68.

Once the knowledge and cognitive process dimensions are determined, learning objectives can be correctly placed in the taxonomic table. Learning objectives placed in the upper left hand corner of the taxonomic table tend to be more concrete, simple, structured, and require less learner independence. And as the taxonomic niches traverse the table diagonally toward the lower right hand corner the learning objectives tend to be more abstract, complex, open, multifaceted, and require greater learner independence.

Table 4

*A two-dimensional illustration of the relationship between the knowledge and cognitive processing dimensions of Bloom's revised taxonomy*

| | Cognitive Process Dimension | | | | | |
|---|---|---|---|---|---|---|
| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
| Factual | A1 | A2 | A3 | A4 | A5 | A6 |
| Conceptual | B1 | B2 | B3 | B4 | B5 | B6 |
| Procedural | C1 | C2 | C3 | C4 | C5 | C6 |
| Metacognitive | D1 | D2 | D3 | D4 | D5 | D6 |

Note. Adapted from Krathwohl, 2002. p. 216.

It may be beneficial to provide several examples in order to more clearly delineate the process enacted by the CLGs to classify each of the learning objectives. To that end, Table 5 illustrates three example learning objectives and their classifications. For brevity only the essential elements of the example objectives are presented.

Table 5

*Example learning objective statements and their classifications*

| Learning Objective Statement | | Classification |
|---|---|---|
| 1 | Identify the 16 essential elements all plants need for life, growth, and reproduction | A1 |
| 2 | Analyze the relationship between a keystone species and the surrounding ecosystem | B4 |
| 3 | Evaluate the efficacy of animal care plans based on real-time data analysis procedures | C5 |

Table 5 illustrates that the object in learning objective one was as follows: the 16 essential elements all plants need for life, growth, and reproduction. Learning objective one required learners to demonstrate a type of knowledge that represents a basic building block which would be utilized in the construction of different types of knowledge. More specifically the object of the learning objective sentence required students to demonstrate knowledge of technical vocabulary, a type of factual knowledge. Therefore, learning objective one was classified as being within the factual knowledge category of the knowledge dimension of Bloom's revised taxonomy.

Table 5 demonstrates that the verb in learning objective one required learners to identify information. In this case, to identify the required information depends only on the learners' ability to recognize or recall, therefore, learning objective one was classified as being within the remember category of the cognitive process dimension of Bloom's revised taxonomy. Once both dimensions of a learning objective have been classified it can be placed into one of the 24 cells created by the intersection of the knowledge and cognitive process dimensions of the taxonomic table illustrated in Table 4. Using Table 4 as a guide, objective one would most appropriately be placed in cell A1 at the upper left hand corner of the taxonomic table.

Table 5 illustrates that the object in learning objective three was as follows: the efficacy of animal care plans based on real-time data analysis procedures. The object of the learning objective sentence required students to demonstrate knowledge of subject specific techniques, as well as, knowledge of criteria for determining when to use appropriate procedures. Therefore, learning objective three was classified as being within the procedural knowledge category of the knowledge dimension of Bloom's revised taxonomy.

Table 5 demonstrates that the verb in learning objective three required learners to evaluate situations based upon real-time data. In order to demonstrate the ability to complete the required evaluations learners must be able to enact appropriate interpretation and appraisal techniques that lead to accurate judgments. Therefore, learning objective three was classified as being within the evaluate category of the cognitive process dimension of Bloom's revised taxonomy. Utilizing Table 4 as a guide, objective three would most appropriately be placed in cell C5 at the lower right hand corner of the taxonomic table.

As part of the research process the CLGs were asked to work cooperatively to complete goal oriented activities. Table 6 illustrates how the goal oriented activities the CLGs were asked to carryout align with the theoretical framework. The first tasks included the CLG participants working together to create a shared understanding of the scope and sequence of the science integrating learning objectives used in the agricultural course of study. The second layer of tasks involved the cooperative groups employing Bloom's revised taxonomy to classify the science integrating learning objectives utilized in the agricultural course of study first individually and then collaboratively. This process took advantage of one of the central strengths of the taxonomic table in that it provides a framework for describing learning objectives by the type of knowledge to be gained and the cognitive process employed to facilitate the actual learning. Employing the taxonomic table as a classification tool provided a visual map that the CLGs could then use in the third layer of tasks to assess the overall arrangement and level of the science integrating learning objectives utilized by the agriculture teachers. The third layer of tasks directed the CLGs to organize and analyze the science integrating learning objective data to look for trends and possible knowledge type or cognitive process gaps.

Table 6

*Links between the theoretical framework work and CLG activities*

| | |
|---|---|
| Positive Outcome Interdependence | Creating or adapting science integrating learning objectives<br>Increasing the level of cognitive processing elicited by the science integrating learning objectives<br>Improving the alignment of science integrating learning objectives to state learning standards |
| Individual Accountability | Reviewing and classifying science integrating objectives<br>Generation and adaption of science integrating objectives<br>Assess alignment of science integrating learning objectives and state standards |
| Promotive Interactions | Actively participate in group work sessions<br>Explaining and elaborating science integrating learning objectives<br>Relationship building through shared understandings and work |
| Interpersonal Skills | Listening for understanding<br>Purposeful checks for understanding<br>Asking questions |
| Group Processing | Work session reflections<br>Describing what was helpful<br>Making decisions about what actions should continue or change |

Once the CLGs had analyzed the data for trends and gaps, the fourth layer of tasks requested that they work collaboratively to create new and adapt existing science integrating learning objectives in order to increase: a) the number of science integrating learning objectives within at least one course of study; and b) the level of cognitive processing elicited by the science learning objectives utilized by the agriculture teacher in at least one course of study. The fifth layer of tasks asked the CLGs to utilize Bloom's revised taxonomy to reclassify the science integrating learning objectives for the agriculture course of study first individually and then collaboratively in order to assess the level of change that had occurred throughout the CLG process.

Data for the current research study were collected after the second and fifth layers of activities. Collected data included frequency counts of the total number of science integrating learning objectives and the number of science integrating learning objectives populating each of the cells in Table 4. For the purposes of this study science integrating learning objectives that were classified as being in the analyze, evaluate, and create categories of the taxonomic table were considered to require higher levels of cognitive processing.

Data analysis included calculating difference scores that resulted from the change in the number of science integrating learning objectives in the agricultural teachers' courses of study from the beginning to the end of the CLG process. In addition, data analysis also included converting frequency data resulting from the classification of the science integrating learning objectives by the CLGs into percentages. Converting the frequency data to percentage data was done to facilitate analyses of the dispersal of the science integrating learning objectives across Bloom's revised taxonomic table (Table 9). In order to test the null hypotheses matched-sample *t* tests were utilized and an a priori level of significance of 0.05 was set as the standard for rejecting the null hypotheses (Howell, 2002). Effect size was estimated utilizing Cohen's *d*; calculation procedures for estimating effect size for matched-sample *t* tests were carried out according to Howell (2002).

## Findings

The 16 agriculture teachers participating in the study taught an average of 146 (SD= 9.2) students per year and taught an average of 5.2 classes (SD=.54) a day. A minority of the teachers were female 6 (38%) and 15 (94%) of the instructors had completed an accredited teacher preparation program. The mean number of hours the CLGs worked on the overall process was 43.5 (*SD* = 12.24) hours. With respect to research objective one, before beginning the CLG process the agriculture teachers had a composite total of 781 science integrating learning objectives situated within a mean of 8 units of study. After engaging in the CLG process the agriculture teachers had a composite total of 1,126 science integrating learning objectives situated within a mean of 8 units of study.

Table 7 shows that the CLG process resulted in each of the agriculture teachers increasing the total number of science integrating learning objectives in their course of study. Additionally, Table 7 reveals that all of the agriculture teachers increased the total number of science integrating learning objectives that require higher levels of cognitive processing in their course of study. Analyzing the data presented in Table 7 demonstrates that all of the agriculture teachers were also able to increase the proportion of their science integrating learning objectives that require higher levels of cognitive processing.

Figure 1 shows a box and whisker plot which summarizes the difference scores that resulted from the change in the number of science integrating learning objectives in the agricultural teachers' courses of study from the beginning to the end of the CLG process. Reviewing the data in Figure 1 reveals that the median difference score was -20.5 and most of the difference scores fell into a band that ranged from -29 to -17.

Table 8 illustrates the results of the matched-sample *t* test which was utilized to test the first null hypothesis: $H_0$: There will be no difference in the number of science integrating learning objectives within the agriculture teachers' courses of study before and after the engagement of the cooperative learning group process ($H_{0\text{number}}$: $\mu_{\text{pre}} = \mu_{\text{post}}$). The results indicate that the number of science integrating learning objectives (M = 70.38, SD = 14.13) within the agriculture teachers' courses of study following the CLG process was significantly greater ($t = -12.50$, $p = .0001$) than the number of science integrating learning objectives (M = 48.81, SD = 10.29) in the agriculture teachers' courses prior to the CLG process. The difference between the means represents a large practical effect ($d = 1.74$). In this case, the null hypothesis was rejected.

Table 7

*Number of course units, number of science integrating learning objectives, and number of science integrating learning objectives require higher levels of cognition before and after the CLG process* (*n* = 16)

| | Pre | | | Post | | |
|---|---|---|---|---|---|---|
| P[1] | # of Units[2] | # of Objectives[3] | # High[4] | # of Units | # of Objectives | # High |
| 1 | 7 | 43 | 6 | 7 | 61 | 28 |
| 2 | 9 | 58 | 14 | 9 | 78 | 36 |
| 3 | 10 | 64 | 11 | 10 | 93 | 48 |
| 4 | 4 | 36 | 4 | 5 | 53 | 28 |
| 5 | 8 | 48 | 10 | 8 | 65 | 27 |
| 6 | 7 | 46 | 12 | 7 | 66 | 31 |
| 7 | 8 | 40 | 7 | 8 | 61 | 31 |
| 8 | 10 | 52 | 6 | 10 | 80 | 35 |
| 9 | 6 | 40 | 5 | 6 | 46 | 31 |
| 10 | 5 | 39 | 12 | 5 | 52 | 22 |
| 11 | 9 | 45 | 7 | 9 | 74 | 33 |
| 12 | 11 | 64 | 14 | 11 | 90 | 50 |
| 13 | 8 | 48 | 3 | 8 | 69 | 31 |
| 14 | 9 | 54 | 9 | 9 | 84 | 39 |
| 15 | 9 | 68 | 13 | 9 | 87 | 41 |
| 16 | 8 | 36 | 8 | 8 | 67 | 34 |

Note: [1]Participant number. [2]total number of units in course of study. [2]total number of science integrating learning objectives in course of study. [4]Number science learning objectives in course of study that require higher levels of cognitive processing.

Table 9 demonstrates that the agriculture teachers were utilizing very few science integrating learning objectives aimed at supporting the utilization of higher levels of cognitive processing. Table 9 illustrates that 82% of the science integrating learning objectives described and assessed by the CLGs required only lower levels of cognitive processing. Further, 60% of all the science integrating learning objectives utilized by the agriculture teachers addressed lower order cognitive processes within the factual knowledge dimension category.

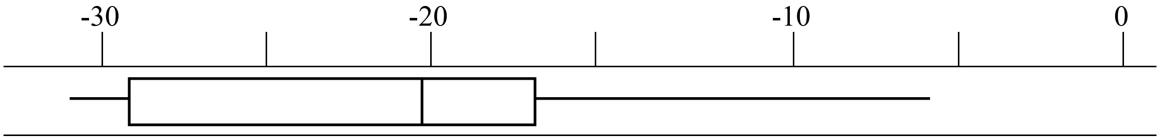

Figure 1. Box and whisker plot illustrating the difference scores resulting from the change in number of science integrating learning objectives between the beginning and completion of the CLG cooperative process.

The findings illustrated in Table 9 also reveal that the agriculture teachers placed more emphasis on factual and conceptual knowledge than on procedural knowledge. That indicates that, when integrating science, the agriculture teachers placed more emphasis on conceptual understanding

Table 8

*Comparison of number of science integrating learning objectives* (*n* = 16)

| Group | *M* | *SD* | *t* | *p* |
|---|---|---|---|---|
| Pre CLG Process | 48.81 | 10.29 | -12.50 | .00001* |
| Post CLG Process | 70.38 | 14.13 | | |

than they placed on actually executing appropriate techniques or procedures using learned skills. Therefore, it is not likely that the agriculture teachers were engaging in "inquiry-oriented" instruction in which learning is an active process that is geared towards implementing higher order learning objectives and experiential learning activities that support science as a process.

Table 9

*A classification of the  learning objectives CTE teachers operationalize in their classroom* (*n* = 16)

| | Cognitive Process Dimension | | | | | |
|---|---|---|---|---|---|---|
| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
| Factual | [1]29 | 19 | 11 | 9 | 2 | * |
| Conceptual | 9 | 5 | 5 | 5 | * | * |
| Procedural | 2 | 1 | 1 | * | * | + |
| Metacognitive | + | + | + | + | + | + |

Note. [1] Percent of the overall total number of objectives in classification rounded to the nearest whole number. * The percent of the overall total number of objectives is equal to less than 0.50. + No objectives in classification.

Part of the generalizable CLG process delineated in the current study included each of the CLGs collaborating to revise the science integrating learning objectives they had initially described and assessed. After the revisions were enacted the CLGs again went through the process of reviewing the science integrating learning objectives included in the agriculture teachers' courses of study using Bloom's revised taxonomy as a framework. Table 10 illustrates the results of each CLGs review of the revised science integrating learning objectives. Table 10 reveals that the revision process resulted in a more even distribution of science integrating learning objectives across a range of cognitive process and knowledge dimensions.

Table 10 shows that after the CLG revision process only 51% of science integrating learning objectives described and assessed were designed to elicit lower order cognitive processes and just over a quarter (28%) of all the science integrating objectives were characterized as addressing lower order cognitive processes within the factual category of the knowledge dimension. Table 10 illustrates that while the revised science integrating learning objectives still placed slightly more emphasis on conceptual understanding, the cooperative revision process lead to an increase in the number and proportion of science integrating learning objectives that emphasized utilizing knowledge or learned skills. This finding implies that the agriculture teachers would be more likely to incorporate more student learning experiences around the processes and applications of science in the future.

Table 10 also illustrates that the review and revision process enacted by the CLGs resulted in the addition of a substantial number of science integrating learning objectives in the evaluate and create categories in the cognitive process dimension of Bloom's revised taxonomy.

Meaning that the students of the agriculture teachers are likely to have more opportunities to: a) make judgments based on criteria and standards; and b) assemble elements together to form novel, coherent, and functional wholes. Making judgments and creating novelty are critical facets of the process of science, without including those aspects of the scientific process agricultural programs of study are not really integrating science as much as they are teaching science facts.

Table 10

A classification of the revised and adapted learning objectives (*n* = 16)

| | Cognitive Process Dimension | | | | | |
|---|---|---|---|---|---|---|
| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
| Factual | [1]10 | 10 | 8 | 7 | 8 | 6 |
| Conceptual | 5 | 4 | 4 | 5 | 3 | 6 |
| Procedural | 3 | 4 | 3 | 4 | 3 | 3 |
| Metacognitive | + | + | + | 2 | 2 | + |

Note. [1] Percent of the overall total number of objectives in classification rounded to the nearest whole number. * The percent of the overall total number of objectives is equal to less than 0.50. + No objectives in classification.

Figure 2 shows a box and whisker plot which summarizes the difference scores that resulted from the change in the number of science integrating learning objectives that require higher levels of cognition in the agricultural teachers' courses of study from the beginning to the end of the CLG process. Reviewing the data in Figure 2 reveals that the median difference score was -26. Most of the difference scores fell into a band that ranged from -30 to -19.

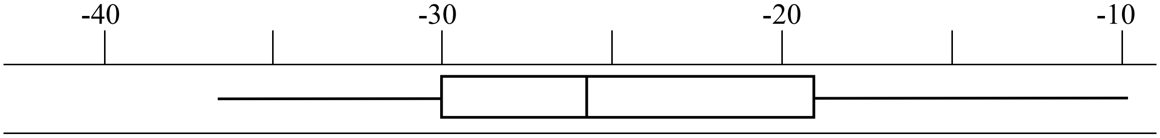

Figure 2. Box and whisker plot illustrating the dispersal of difference scores resulting from the change in number of science integrating learning objectives requiring higher levels of cognition between the beginning and completion of the CLG cooperative process.

Table 11 illustrates the results of the matched-sample *t* test which was utilized to test the second null hypothesis: $H_0$: There will be no difference in the number of science integrating learning objectives that require higher levels of cognition within the agriculture teachers' courses of study before and after the engagement of the cooperative learning group process ($H_{0higher}$: $\mu_{pre} = \mu_{post}$). The results indicate that the number of science integrating learning objectives that require higher levels of cognition (M = 34.06, SD = 7.45) within the agriculture teachers' courses of study following the CLG process was significantly greater (*t* = -15.10, *p* = .0001) than the number of science integrating learning objectives requiring higher levels of cognition (M = 8.81, 3.38) in the agriculture teachers' courses prior to the CLG process. The difference between the means represents a large practical effect (*d* = 4.32). In this case, the null hypothesis was rejected.

Table 11

*Comparison of number of science integrating learning objectives requiring higher levels of cognitive processing* (*n* = 16)

| Group | *M* | *SD* | *t* | *p* |
|---|---|---|---|---|
| Pre CLG Process | 8.81 | 3.58 | -15.10 | .00001* |
| Post CLG Process | 34.06 | 7.45 | | |

## Conclusions and Implications

It is clear that, agricultural education must be adapted to account for the sociological and technological advances which continually transform the nature of work and life (Weimer, 2003). As Flecther and Zirkle (2009) highlighted, the new modus operandi for agriculture teachers and other CTE teachers is to prepare students to be college and career ready. This new focus has created a need for agriculture programs to redesign the ways in which curricula are constructed and aligned. One of the most active discourses related to redesigning secondary agricultural education has encompassed the integration of science instructional content within agricultural courses of study (Blaschweid & Thompson, 2002; Brister & Swortzel, 2007; Conroy & Walker, 2000; Washburn & Myers, 2008). It is critical that agricultural education practitioners and researchers engage in creating learning activities designed to assist students in constructing new understandings through the contextualization of science concepts within authentic learning activities. It is those contextualized understandings that epitomize the outcome potential that agricultural and science content integration may realize within secondary agricultural programs of study.

The purpose of this case study was to create information about the employment of Cooperative Learning Groups (CLG) intended to improve the integration of science learning objectives within secondary agriculture programs of study. Matched-sample *t* tests revealed that the increases in the number of science integrating learning objectives and objectives that require higher levels of cognition were statistically significant. In addition, the utilization of Cohen's *d* as a statistic for assessing the changes in the number of science integrating learning objectives and objectives that require higher levels of cognition demonstrated that the CLG process lead to large practical effects. Therefore, it can be concluded that the CLGs were an effective means for: increasing: a) the number of science integrating learning objectives in agriculture courses; and b) the number of science integrating learning objectives that require higher levels of cognitive processing in agriculture courses. These conclusions match previous research that has demonstrated that properly organized and operationalized cooperative groups support higher levels of productivity and the enactment of more effective processes (Johnson & Johnson, 2009).

For the CLGs, utilizing the table specified in Bloom's revised taxonomy was an effective tool for assessing, analyzing, and adapting the science integrating learning objectives in the agriculture teachers' courses of study. While there was variation in the extent to which the CLGs changed the number of science integrating learning objectives, all of the CLGs added additional science integrating learning objectives and integrating objectives that support higher levels of cognitive processing to their respective agricultural course of study. The substantial change in the number of science integrating learning objectives and objectives fostering higher levels of cognitive processing across the participants is of practical significance. The findings illustrate that while science integration may be occurring in secondary agricultural programs, at this point in time the level of what is being taught as a consequence of that integration is still in question. The findings further indicate that it is a possibility that many secondary agricultural programs integrating science are teaching about science facts rather than engaging students in the process of science through open ended inquiry or even applying science concepts through meaningful activities. This finding is particularly relevant because what teachers do as instructors will be less important than what they ask their students to actually do before, during, and after instruction (Haskell, 2001; Mestre, 2005). Further, it is important to consider that by utilizing science integrating learning objectives in agricultural courses of study that require students to imagine, analyze, and create solutions to novel challenges throughout the instructional process instructors can more effectively assist students to construct knowledge and practice skills that facilitate knowledge retention and transfer (Mestre, 2005).

## Recommendations

Part of the need for this research is reflected within the increasing calls to more clearly define and assess the critical role agricultural education may have in contributing to the future academic achievement of students in the area of science. The need for this specific research arose in response to the call to more closely examine how agricultural and science content integration was being operationalized within secondary agricultural programs of study (Brister & Swortzel, 2007; Edwards, 2004; Myers & Washburn, 2008; Spindler, 2013). Because the current study is only one step toward creating a body of related literature, it is recommended that more research investigate the process of integrating science within agricultural courses of study. It is also recommended that researchers and practitioners consider creating more information about cooperative efforts between agriculture teachers and science teachers as a basis for exploring effective means of integrating science within agricultural courses of study.

The findings and conclusions of the current study indicate that the learning objectives agriculture teachers are using to integrate science within their courses of study may be insufficient for the preparation of persons able to utilize scientific methods and processes as tools for reasoning, decision making, and problem solving across domains of knowledge. Therefore, it is recommended that researchers investigate methods for improving the specification, revision, and implementation of science integrating learning objectives used to guide student learning experiences in secondary agricultural programs of study.

The current case study used social interdependence theory as a basis for investigating the utilization of CLGs as an effective way to facilitate and improve the process of integrating science into agricultural courses of study. Social interdependence theory is well supported by research and practice. The tenets of effective cooperation which have arisen from the social interdependence theory are also well supported by research and practice (Eddy, 2010; Johnson & Johnson, 2009). However, Johnson and Johnson (2009) call for more research to be carried out that investigates how social interdependence theory may be integrated with other psychological theories. It is recommended that researchers also consider investigating the potential connections between social interdependence theory and other prominent theories utilized in agricultural education and research. One example might be the theory of planned behavior which posits that attitudes toward behavior, subjective norms, and perceived behavioral control effect a person’s behavioral intentions and behaviors.

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